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DIO

Special Triple Issue

Tycho's 1004-Star Catalog

The First Critical Edition

Dedication

To my stepfather, John Williams Avirett 2nd, who died prematurely at age 91, just 4 days after this work's essential completion and first printing (1993/10/19). My wife Barbara and he were the only confidantes who then knew of *DIO*'s catalog D project. His optimism, loyalty, civic-mindedness, courage, and high standards of intellectual excellence will live forever in our family.

At his death, a little note from his Godmother was discovered, which he had evidently kept privately in his desk, all his working life. Dated 1909 Christmas, when he was 7 years old, the note spoke with the exemplary simplicity of an antique era:

To John Avirett, a brave boy who will grow up to be a useful man.

Dennis Rawlins, *DIO*

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Tycho's Star Catalog: the First Critical Edition

Neither wealth nor power, but only knowledge, alone, endures.

A KiloPerfectionism

A1 Tycho Brahe, author of that inspirational and knowing prediction[1] of his own immortality, issued his still-legendary "Thousand Star Catalog" in 1598. Cat D[2] (as we will henceforth call it, here) was one of history's outstanding attempts at mass-perfection[3] in the search for knowledge, pioneering & exemplifying postmedieval scientists' realization that the accord of knowledge with reality — and the accord of prediction with reality's future — must be based upon the most precise & persistent attention to present reality.

A2 This *DIO* triple-issue represents the first formal critical edition of catalog D (epoch 1601.03), which has until now been the only great pretelescopic star catalog not thusly made available to modern scholars. Provided for the first time: a numbered listing of all 1004 stars' cat D positions (O) with their real (C) positions (mean E&E 1601.03), as well as their O−C errors (in both ecliptical & equatorial frames). Our cat D establishes new standards for modern editions of antique star catalogs, including in particular: [a] Identification of every single one of the 1004 star-entries (Table 21). [b] Listing each star's (null dust&water) culmination-postextinction magnitude μ (also Table 21). [c] Spotlighting of all stars where $\mu > 6$ (Table 18). [d] Providing (Tables 21-23) the great-circle O−C errors for non-great-circle coordinates (longitude λ & right ascension α). [e] Computation of not only error standard deviations (Tables 5-17) but error medians (Tables 1-4). [f] Tabulated least-squares-fits (of constant & of 3-unknown-sinusoid) to catalog errors (Tables 9-12). [g] Individual investigation (by consultation of original field data) of every[4] cat D equatorial position error exceeding a tenth of a great-circle degree (c.200 cases: §M). [h] Rigorous sph trig computation (from the original raw observational data) of all of Tycho's long-murky Final Fifty stars (1596-1597: Tables 19&20). [i] Weeding out stars that are nonexistent, hybrid, fishy, forced, fake, and-or mere repeats (of earlier entries), in order to arrive at an accurate count of the number (965) of distinct outdoor stars Tycho recorded (§K4).

[1] See also §O3.

[2] Tycho's ecliptical 1004-star "cat D" (OO 3:341-373) is to be distinguished from the briefer "cat C" published posthumously in his *Progymnasmata* & later by his chief assistant, Christen Longberg ("Longomontanus"): the less error-plagued 777 star version (OO 2:258-280), which excludes the stars taken late in TB's career. See Dreyer 1890 p.266 & Rawlins 1992T §B1. Longomontanus claimed that he was the supervisor of star cataloging at Hven. See Thoren 1990 p.297 n.133, which also includes a useful numerical breakdown of cat C's evolution. Note that Tycho himself definitely claimed in 1598 that he had observed 1000 stars: Ræder & Strömgrens 1946 p.112.

[3] It is little known that, after cataloging nearly 1000 stars within c.120° of the celestial North Pole (i.e., those visible from Denmark), Tycho inevitably longed to tackle the stars around the South Pole. (See his plea for support of the project: Ræder & Strömgrens 1946 p.114-115.) The 20th century arctic explorers Peary&Amundsen were similarly inspired, after magnificent northern achievements, to turn their attention to the Antarctic; and the latter man ultimately discovered the South &North Poles (*DIO 2.2*&*DIO 10*). Much like Tycho, Peary forcefully proposed to lend his equipment & hard-earned expertise to an antarctic venture that unfortunately never materialized. (D.Rawlins *Peary . . . Fiction* Wash DC 1973 p.189.) Thus died Peary's last hope of genuinely reaching a geographical pole.

[4] I have computed & listed (Tables 19&20) all the errors in the Final Fifty stars (§N), but I have not attempted to explain every instance, since much of these pstns' underlying math is (within Occamite constraints: fn 41) multiply-corrupt beyond any possibility of convincing resurrection.

A3 Tycho Brahe was driven — one might even say made alive — by the intensity of his extraordinary perfectionism. In cat D, he fell short, not only (needless to say) of perfection, but even of his own announced high standards. However, anyone, examining cat D's raw data and appreciating the ever-rippling ocean of scrupulous observations and calculations which went into its construction, must come away overwhelmed by the undiscourageable force, persistence, pains, and dedication with which Tycho battered[5] *for twenty years* against a mass-precision challenge unique[6] in the history of pretelescopic astronomy.

A4 The §M discussion preceding this edition of cat D will trace every error in it exceeding $0^\circ.1$ — thus, it will be a compendium of imperfections in Tycho's drive at perfection. But these errors are exactly what Tycho's star-catalog program would have eliminated, had he been able to finish the work according to the same scrupulous standard by which so much of it was accomplished. It is one of science-history's tragedies that Tycho was (due to teenie-minded Christian IV, the new Danish kinglet) denied that chance: ungrateful[7] eviction and death prevented his carrying out his program — and even drove his school to add a few fabricated stars at the very end, to fake cat D's completion as a 1000 star achievement.

A5 I have no doubt that Tycho would have double-checked all errors — in much the spirit of DR's analyses below (§M). Thus, in a sense, I am merely continuing Tycho's work. I consider it a matter of luck & of privilege to be the first to unravel every one of his stars. And, further (despite the inevitable dogwork[8] component), I've immensely enjoyed this investigation, both as personal detective-work (the wildly-misplaced stars handed me a well-stuffed treasure-chest of tricky induction-mysteries, which I especially enjoy) — and as a sort of reincarnation-experience. (I trust that no one will take this expression of happy admiration too literally, since I am an utter nonmystic.)

B Spherical Trig: Precision by Brainpower

B1 Cat D was first[9] distributed on[10] 1598/1/2, from Wandsbeck (outside Hamburg, Germany), where Tycho had temporarily settled after his unhappy 1597 emigration from Denmark. Cat D comprised 1004 stars' celestial longitudes & latitudes, almost all of them based upon accurate & original observations made at Tycho's longtime observatory-homes, Uraniborg[11] ("SkyCastle") and next-door Stjerneborg ("StarCastle"), both on Hven isle, situated in the strait between modern Sweden & Denmark. The island is easily visible from atop my brother Bill's north Copenhagen home, Toad Hall. Hven was a fateful gift to Tycho, granted (at the generous instigation of Wilhelm IV of Cassel) on 1576/5/23 by foresighted Frederick II, who, by this one act, assured forever his remembrance as the most important monarch in the intellectual history of Denmark. (See Dreyer 1890 pp.84-87.)

B2 Tycho's star catalog is a monument of far greater magnificence than is now generally realized. In it, Tycho achieved, on a mass scale, a precision far beyond that of earlier catalogers. Cat D represents an unprecedented confluence of skills: instrumental, observational, & computational — all of which combined to enable Tycho to place most of his hundreds of recorded stars to an accuracy of ordmag $1'$! Accomplished, incredibly, without telescope, reliable timepiece, or logarithms,[12] cat D thus represents a kind of science-labor miracle — but, perversely, the soon-after onset of all three of these marvelous inventions swiftly made cat D obsolete.[13] Which largely accounts for its modern neglect — even disparagement.[14] Indeed, cat D is so neglected, that DR is only the second scholar just to count its stars (§K1). And *DIO* has the undisputed honor to publish herewith the first full critical edition[15] of cat D, identifying[16] every star in it. (Other editions will someday follow; but the various here-solved mysteries of identity & misplacement in cat D represent a breakthrough which can never again be accomplished afresh — and they were the particular inductive challenge that attracted DR to a task that would otherwise be almost pure drudgery.) Below, we will number the stars with the prefix "D", since: [a] We are calling this Danish catalog "cat D". [b] We are depending upon the OO 3:344-373 edition[17] (taken from the original

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[5] That Tycho was a forceful, dominant personality is most simply demonstrated by the loss of part of his nose in a famous 1566/12/29 duel with fellow Danish noble M.Parsbjerg. Also: Tycho [married only morganatically the lifetime companion he left several children by. (See Dreyer 1890 pp.26-27 & 70f & Christianson 2000 pp.10f.)] The duel-injury was lucky in one sense: ponder how close Parsbjerg's swinging sword must have come, to the eyeballs of him who was about to revolutionize observational science.

[6] It should be noted that Tycho's correspondent, Wilhelm IV of Cassel (whose observatory included C.Rothmann, P.Wittich, & J.Bürgi), produced a 1586 star catalog with less random error than Tycho's (Rybka 1984 Chap.4), but with a $6'$ systematic error (many times Tycho's) — on which, see Dreyer 1890 p.352-353. The Wilhelm catalog was neither completed nor contemporaneously published (*ibid* p.353 n.2). Rybka 1984 pp.188f cites 378 Wilhelm IV stars, of which he analyses all but 6 of the 306 he found in the modern FK4 catalog.

[7] See Tycho's 1597 lament at OO 13:102-104.

[8] Even the mechanical part of DR's work on cat D imparted a feeling of reliving the Tycho school's travails — which, I am happy to say, were not borne silently. One of the aggravations of dealing with Tycho's star data is the bewildering spectrum of names used for the same star in too many cases. So, on the night of 1589/10/28 (OO 11:370), a classically-educated Tycho employee rebelled, and — during an obs series of Psc stars' g vs. Aldebaran, his frustration reeled off a catalog of synonyms for this Principal star: oculum Tau, Aldeboram, Palilicium, lucidißimam, lucidiß. in capite Tau, lampadiada, ingentam & rutilam, taurou splendidissimam, ophthalmon Tauri, maxime splendet in Tau, in capite Tau maxime conspicua, insignem. It's rare & gratifying to find humor — and pointedly useful humor, at that — in a record of numerical data. (As the only modern scholar ever to plow through most of these data, correlating them to the cat D pstns, I wearily share the reaction of this longago astronomer. Such experiences are the nearest actual approach to the durable illusion of soul-immortality.)

[9] Sent out in ms form to a few high officials in order to encourage their then-desperately needed fiscal generosity towards astronomy, i.e., Tycho. (A not-much-exaggerated equation at this time.) Later printed by Kepler (1627). See Dreyer 1890 pp.265-266 & Thoren 1990 pp.383-384.

[10] Throughout, all dates here are in the Julian calendar, which was at this time used by Tycho and by Denmark & other Protestant nations.

[11] Geographical latitude $55^\circ54'25''$N & longitude $12^\circ41'55''$E of Greenwich (c.$50^{\mathrm{m}}48^{\mathrm{s}}$). (See OO 10:XXVI. Thoren 1990 p.226 has latitude $55^\circ54'26''$N.) Height above sea-level about 50 m. (See Dreyer 1890 p.93, R.Newton 1979-84 p.33. Modern charts make it 45 m, and that is exactly the figure cited by the Tycho Museum's Karin Hindfelt at Hven during our family's 1994/5/28 visit there. Note: Hven Isle now belongs to Sweden, not Denmark.) All calcs of refraction & extinction here are for sealevel P = 1013 mb & T = 283°K, both adjusted for hgt = 50 m.

[12] However, use of a clever identity (known to the Arabs) converted multiplication of trig functions (a staple of sph trig) into mere addition of same. (See Dreyer 1890 p.361 & Thoren 1990 p.282. See latter source's n.65 for discussion of Tycho's trig tables.) Since this is just the advantage of log-trig tables, we see that Tycho did have some log-like math capabilities at his disposal. The identity (which follows from Ptolemy's Theorem, known 300^{y} before Ptolemy: *DIO 1.3* fn 234): $\sin A \sin B = [\cos(A-B) - \cos(A+B)]/2$. From this, one may easily derive $\cos A \cos B = [\cos(A-B) + \cos(A+B)]/2$ and other such rules.

[13] It's no coincidence that this great naked-eye star catalog occurred merely a decade before the telescope's invention. Science was awakening all over Europe. The machined instruments (fn 37) that made possible Tycho's unprecedented precision (in reduced observations, not just raw vision) were, like Tycho, part of that burst of curiosity & creativity. So were logs & the pendulum clock. I.e., the very revolutionary wave, which brought in Tycho on its crest, swept on and left him in its wake. Such is ever the lot of he who pursues the chimera: Bestness.

[14] See Thoren 1990 p.295 (n.123) on the slight "disappointment" at cat D expressed by OO's editor, J.Dreyer.

[15] Thoren 1990 p.295: "How accurate the observations for Tycho's catalogue were has never been investigated systematically." Actually, except for one subset (the long-troublesome Final Fifty stars: Tables 19 & 20, below), DR has not systematically analysed all TB's thousands of extant individual raw δ, h, g, & other data (though numerous specific cases are evaluated in §M). This for several reasons. [a] Some of the orig records are lost, while the cat D pstns survive. [b] The large labor involved would hardly throw proportionally more light upon Tycho's achievement than the present work. [c] Comparing error-spreads of Tycho observation-sets of the same phenomenon on different occasions often reveals systematic discrepancies exceeding an arcmin or so. Only by averaging such repetitions could Tycho shrink his ultimate measurement error. (See fn 37.) Studying such data today would primarily be an exercise in cataloging [i] his various instruments' characteristic errors (e.g., mounting, zero-pt, arc-nonuniformities, weather-dependence, etc), as well as [ii] unaccounted-for effects of refraction, aberration, & nutation. (See at fn 120.) Such analyses I gladly leave to a hardy future researcher.

[16] According to Thoren 1990 p.296 n.130, J.Dreyer stated in 1917 (before publication of OO 10-13) that he had "traced the causes of fifty-five errors out of a thousand stars". Our present investigation far exceeds that number; but, keep in mind that Dreyer's dedicated work lacked the assistance of electronic computers. Note also that several of Dreyer's initial misidentifications in his edition of cat D were later corrected by him when he came to examine the original data. An example is D961, which he at first (OO 3:372) identified with 9 Crt — but later (OO 13:72) realized was 29α Mon. See below at fn 158.

[17] Readers are urged to consult OO 12:53, where Dreyer provides a photocopy of the kind of scrawl he had to render into print (which he does, in this instance, at OO 12:52). Multiply this decipherment by thousands of such challenges. My gratitude to Dreyer needs no further explanation.

manuscripts in Copenhagen), which is that left us by the scrupulous and herculean efforts of astronomer J.Dreyer. (The stars are here numbered exactly in the order in which they appear in the unnumbered Dreyer compilation.) [c] The journal publishing this edition is *DIO*. [d] The stars' numbering and the present critical edition of the catalog are due to Dennis R. (Besides expressing here my debt to Dreyer, I must also do so to the late Victor Thoren. It was wonderful good luck for DR that the now-dominant Tycho biography Thoren 1990 appeared during my 1987-1993 cat D researches, and equally good fortune that Thoren lived just long enough to finish the task. But I regret that his sudden death deprived me of the chance to thank him personally for creating such a monument to Tycho — and likewise prevented him from enjoying DR's completion here of another monument, which Thoren also desired.[18] Thoren disagreed with my view of ancient astronomy; but I trust that this would not have prevented his appreciation[19] of valid new accomplishments in his favorite field. As to how often the occasional knowledgeable remarks contained in the current publication are actually due to Thoren: that will be evident to anyone who merely counts the number of citations of Thoren 1990 that appear below.)[20]

B3 The only previous[21] original precise & massive star catalogs (now surviving) were those of Hipparchos (epoch -127) & Ulugh Beg (epoch 1437). Each was taken by ecliptical armillary astrolabe, and each has mean errors in both coordinates (longitude λ & latitude β) of about $1^\circ/3$. Tycho proceeded differently and achieved an accuracy about *ten times* better, even though still in the naked-eye & crude-chronometer[22] era of Hipparchos & Ulugh Beg. (Note: the Hist.sci crowd has decreed it declassé merely to "hand out medals to those who 'got it right'." See *JHA 11.2*:145, 1980. Hmmmm. Tycho's workers, night after night, poured out their life's vitality, for decades, taking pains to achieve the greatest possible precision, luckily for Kepler, Newton, & us. Thought-experiment: imagine the Tycho team's exhausted shades now encountering a mod paradigmal priest of Hist.sci, whose inspirational litany is the field's ritual shrug: who cares about rightness & wrongness?)[23]

B4 A key difference in Tycho's approach was his exploitation of sph trig's full powers, instead of depending upon the automatic analog-computer ringed-astrolabe of his predecessors. (He describes his plan at Ræder & Strömgrens 1946 p.113, understating the math as "cumbersome".) Generally, the results were of greatly improved accuracy, though there were some downsides:[24] [a] more labor (thus expense: Tycho spent royal monies in Wagnerian style), [b] greater chance of large-scale foul-up — the number of grossly misplaced stars in cat D is much greater than in those of Hipparchos or Ulugh Beg. However, the math accuracy of Tycho's sph trig has not hitherto been realized. One particularly difficult calculation was good to $3''$ accuracy.[25]

[18] Thoren 1990 p.295. See fn 15 here.

[19] Thoren seems to have felt the strong weight of evidence that Ptolemy probably stole the Ancient Star Catalog from Hipparchos. (See, on this, Thoren 1990 p.155 n.23, p.172-174 n.52, & p.299 n.141.) But Thoren held that this didn't make Ptolemy a poor scientist. And Thoren seemed (at least in 1979) to have a low estimate of those who didn't agree with this curious opinion. (See Rawlins 1987 n.12.) But Thoren's fallibility here: [a] is merely human, and [b] is in itself no cause for my doubling the error by aping it.

[20] This is not to slight the dedicated labors of Dreyer, whose 1890 biography and later massive OO laid the groundwork for all future Tycho researches — and at a level of astronomical expertise inevitably higher than Thoren's.

[21] Regarding an independent 13th century 40-star catalog, see Thoren 1990 p.297 n.134.

[22] Tycho's trials of & by his clocks are recounted at Thoren 1990 p.157f. Meantime, J.Bürgi (working for Wilhelm IV at Cassel: fn 6) instead rightly applied the pendulum to chronometry. (This was before Galileo. Likewise, Bürgi was developing logs before Napier. See Dreyer 1890 pp. 352, 361-362.) Less than a century after cat D, J.Flamsteed (1st Astronomer Royal) was first to exploit fully the combined advantages of pendulum chronometry & telescope for massive sky-mapping — ensuring the primacy henceforth of eqt coords for such pursuits. (In the now-dawning space age, this primacy could wane.)

[23] See similarly at *DIO 1.1* ‡7 §G4. (See also *J.Hysterical Astronomy* 1.2 fn 36.)

[24] I find that Thoren 1990 p.294 independently sets out the problems with Tycho's approach and does so both learnedly & clearly.

[25] Kochab's two-g-based pstn (where, sadly, the underlying obs data were in error by about $3'$); see fn 179. Note also the ordmag $10''$ acc of the two-g calcs that may (fn 128) underlie the D585-586 pstns. (See discussion below, at those stars, in §M4.) High-accuracy trig tables go back much further than most laymen are aware. [See *DIO 1.2-3* fnn 99, 234, 283.] The 2nd century *Almajest* tables are remarkable. And the 15th century tables of Ulugh Beg are better yet.

B5 Tycho's zero-point was of course the Vernal Equinox, which required relating the Sun's position to the stars. Lacking pendulum chronometry,[26] Tycho effected this through day-night observations of Venus — instead of the Moon, which was Hipparchos' relatively crude (see, e.g., Rawlins 1982C Appendices) celestial stepping-stone for relating stellar positions to solar. (Venus is far better: [a] punctal, [b] slower in motion, [c] smaller parallax.) By this means, his sole Fundamental star, Hamal (α Ari) was firmly[27] secured in right ascension (α). (The error in its 1601.0 explicit α was merely $-0'.1$: Table 22, star S12. I have shown elsewhere here — Table 9 — that the entire 1601.0 cat D's α error was $+0'.2$. Note that both errors are less than 1 timesec. Considering the necessity for two persons making the observations, with the resultant need for near-simultaneous cooperation,[28] we see here an instance of the sort of care which represented a quantum leap above ancient work.) Then, based upon Hamal, Tycho reared a growing network of multiply-observed reference ("ref") stars. First, a collection of nine Principal stars was carefully established. (Eqt & ecl coords listed, for epoch 1586.0, at OO 2:207&211, resp. Errors evaluated at Dreyer 1890 pp.387-388 and here in Table 13.) Next, a somewhat fuller list of twenty-one Exceptional stars' 1586.0 eqt & ecl coords was formed (OO 2:233). Ultimately, a larger collection of Select stars (§I) gave Tycho the ability to compare any one of his c.1000 quarry stars to as many conveniently-placed reference objects as he desired. Exactly 100 Select stars' 1601.0 & 1701.0 eqt coords were listed by TB — including differential equatorial precession[29] rates — in an appendix to his cat D, at OO 3:375-377. See here in Tables 22&23; also Ræder & Strömgrens 1946 p.114. However, a few stars used as Tycho ref objects were not on any of the aforementioned Tycho lists. (E.g., see β UMi = Kochab at fn 179, & β Vir at D168 in §M3; and note that, for the observations cited, confusion reigned.) The rest of cat D's stars were placed by depending largely upon this ref-star network of 100 Select stars. When the process of placing stars is discussed below, we will distinguish between these "ref stars", vs. those positioned with respect to them, by referring to the latter as "quarry stars". (And, keep in mind throughout that Hamal's foundation-α, OO 2:197-198, was — along with Tycho's equally excellent[30] determination of Hven's latitude — the basis for all the hundreds of real star positions in cat D.)

B6 The standard procedure was to combine: [a] an observation for the quarry star's declination δ (found either from a meridian altitude or a direct reading off Tycho's equatorial armillary) and [b] a sextant measure of the great-circle (gt-circ) distance g between the quarry star and a conveniently chosen reference star (customarily about due east or west of the quarry star). From g, the quarry star's δ, and the ref star's already-known[31] δ_r, sph trig will (by eq. 6: §N6) yield $\alpha - \alpha_r$, the difference between the quarry star's α & the ref star's

[26] Fn 22. See Thoren 1990 p.294 and thereabouts (pp.287f) for Thoren's valuable account of the trials & techniques of putting the star catalog together.

[27] See list of 15 impressively consistent determinations (of Hamal's 1586.0 α) at OO 2:197. (Comparing these excruciatingly hard-wrought outdoor data to Ptolemy's trivially indoor-faked star-data at *Almajest* 7.3-8.1: it takes consummate nerve to elevate both men to roughly equivalent stature as scientific immortals. Teaching this kind of nerve is something which History-of-science dep'ts can do right.)

[28] See Ræder & Strömgrens 1946 pp.74-75 (& suggestion at fn 178). Note that our best available estimate (*DIO 1.1* ‡6 §G4) of pstn-error caused by non-simultaneity in ancient armillary-astrolabe observation-correlation is: $19^s \pm 8^s$. This is over an ordmag cruder than Tycho's results, which is a ratio roughly consistent with other comparisons of Tycho's accuracy to that of previous mass-star-catalogers.

[29] Among Tycho's numerous epochal contributions to science was his discovery that precession was nearly constant (Moesgaard 1989 p.311). This critical finding was based upon his realization that the "Ptolemy" star catalog's enormous discord (vs. all other star records) was due to the $-1^\circ.1$ net bungle that resulted when Ptolemy stole this thousand-star catalog from Hipparchos (fn 141) by precessing all λ for 2 2/3 centuries at the false rate, $1^\circ/100^y$. TB's adopted value, $51''$/yr (tabulated OO 3:374), was only ordmag 1% higher than the correct 1601 value, $50''.19$/yr.

[30] Both errors ordmag $0'.1$. On Hven's latitude, see fn 11. Hven latitude error = $+0'.1-$.

[31] Ref star eqt coords in 1601.0 S list (Table 22) or 1589.0 catalog at OO 12:231f.

already-known α_r. Simple addition or[32] subtraction will then yield the quarry star's α. (An example, for star D569, is provided below at §N6.) We will call this: the "δ&g method".

B7 An alternate method for finding α (used, e.g., for stars D199-206) was simply to read the equatorial difference, $\alpha - \alpha_r$, directly off an equatorial armillary. (Tycho's eqt armillaries are described in Ræder & Strömgrens 1946 pp.56-67. Fig. at p.64 reproduced at Thoren 1990 p.175.)

B8 Mathematically, the most interesting method was what I'll call the "two-g method". It required an observation of the gt-circ arc g vs. each of *two* ref stars, star a & star b. (See, e.g., D343-4 at OO 13:76, or D448-454 at OO 13:63. Note that the two-g placement-method was applied almost exclusively to far northern[33] stars: UMi, UMa, Dra, & Cep. Rare, evidently-inadvertent exception: D836. Also D904.) Given the resulting data g_a and g_b (as well as the already-known Table 21 ref-star data: λ_a & β_a and λ_b & β_b), the quarry star's λ & β may then be computed via sph trig. However, especially in a pre-log era, the math-labor involved was staggering.[34] Such elaborate sph trig represents the pinnacle of Tycho's historic triumph — by sheer brainpower — over an army of imposing obstacles (§B2) to the creation of the best star catalog possible in his day. Indeed, the math is so complex that no previous Tycho historian has mastered it. E.g., while Dreyer 1890 (p.353) & Thoren 1990 (p.294 n.120 & p.498 Fig. A.4.5) describe the relatively simple δ&g method (§B6), neither performs Tycho's two-g math. Realization that the two-g method was applied by Tycho to many dozens of stars only enhances our amazement at the effort and dedication that went into cat D. (On the negative side: too many[35] two-g-based stars were placed via nearly parallel g, when, obviously, the optimal situation is perpendicularity. These are the "flab" cases we will encounter here&there in cat D, e.g., D345-348, D585-587, D611-614. Had the observers been knowledgeable — or knowledgeably forewarned — about such procedure, these stars' cat D places would have been far more reliable. Instead, their coordinates' errors are ordmag 1°. Some flab cases arose just from bad luck. Arc g of the §B6 standard method is preferably oriented E-W; but, if two g & no δ were observed, then those g remained as the sole basis of the star's cat D position — and the usual E-W configuration ensured flabbiness in the N-S direction. E.g., D836's α is OK, but δ is off by over 1° 1/2 southerly, due to observing errors of but a few arcmin, in a flabby configuration. This star should not have been in cat D. Sadly, it is also included in cat C, as star C667. And even in the 1589.0 catalog appended to TB's 1592 obs, at OO 12:259. Which suggests that TB's inclusion-standards for star-positions were slipping well before 1595-1598.)

B9 Finally, there is what I call the "lineup" method of placing a quarry star. In very flab cases, where the ref stars & quarry star are about on the same gt-circ, TB sometimes (see D345-348, D587, D611-613, D645-647) just quietly put the star on the gt-circ between the two ref stars. (Note that this requires sph trig use of but one[36] of the two observed g data.) Naturally, the results were inferior; but in some highly flab cases (as well as stars where only one g got observed, e.g., D348), this was a tempting method — and full calculations might not improve much upon it.

[32] Note that this method formally yields two solutions, just as does the two-g method. (See fn 181.) However, the only WCP case in cat D which results from any but the latter is D789. See its discussion in §M4 & fn 192.

[33] I believe that the standard δ&g method would work well for far northern stars. (Though, culmination-obs would be tedious.) But, near the Pole, where $\Delta\alpha$ becomes artificially inflated, TB evidently felt it wiser to use the two-g approach. See further discussion (of the two-g method) at §N12 & §N14.

[34] It is possible that Tycho used an equivalent of the simpler St.Hilaire method. (See also special-case shortcut suggested at fn 128.) My own computations have used rigorous sph trig in all cases. (E.g., for the "Obs" columns of Table 20.) For sole math-easement connected to two-g method, see §N14.

[35] I suspect that the problem was simply: it was physically easier not to have to swing the sextant around 90° frequently — if both ref stars & the quarry star were nearly on the same gt-circ, this seemed convenient to one who didn't have to deal with the math mess that results. (The suggestion is strong that at least some of the observers — especially in 1597 — were not computers & indeed had surprisingly primitive knowledge of spherical astronomy.)

[36] The other may enter additively. Unless a list of g_r between ref-stars was in regular use by Hven computers, a shortcut method for obtaining g_r during a lineup calc would be simply to set $g_r = g_a + g_b$. DR's lineup calcs here assume this approach. See §N17.

C The Catalog's Misunderstood Accuracy

C1 While the high accuracy of Tycho's observations of the Sun and of his Principal stars is well known, the accuracy of most stars in cat D is generally regarded as not nearly so good. E.g., H.Pledge, *Science Since 1500* (1939) p.291 repeats the widely believed contention that Tycho's mean error was 4′. The mean errors[37] (a little smaller than 3′ in each coordinate for nonbright stars) found in the excellent 1984 study, by the highly experienced & capable stellar astronomer Przemysław Rybka, are much better,[38] if perhaps slightly high. A main result of the present analysis will be to find a correct value for cat D's average positional error (see Table 5 & §J1) — and thereby render full justice to the Tycho school's immense & painstaking labors.

[37] Cited at Thoren 1990 pp.296-297 n.130. By contrast, Thoren 1990 p.299 n.139 notes that Tycho himself (fn 40) & modern A.Pannekoek believed the stars' accuracy was 1′. But Pannekoek's view was evidently based upon Tycho's or upon the wellknown study, of TB's nine Principal stars, by Dreyer 1890 pp.387-388. There is a common suggestion, repeated by Thoren 1990 *loc cit*, that cat D's faint stars are less accurate than the brighter ones. (Actually, the extensive OO records of repeat-observations of raw data seem roughly as consistent for 4th magnitude stars — and even most of the dimmer ones — as for 1st magn: the data-spread is almost always just a fraction of an arcmin, except, notably, when the data are simultaneously taken on different instruments. This obvious point seems somehow to have escaped previous commentators.) Of course, at some faint magnitude such an accuracy falloff must begin to be true; but dim cat D stars also seem less accurate because: [a] they were repeatedly-observed (doubled) less often than the brightest stars, & [b] the rushed late-1596-early-1597 Final Fifty stars (Tables 19&20) are naturally all rather dim ones (the bright stars having long since been cataloged). See here at §J4 & fn 15. It is my contention that the greater part of the errors in cat D are not due to ocular causes but rather to: instrumental mis-sets, screrr & misrd, atm refr, temperature effects on instruments. Tycho was perhaps the first scientist who fully understood that ultrascrupulous attention to instrumental-mounting, checks, & zero-points, plus data-crosschecking by *persistent observational repetition* were his main weapons in eliminating errors from these sources. (J.Bradley & G.Piazzi were later to benefit from the same wisdom & drive.) It is initially tempting, for those unfamiliar with instrumental work, to find nothing remarkable in Tycho's 1′-acc results, figuring that this is roughly the naked eye's ability, so naturally Tycho could measure objects' pstns this well. To the contrary, Tycho's prime miracle WAS his ability to produce ultimate (reduced) results, with an accuracy comparable to the original raw data's. For a 1000 star catalog, this could, theoretically, have been done by anyone from the 2nd century BC onward (since armillary instruments were certainly in use by then) — that is, by anyone who possessed Tycho's burning desire (which exemplifies science) to: [a] match reports & concepts accurately to reality, and [b] discover reality through accurate observation. But no one before Tycho possessed this desire so intensely. And we must not neglect to give a nontrivial share of the credit for cat D to the instrument-makers of Tycho's day, who made for him, e.g., carefully fashioned rings of a quality far superior to those probably available to Hipparchos. See Ræder & Strömgrens 1946 and Thoren 1990 pp.150f, 162f, 189f, 281.

[38] Occurring merely as a kind of extended footnote to an excellent critical edition of Hevelius' 1661.0 star catalog, Rybka 1984 is the only previous astronomically sound mass-study of Tycho's star-cataloging errors. (Rybka 1984 has not gotten the recognition it deserves. I thank Thoren for bringing it to my attention, though I do not think his remarks do it justice.) Rybka's coords (expressed to the nearest half-arcmin) are meticulously accurate. The mean errors he finds are similar to DR's, and I suspect that nontypo discrepancies have 2 primary causes. [1] Different sampling procedure. Rybka cautiously analysed barely 1/2 the stars in cat D: those in the modern FK4 star catalog which he could reliably correlate to cat D positions. (Our entire-catalog samples are c.3/4 of cat D for means, c.8/9 for medians, & 100% for Table 21.) [2] Rybka used (without reprinting it) Kepler's unreliable (& alloyed) edition of Tycho's stars, not Dreyer's (OO). Some further criticisms of Rybka 1984: [a] Best to provide subsample-sizes in tables. [b] Performing full-catalog error analyses (Rybka 1984 pp.193-194, 202: Tables 30-37 & Table 54) exclusively in the ecl system is risky (cats C&D were mostly compiled in eqt coords), due to [i] TB's large obliquity errors and [ii] the gross numerical-asymmetry for deep southern stars in the regions of the 2 solstitial colures. (The latter criticism must apply, at least in part, to any analysis of the southern part of cat D, including DR's.) [c] Some superficial typos. At p.191, both percentages are mistaken; at p.195, for 97.7% read 96.7%. [d] At p.192, there is an impeccably computed Table 30, exhibiting large TB errors (epoch 1661.0) for stars: D811, D944, D585, PK918, D143, D677, D368, D369, D164. However: D585 (actually 50 Cas) is misidentified as 40 Cas, due to nonconsultation of the orig OO obs data, which reveals Tycho's WCP. And π Hya (Rybka Table 30's 4th star) was never obs by Tycho. It is from Kepler's augmentation of cat D (Kepler *GW* 10B[1969]:135 line 40) & is obviously based upon the ancient HP catalog. (The cited β is that of Hipparchos: PK918, which is 49π Hya.) D677 (one of Tycho's fakes) is superficially misidentified as υ Sgr (Table 30's 6th star) & TB's 19th Ser star (both wrong), though the coords Rybka computes are both absolutely accurate and are for the correct star, 42θ Sgr. For 4 of the other stars, eqt analyses would have revealed virtually null error in one coord: α for D143, and δ for D368, D369, & D164. These nulls provide broad hints as to what went wrong with the reductions. See under these stars in our §M. It should be pointed out that Rybka's Table 30 is the first source to correctly identify D143 as 41 LMi — which suggests that he noted the agreement in one eqt coord. Considering that Rybka's exam of cat D was actually just an extension of his study of Hevelius, his omissions are more than understandable, and I am much impressed by the high quality of his analysis: Rybka 1984 should always be remembered as the first serious appraisal, ever, of the accuracy of Tycho's star catalog.

C2 Doing right by Tycho is also a motive for the pains taken here to track down every cat D implicit[39] equatorial error exceeding[40] $0^\circ.1$ (gt-circ). In no other way would it be possible to show the true accuracy of the work, since if, e.g., a few merely-computational botches[41] are tossed in with the great majority of properly-prepared stars, a deceptively-inflated mean error will naturally result. Note: in this *DIO* edition (Table 21) of cat D, some scribal errors in ecliptical (not equatorial) coordinates will be restored,[42] with the mark "r" (or "R") in Table 21's column x, to indicate that. (See §P4. Note that all these stars are dropped from the large statistical analyses below, though D98 & D222 are retained in the smaller sample of §H, for reasons discussed in §M3.)

C3 Therefore, *DIO* has first, in §D, tabulated the medians of the gt-circ errors' absolute magnitudes (instead of the rms errors of §E) for the positions in cat D. In §D, we have dropped out of each sample those stars marked as problem-cases (in our Table 21 edition of cat D) in column x. (For the codes used in col.x, see §P4.) Sole exception: D699, which is marked "d" since it is doubled by D701; the latter star (marked "D") is dropped, but not the former. (See fn 191.)

C4 Of cat D's 335 zodiacal stars, 481 northern stars, & 188 southern stars, our median samples (filtered as described in §C3) include 324 stars, 390,[43] & 172, resp. The sum is 886 stars. In the next section (§D) we set out the median errors in 4 tables. Following that, we will (§E) similarly tabulate the conventionally-defined mean errors. Finally, in §F, we will provide the results of least-squares analyses upon cat D's errors, again in 4 tables.

D Error Medians

D1 For the entire 886 star total and each of the three sections of cat D, we now provide tables of all 4 coordinates' absolute-magnitude |O−C| median-errors (great-circle), for each post-extinction magnitude, essentially[44] from μ = 1 to μ = 6. (Recall from §A2 — and see §L8 & fn 188 — that μ is computed here on the assumption of zero atmospheric dust.)[45]

[39] I.e., the eqt pstn calc (with TB's obliquity $\epsilon = 23^\circ 31' 1/2$ or $23^\circ 31'$, depending: see fn 190) from the ecl pstn given in cat D. In several places, TB provides hundreds of explicit eqt coords (which our Table 21 does not use), e.g., OO 3:375-377 (our Tables 22&23), OO 11:383f, OO 12:231f, OO 13:61f. Most TB explicit eqt coords agree acc with the implicit ones of Table 21. (Though, there are several exceptions, e.g., D621.) Besides the data provided here in Tables 22&23, many of these explicit eqt coords are cited in our §M discussion. See also §I & §J6.

[40] Tycho himself might be almost insulted at such slack brackets, since he held that cat D was acc to $1'$ or better. (See fn 37 & Ræder & Strömgrens 1946 p.112.)

[41] Cat D is affected by numerous 1° errors of math or of table-entry (e.g., D487). There are also a large number of $1^\circ/2$ errors (e.g., D530, D619). (Sometimes both occur for the same star's calcs, e.g., D500.) The frequency of $1^\circ/2$ calc errors suggests that some of the Hven computers (fn 12) were occasionally using ancient tables of chords, not just modern trig functions (as, e.g., those of Copernicus 1543 1:12). The traceability here of so many such slips suggests that, while the calcs were perhaps doubled (see the intelligent & informative discussion at Thoren 1990 p.297 n.131), the recording & transmissal of data were not. In most cases, cat D errors were evidently not due to calc. Even for D914, where an error in the calc process is suggested below (§M5), the proposed slip is scribal not arithmetic. For a few misplaced stars in cat D, I may have set forth scribal error-explanations that are uncertain — perhaps partly because, for an arithmetic error, there are usually too many possible explanations, to permit our giving exclusive credence to any particular theory. Nonetheless, it usually seemed better to offer a hypothesis (or two) rather than none. Without supporting evidence at intermediate steps, explanations were generally avoided if they would have to involve (see, e.g., fn 4) several special assumptions. (Exceptions: D566 & D938.) That is, Occam was ever in mind.

[42] The 28 stars with ecl scribal errors restored here (Table 21) are: D14, D82, D98, D200, D222, D342, D429, D555, D567, D595, D599, D607, D657, D682, D737, D758, D782, D798, D808, D832, D890, D908, D954, D959-961, D978, D1000.

[43] All of the here-dropped Final Fifty entries (§N) are northern.

[44] The 1st magn row = all stars with $\mu < 1.5$; the 2nd magn row = all stars with $1.5 < \mu < 2.5$; similarly down to 6th magn = all stars with $5.5 < \mu$.

[45] See fn 188. (I also assume dry air, which is not uncommon in Danish winters.) By dust (or aerosols), I refer to the nongaseous atmospheric obstructors of light. In recent centuries, manufacturing & vehicular pollution has spewed so much dust into the entire Earth's atmosphere that one ought to remove this factor from modern calculations of ancient extinction, in order to approximate pre-industrial air transparency in a reasonable and definable fashion. Note Ptolemy's detailed testimony, cited at §L8. And, fortunately, the sheer dimness of the Tycho stars collected in Table 18 has confirmed the clarity of ancient skies. See especially fn 95 (four Cen stars from Wandsbeck) and §L10.

These will be Tables 1-4.

D2 The two left columns cite each row's post-extinction magnitude bounds, $\mu_{\rm b}$ (brightest) & $\mu_{\rm d}$ (dimmest). (In each row, stars' μ are entirely within the range $\mu_{\rm b} < \mu < \mu_{\rm d}$.) The 3rd column, n, lists the number of stars falling within these bounds. The next 4 columns list the medians of, respectively, $\Gamma\lambda$, $\Delta\beta$, $\Gamma\alpha$, $\Delta\delta$. (See fn 185 and fn 103 for our definition of Γ.)

E Error Standard Deviations

E1 We then present (Tables 5-8) normal root-mean-square (rms) averages of coordinate-errors, based upon the very same data for which we found the medians of §D — except that, in this case (unlike §D), it is absolutely necessary to eliminate the gross errors.

E2 Thus, in addition to the 118 stars already removed at §C3 (leaving 886), we here also drop all the remaining stars for which either equatorial coord gt-circ error ($\Gamma\alpha$ or $\Delta\delta$) exceeds absolute magnitude $6'$. (Anyone familiar with Tycho's star work will know that a TB error as large as $6'$ is not due to random causes.) So, eliminating also these 125 stars, we now have a net sample of 761 stars (not all distinct objects: fn 77) which have survived the foregoing filters. (This is somewhat smaller than the total of 777 stars in cat C.)[46] Notice that each coordinate's rms standard deviation (stdev), σ_0, is roughly proportional[47] to the corresponding value obtained previously (§D) by the median method.

F Least-Squares Analyses of Errors

In Tables 9-12, we next present the results of several least-squares analyses upon cat D's errors, using precisely the same 761-star sample as in §E (Tables 5-8). Each table will provide σ_i, the random error stdev of a single datum, where i = no. of unknowns simultaneously being sought via least-squares, setting i = 0, 1, & 3, successively. First, the tables here list (in the 2nd column) σ_0, the zero-unknowns least-squares solution, which of course must be identical to the §E analyses' corresponding "All"-row result (Tables 5-8). Second, we seek & tabulate each coordinate's mean systematic error a (1 unknown) and its stdev, σ_a, and the random-error single-datum stdev for this case, σ_1. Finally, we thread a 3-unknown sinusoid through each coordinate's errors, least-squares-fitting the expression $b + A\sin[\lambda - \theta]$ to the ecliptical errors, and $b + A\sin[\alpha - \theta]$ to the equatorial errors. (Convenient check: $\sigma_0^2 \approx \sigma_1^2 + a^2 \approx \sigma_3^2 + b^2 + A^2/2$.) Tables 9-16 here list for the 3-unknown case: constant b & its stdev σ_b, amplitude A & its stdev σ_A, phase θ & its stdev σ_θ, and random-error single-datum stdev σ_3. Again, our tables start with the whole cat D (Table 9), then attend to each section: zodiac (288 stars, Table 10); north (322 stars, Table 11); south (151 stars, Table 12). However, this time, we stratify each table by coordinate (not magnitude bounds, as for Tables 1-8), in the vertical order: λ, β, α, δ.

[46] While the two samples (§E2's 761 stars & cat C's 777 stars) are not independent, they are at the same time far from identical.

[47] Since half the area under the curve $e^{-\sigma^2/2}$ lies in the range $\pm 0.67\sigma$, §F's straight rms averages σ_0 should naturally be somewhere around 3/2 bigger than the corresponding medians found in §D. And the ratio 3/2 is indeed crudely valid here (*very* crudely for the tinier subsamples), despite [a] the differences in sampling procedure, & [b] the highly nonGaussian tails of the cat D error curves. This confirms the propriety of our trimming (from samples), stars with eqt errors greater than $6'$.

Table 1: Median Errors by Magnitude: Entire Cat D

μ_b	μ_d	n	$\Gamma\lambda$	$\Delta\beta$	$\Gamma\alpha$	$\Delta\delta$
$-\infty$	1.5	12	$0'.6$	$1'.2$	$0'.6$	$0'.8$
1.5	2.5	33	$1'.3$	$0'.7$	$0'.8$	$1'.2$
2.5	3.5	95	$1'.5$	$1'.4$	$1'.4$	$1'.1$
3.5	4.5	280	$1'.5$	$1'.6$	$1'.5$	$1'.3$
4.5	5.5	391	$1'.5$	$1'.4$	$1'.4$	$1'.5$
5.5	∞	75	$1'.9$	$2'.1$	$1'.8$	$2'.1$
All		886	$1'.5$	$1'.4$	$1'.4$	$1'.4$

Table 2: Median Errors by Magnitude: Zodiac

μ_b	μ_d	n	$\Gamma\lambda$	$\Delta\beta$	$\Gamma\alpha$	$\Delta\delta$
$-\infty$	1.5	3	$0'.5$	$1'.3$	$0'.3$	$0'.1$
1.5	2.5	8	$0'.9$	$0'.9$	$0'.9$	$0'.4$
2.5	3.5	20	$1'.3$	$1'.6$	$1'.3$	$1'.2$
3.5	4.5	89	$1'.4$	$1'.1$	$1'.3$	$1'.3$
4.5	5.5	152	$1'.3$	$1'.2$	$1'.3$	$1'.6$
5.5	∞	52	$1'.9$	$1'.9$	$1'.5$	$2'.0$
All Zodiac		324	$1'.3$	$1'.3$	$1'.3$	$1'.5$

Table 3: Median Errors by Magnitude: North

μ_b	μ_d	n	$\Gamma\lambda$	$\Delta\beta$	$\Gamma\alpha$	$\Delta\delta$
$-\infty$	1.5	5	$0'.5$	$1'.8$	$0'.5$	$0'.6$
1.5	2.5	18	$1'.6$	$0'.6$	$0'.9$	$1'.5$
2.5	3.5	58	$1'.9$	$1'.5$	$1'.5$	$0'.9$
3.5	4.5	143	$1'.8$	$2'.3$	$1'.6$	$1'.1$
4.5	5.5	156	$2'.0$	$2'.1$	$1'.6$	$1'.6$
5.5	∞	10	$2'.1$	$2'.8$	$2'.2$	$2'.4$
All North		390	$1'.8$	$2'.0$	$1'.6$	$1'.2$

Table 4: Median Errors by Magnitude: South

μ_b	μ_d	n	$\Gamma\lambda$	$\Delta\beta$	$\Gamma\alpha$	$\Delta\delta$
$-\infty$	1.5	4	$1'.1$	$1'.0$	$1'.1$	$1'.1$
1.5	2.5	7	$0'.4$	$0'.7$	$0'.3$	$1'.3$
2.5	3.5	17	$1'.4$	$0'.9$	$1'.2$	$1'.6$
3.5	4.5	48	$1'.3$	$1'.2$	$1'.7$	$1'.5$
4.5	5.5	83	$1'.3$	$1'.1$	$1'.4$	$1'.4$
5.5	∞	13	$2'.3$	$2'.2$	$2'.3$	$2'.0$
All South		172	$1'.3$	$1'.1$	$1'.4$	$1'.5$

Table 5: Mean Errors by Magnitude: Entire Cat D

μ_b	μ_d	n	$\Gamma\lambda$	$\Delta\beta$	$\Gamma\alpha$	$\Delta\delta$
$-\infty$	1.5	12	$0'.85$	$1'.59$	$0'.84$	$1'.23$
1.5	2.5	31	$2'.07$	$1'.86$	$1'.49$	$1'.73$
2.5	3.5	82	$1'.95$	$1'.87$	$1'.74$	$1'.57$
3.5	4.5	244	$2'.12$	$2'.09$	$2'.05$	$1'.78$
4.5	5.5	336	$2'.06$	$2'.03$	$1'.87$	$1'.93$
5.5	∞	56	$2'.46$	$2'.58$	$2'.35$	$2'.40$
All		761	$2'.09$	$2'.07$	$1'.93$	$1'.87$

Table 6: Mean Errors by Magnitude: Zodiac

μ_b	μ_d	n	$\Gamma\lambda$	$\Delta\beta$	$\Gamma\alpha$	$\Delta\delta$
$-\infty$	1.5	3	$0'.51$	$1'.78$	$0'.30$	$1'.25$
1.5	2.5	8	$1'.08$	$1'.69$	$0'.95$	$1'.02$
2.5	3.5	18	$1'.68$	$2'.12$	$1'.68$	$1'.50$
3.5	4.5	85	$1'.88$	$1'.86$	$1'.70$	$1'.80$
4.5	5.5	135	$1'.93$	$1'.88$	$1'.79$	$1'.88$
5.5	∞	39	$2'.49$	$2'.54$	$2'.34$	$2'.49$
All Zodiac		288	$1'.96$	$1'.99$	$1'.81$	$1'.91$

Table 7: Mean Errors by Magnitude: North

μ_b	μ_d	n	$\Gamma\lambda$	$\Delta\beta$	$\Gamma\alpha$	$\Delta\delta$
$-\infty$	1.5	5	$0'.85$	$1'.84$	$0'.83$	$0'.57$
1.5	2.5	16	$2'.52$	$2'.22$	$1'.57$	$2'.09$
2.5	3.5	47	$1'.98$	$1'.90$	$1'.62$	$1'.51$
3.5	4.5	119	$2'.33$	$2'.38$	$2'.27$	$1'.69$
4.5	5.5	127	$2'.39$	$2'.47$	$2'.04$	$2'.12$
5.5	∞	8	$2'.57$	$2'.92$	$2'.48$	$1'.89$
All North		322	$2'.31$	$2'.35$	$2'.05$	$1'.87$

Table 8: Mean Errors by Magnitude: South

μ_b	μ_d	n	$\Gamma\lambda$	$\Delta\beta$	$\Gamma\alpha$	$\Delta\delta$
$-\infty$	1.5	4	$1'.02$	$0'.98$	$1'.09$	$1'.73$
1.5	2.5	7	$1'.74$	$0'.87$	$1'.76$	$1'.41$
2.5	3.5	17	$2'.13$	$1'.48$	$2'.09$	$1'.78$
3.5	4.5	40	$1'.91$	$1'.55$	$2'.01$	$1'.97$
4.5	5.5	74	$1'.65$	$1'.34$	$1'.71$	$1'.67$
5.5	∞	9	$2'.20$	$2'.42$	$2'.28$	$2'.45$
All South		151	$1'.81$	$1'.48$	$1'.87$	$1'.81$

Table 9: Mean Errors by Coordinate: Entire Catalog D (761 Stars)

Err	σ_0	$a \pm \sigma_a$	σ_1	$b \pm \sigma_b$	$A \pm \sigma_A$	$\theta \pm \sigma_\theta$	σ_3
$\Gamma\lambda$	2′.09	0′.31±0′.07	2′.06	0′.28±0′.07	1′.08±0′.10	255°±05°	1′.93
$\Delta\beta$	2′.07	0′.51±0′.07	2′.00	0′.80±0′.06	1′.69±0′.08	179°±03°	1′.61
$\Gamma\alpha$	1′.93	0′.23±0′.07	1′.92	0′.23±0′.07	0′.31±0′.10	218°±18°	1′.91
$\Delta\delta$	1′.87	0′.92±0′.06	1′.63	0′.89±0′.06	0′.25±0′.08	325°±20°	1′.63

Table 10: Mean Errors by Coordinate: Zodiac (288 Stars)

Err	σ_0	$a \pm \sigma_a$	σ_1	$b \pm \sigma_b$	$A \pm \sigma_A$	$\theta \pm \sigma_\theta$	σ_3
$\Gamma\lambda$	1′.96	0′.25±0′.11	1′.95	0′.31±0′.10	1′.35±0′.14	236°±06°	1′.70
$\Delta\beta$	1′.99	0′.53±0′.11	1′.92	0′.78±0′.10	1′.53±0′.15	184°±05°	1′.64
$\Gamma\alpha$	1′.81	0′.21±0′.11	1′.81	0′.29±0′.10	0′.98±0′.15	220°±08°	1′.68
$\Delta\delta$	1′.91	0′.99±0′.10	1′.63	1′.01±0′.10	0′.28±0′.14	229°±30°	1′.63

Table 11: Mean Errors by Coordinate: North (322 Stars)

Err	σ_0	$a \pm \sigma_a$	σ_1	$b \pm \sigma_b$	$A \pm \sigma_A$	$\theta \pm \sigma_\theta$	σ_3
$\Gamma\lambda$	2′.31	0′.12±0′.13	2′.31	-0′.09±0′.12	1′.46±0′.18	248°±06°	2′.11
$\Delta\beta$	2′.35	0′.87±0′.12	2′.19	0′.68±0′.10	1′.94±0′.13	179°±04°	1′.68
$\Gamma\alpha$	2′.05	-0′.05±0′.11	2′.05	-0′.29±0′.13	0′.82±0′.16	163°±13°	1′.98
$\Delta\delta$	1′.87	0′.66±0′.10	1′.75	0′.71±0′.11	0′.21±0′.13	326°±45°	1′.75

Table 12: Mean Errors by Coordinate: South (151 Stars)

Err	σ_0	$a \pm \sigma_a$	σ_1	$b \pm \sigma_b$	$A \pm \sigma_A$	$\theta \pm \sigma_\theta$	σ_3
$\Gamma\lambda$	1′.81	0′.84±0′.13	1′.61	0′34±0′.32	0′.69±0′.39	354°±20°	1′.60
$\Delta\beta$	1′.48	-0′.27±0′.12	1′.46	0′.86±0′.27	1′.56±0′.32	172°±08°	1′.35
$\Gamma\alpha$	1′.87	0′.86±0′.14	1′.66	0′.35±0′.39	0′.74±0′.40	334°±27°	1′.64
$\Delta\delta$	1′.81	1′.31±0′.10	1′.25	1′.38±0′.30	0′.18±0′.29	238°±93°	1′.26

G Principal-Star Error Trends

In this section, we examine the pattern of great-circle errors in the nine Principal star 1586.03 positions (§B5) upon which cat D was (ultimately) founded. These stars were (in order of increasing rt asc): α Ari (D3 = S12), α Tau (D66 = S19), μ Gem (D79), β Gem (D66 = S36), α Leo (D117 = S43), α Vir (D163 = S55), δ Oph (D694 = S65), α Aql (D736 = S79), α Peg (D783 = S95). Upon these stars' equatorial coordinate errors, we will now perform the same sorts of least-squares analyses just completed in §F for all of cat D (1601.0). The results, presented in Table 13, are for 1586.0 equatorial coordinates, with the table's rows assigned successively to: [a] α_{P} & δ_{P} of the Principal stars (P list) given by Tycho at OO 2:207 (Dreyer 1890 p.387); [b] α_{S} & δ_{S} of the same 9 stars, taken from his cat D-appended list of 100 Select stars (the S list, at OO 3:375-377) and precessed by TB's rates (*idem*) from 1601.03 to 1586.03 (only eight S stars are used in Table 13, since μ Gem is not on the S list),[48] [c] α_{D} & δ_{D} implicit[49] (for 1586.03) in the cat D ecliptical positions for the nine stars.

H Exceptional-Star Error Trends

We next present tables that summarize, for the 21 Exceptional stars (see OO 2:233 or §B5), the same type of analyses[50] carried out in the previous section (for the 9 Principal stars). These are Tables 14-15. The Exceptional stars (E list) are the 9 Principal stars (specified at §G, & their coordinates changed not a jot here), plus the dozen stars: γ Ari (D1 = S7), ϵ Tau (D36 = S18), γ Gem (D81 = S32), γ Cnc (D98 = S39), γ Leo (D115 = S45), γ Vir (D156), β Lib (D191 = S61), α Sco (D214 = S66), o Sgr (D222), γ Cap (D253 = S88), β Aqr (D262 = S87), α Psc (D318 = S11). In addition to Table 14 (paralleling Table 13 for the P list), we also present Table 15, based upon the E list ecliptical coordinates.

I Select-Star Error Trends

I1 At the end of cat D appears (OO 3:375-377) what we will call the "S list": Tycho's 100 Select (or "particularly important": Ræder & Strömgrens 1946 p.114) stars, already noted here in §B5. These 100 stars' coordinates & centennial precession rates (entirely equatorial) are provided for 1601.03 & 1701.03. All 400 coordinates & their O−C errors are fully listed later here in our Tables 22&23. With respect to our earlier remarks on Tycho's perfectionist passion for predictivity (§A1), note the boldness of his S list for 1701: for the first time in history, an astronomer was able to predict the tropical positions of hundreds of celestial bodies to near naked-eye accuracy (ordmag 1 arcmin) — *a century into the future*. (For Tycho's just pride at his ability to do this, see Ræder & Strömgrens 1946 p.114.) The achievement was a startling initial gleam at the morn of the age of high-precision science.

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[48] Originally, TB (1586) must've chosen D79 = μ Gem for its proximity to S.Solstice. But, at 3rd magn, it was the dimmest of the nine; being so near numerous much-brighter objects, μ Gem was naturally not a commonly-used ref star in practice; so it got dropped from the Select star list.

[49] As elsewhere here, our transf-calcs use (in §G & §H) a different TB obliquity for zodiacal stars, as against that used for northern or southern stars. See fn 190.

[50] The Select stars used in Table 14 are only 18 in number. This is because, though stars D79 (fn 48), D156, & D222 are on the Exceptional star list, they did not make the Select star list. None are bright; indeed, D222 = 39o Sgr is merely 4th magn, and I theorize that its original appearance on the E list was due to its α being precisely 280°00′. This has long been the traditional mark of the Sun's position at New Year. (The definition of the start of the long-standard Besselian year was the mean Sun's crossing α = 280°.) Since the Julian calendar had drifted away from this mark, there is a hint here that Protestant Tycho was privately attracted to the Church's then-newfangled (barely 3y old!) but obviously more-accurate Gregorian calendar. (Designed by C.Clavius, S.J.)

Table 13: Mean Errors of the 9 Principal Stars' 1586.0 Equatorial Coordinates

Err	σ_0	$a \pm \sigma_a$	σ_1	$b \pm \sigma_b$	$A \pm \sigma_A$	$\theta \pm \sigma_\theta$	σ_3
$\Gamma\alpha_{\rm P}$	0′.53	-0′.26±0′.16	0′.49	-0′.30±0′.16	0′.33±0′.23	028°±040°	0′.48
$\Delta\delta_{\rm P}$	1′.01	0′.87±0′.18	0′.54	0′.86±0′.20	0′.28±0′.29	067°±056°	0′.58
$\Gamma\alpha_{\rm S}$	0′.79	0′.09±0′.30	0′.84	0′.10±0′.34	0′.23±0′.48	130°±120°	0′.97
$\Delta\delta_{\rm S}$	1′.00	0′.56±0′.31	0′.88	0′.55±0′.36	0′.29±0′.50	061°±099°	1′.01
$\Gamma\alpha_{\rm D}$	0′.40	-0′.17±0′.13	0′.38	-0′.16±0′.14	0′.17±0′.21	100°±064°	0′.42
$\Delta\delta_{\rm D}$	0′.93	0′.39±0′.30	0′.90	0′.39±0′.35	0′.14±0′.51	108°±201°	1′.04

Table 14: Mean Errors of the 21 Exceptional Stars' 1586.0 Equatorial Coordinates

Err	σ_0	$a \pm \sigma_a$	σ_1	$b \pm \sigma_b$	$A \pm \sigma_A$	$\theta \pm \sigma_\theta$	σ_3
$\Gamma\alpha_{\rm E}$	1′.27	-0′.46±0′.27	1′.21	-0′.42±0′.25	0′.73±0′.35	196°±28°	1′.14
$\Delta\delta_{\rm E}$	1′.59	1′.21±0′.23	1′.06	1′.26±0′.21	0′.77±0′.29	194°±22°	0′.94
$\Gamma\alpha_{\rm S}$	1′.19	-0′.45±0′.27	1′.13	-0′.40±0′.26	0′.67±0′.37	188°±31°	1′.09
$\Delta\delta_{\rm S}$	1′.46	1′.06±0′.24	1′.04	1′.09±0′.24	0′.56±0′.34	208°±35°	1′.01
$\Gamma\alpha_{\rm D}$	1′.04	-0′.28±0′.23	1′.03	-0′.23±0′.20	0′.77±0′.28	195°±21°	0′.91
$\Delta\delta_{\rm D}$	1′.59	1′.04±0′.27	1′.24	1′.09±0′.25	0′.86±0′.34	199°±23°	1′.12

Table 15: Mean Errors of the 21 Exceptional Stars' 1586.0 Ecliptical Coordinates

Err	σ_0	$a \pm \sigma_a$	σ_1	$b \pm \sigma_b$	$A \pm \sigma_A$	$\theta \pm \sigma_\theta$	σ_3
$\Gamma\lambda_{\rm E}$	1′.20	-0′.30±0′.27	1′.19	-0′.26±0′.21	1′.09±0′.30	229°±15°	0′.95
$\Delta\beta_{\rm E}$	2′.19	0′.89±0′.48	2′.05	1′.10±0′.19	2′.52±0′.26	192°±06°	0′.86
$\Gamma\lambda_{\rm S}$	1′.25	-0′.09±0′.30	1′.28	-0′.04±0′.25	1′.15±0′.35	217°±17°	1′.04
$\Delta\beta_{\rm S}$	2′.10	0′.78±0′.47	2′.01	1′.02±0′.21	2′.50±0′.29	190°±07°	0′.87
$\Gamma\lambda_{\rm D}$	1′.17	-0′.17±0′.26	1′.19	-0′.11±0′.20	1′.18±0′.28	224°±13°	0′.89
$\Delta\beta_{\rm D}$	2′.13	0′.88±0′.43	1′.98	1′.08±0′.20	2′.39±0′.28	193°±07°	0′.93

Table 16: Mean Errors of the 100 Select Stars' 1601.0 Positions

Err	σ_0	$a \pm \sigma_a$	σ_1	$b \pm \sigma_b$	$A \pm \sigma_A$	$\theta \pm \sigma_\theta$	σ_3
$\Gamma\lambda_{\rm S}$	1′.86	-0′.02±0′.19	1′.87	-0′.10±0′.17	1′.33±0′.24	260°±10°	1′.65
$\Delta\beta_{\rm S}$	1′.84	0′.63±0′.17	1′.74	0′.86±0′.11	1′.84±0′.15	180°±05°	1′.12
$\Gamma\alpha_{\rm S}$	1′.62	-0′.06±0′.16	1′.63	-0′.08±0′.16	0′.27±0′.24	227°±48°	1′.63
$\Delta\delta_{\rm S}$	1′.48	1′.01±0′.11	1′.08	1′.02±0′.11	0′.16±0′.15	026°±57°	1′.09

I2 A previously unnoted oddity about the S list: not one of these 100 stars had negative precession in α. Indeed, there is not even a column[51] for α precession's sign in Tycho's original S list at OO 3:375-377. Since Kochab's α precession was negative, this could well have been the cause of the strange omission of this major star from the table. (Kochab = β UMi was frequently used as a reference star for cat D data, and it was itself more assiduously observed than most of the S list stars.)

I3 I am particularly impressed by the fact that not a single member of the 100 Select Stars had either equatorial coordinate in error by as much as 6′ — an astonishing Tycho achievement. Yet, curiously, the mean ecliptical σ_0 of this seemingly impeccable list is little better than that of the larger cat D. Indeed (as also noted at §J12), its σ_0 for β is not quite as good as that for the South section of cat D. (Compare the ecliptical σ_0 of Table 16 to those of Table 12.) However, the S list's a, for $\Gamma\alpha$ or $\Gamma\lambda$, are about the same as those of cat D, with the lone exception of North's $\Gamma\alpha$, where $a = -0'.05$ (Table 11), a fine result (presumably assisted by small refraction-influence — and some luck, since TB's precession error was 8″/decade).

I4 Comparison of the S list's 3-unknown $\Gamma\alpha$ error curve (Table 16) to that of cat D (Table 9) suggests that the S list (not the P or E stars) was effectively the direct source for the reference-stars used by Tycho during the outdoor collection of the quarry stars he set into his cat D. (See §J2.) The most superficial perusal of the raw observations will confirm this realization: many dozens of stars, most not Principal (& some[52] not even on the S list) are used as reference objects.

I5 The question arises as to whether the equatorial precession-rate data in the S star list were merely post-sph-trig 1701.0−1601.0 arithmetic differences, or were found from differential sph trig. The probable answer is: some of both. Facts:

[a] All 200 of the additions&subtractions on the S list were perfectly done.

[b] Despite mostly 1′ rounding, the S list column for δ centennial precession $d\delta/dT$ suffers not a single zigzag. (See OO 3:375-377.) I.e., every $d\delta/dT$ value between the Vernal Equinox & the Autumnal Equinox is less than or equal to the $d\delta/dT$ before it; and vice-versa. This obviously-deliberate neatness (also commonly found in ancient tables) strongly suggests Tycho's awareness[53] of the simple differential sph trig rule (possibly known as long ago as the 2nd century)[54] for computing the δ precession rate $d\delta/dT$:

$$d\delta/dT = \dot{\delta} = p \sin\epsilon \cos\alpha \qquad (1)$$

where T = time in centuries, TB's ϵ = obliquity (fn 190), p = TB's precession = 85′/cy (fn 29).

[c] As noted (§I3), all 100 stars' 1601.03 coordinates are correct within 6′.

[d] However, of the 1701.0 stars in the same S list, five[55] (1 in 20) of the positions show

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51 Similarly, the S list also lacks any star which is so situated, near the equator, that it would suffer a δ sign change during the 17th century. (Again, the S-star table does not provide a column to deal with such cases.) However, I have noticed no such star prominent enough to be a likely S list candidate. The brightest cat D stars that were crossed by the actual celestial equator (between 1601 & 1701): D899 = 22δ Mon (m = 4.15) & D306 = 18λ Psc (m = 4.50).

52 See §B5 & fn 179.

53 I note that, during the tiny α gap between stars S52&53 (δ Vir & ϵ UMa), the S list's $d\delta/dT$ shifts from $-34'$ to $-33'$ — precisely as it should do, if Tycho were computing differentially. However, the S list as a whole does not (presumably due to neatness-rounding) consistently provide such simple suggestion of the differential hypothesis.

54 DR's speculation of diff sph trig's antiquity is consistent with the 160 AD *Almajest* 7.3 precession discussion's dependence upon 6 stars' α (eq. 1) instead of λ (not in eq. 1). (Note perplexity of Toomer 1984 p.333 n.63 ["*Sic*!"], unaware that Ptolemy is, highly exceptionally, not using λ.) [Note added 1998/4: The more historically supported (if longer) non-calculus method of Manitius 1912-3 (2:20f; presumably understood by Graßhoff 1990 p.75) achieves accuracy nearly equal to eq. 1's by using (polar) longtd μ & decl ν of ecl pt having star's α. ($\Delta\nu/\Delta\mu = \sin\epsilon[\Delta(\sin\mu)]/[\Delta(\sin\nu)] \approx \sin\epsilon\cos\mu/\cos\nu = \sin\epsilon\cos\alpha$.) Our thanks to H.Thurston here.]

55 The five S list stars with 1701.0 gt-circ errors exceeding 6′: S15 (D621 = α Per), S30 (D651 = β Aur), S65 (D694 = δ Oph), S69 (D699 = η Oph), S71 (D509 = δ Her). Note that S65 is one of Tycho's original nine Principal stars. As for the $-38'$ error of S69: it may have been a hurried, unchecked transf-calc attempt to use eq. 4, where S70's δ was inserted instead of S69's. See §I7.

great-circle errors larger than $6'$. (See Table 23.) Some of these errors can provide clues to Tycho's procedure in precessing stars from 1601 to 1701.

I6 Given Tycho's tools, the most efficient method for precessing the S stars would have been something like the following. Call the 1601 coordinates: $\alpha_\circ$, $\delta_\circ$, $\lambda_\circ$, $\beta_\circ$ — and call the 1701 coordinates: α, δ, λ, β. To find the latter from the former: compute the 1701 δ by obtaining centennial precession $d\delta/dT$ via eq. 1 and just add it to the 1601 $\delta_\circ$:

$$\delta = \delta_\circ + \dot{\delta} \tag{2}$$

Obtaining 1701 λ & β is easy:

$$\lambda = \lambda_\circ + 85' \qquad\qquad \beta = \beta_\circ \tag{3}$$

The 1701 α then follows from the shortcut equation (effective so long as the star is not too near the equinoctial colure):

$$\cos\alpha = \cos\lambda \cos\beta / \cos\delta \tag{4}$$

which is alot simpler than the standard equation (which doesn't use δ):

$$\tan\alpha = \cos\epsilon \tan\lambda - \sin\epsilon \tan\beta / \cos\lambda \tag{5}$$

I7 Above (fn 55), we noted that 5 stars on the 1701 S list (Table 23) have gt-circ errors exceeding $6'$ — which is larger than any error in the 1601 S list (Table 22). Two stars are of particular interest: S15 (D621 = α Per) & S30 (D651 = β Aur). Both are OK for 1601 but have outsize 1701 errors, and these latter are in close accord with the 1601 errors of, not the S list, but: cat D. This circumstance would make no sense if the precessions were computed strictly by differential calculus. But it is perfectly consistent with the procedure laid out above, since, at the 1701 data development's crux (eqs. 3-4), the key coordinate (east-west)[56] will be the 1601 cat D's ecliptical $\lambda_\circ$, not the 1601 S list's equatorial $\alpha_\circ$ (which is not used at all in the §I6 equations). Thus, the peculiar errors of D621 & D651 provide double suggestion[57] that Tycho indeed used the (not entirely differential) procedure[58] we have proposed (§I6), when he computed the 1701 S list.

J Discussion of Error Tables

J1 The cat D single-star median accuracy,[59] — about $1'$ to $1'1/2$ — is better than most earlier investigators have concluded. (See, e.g, fn 37.) The mean cat D rt asc single-star error (σ_0 for $\Gamma\alpha$) is $1'.93$. (See Table 5, last row; or Table 9, 2nd column.) Moreover, the mean 1601 systematic rt asc error (a) of the entire cat D is an astounding $+0'.23 \pm 0'.07$! (See Table 9; the Ancient Star Catalog's mean longitude error is c.1 1/2 ordmags bigger, $-9' \pm 2'$: *DIO 1.1* ‡6 §G4. And that error is definitely systematic, not random.)

[56] All five Table 23 errors cited here are east-west: α. This is consistent with use of simple differential eq. 2.

[57] The other three 1701 errors also indicate consistency with the hypothesis. S65 (D694 = δ Oph) is off $+7'$ in α. We find elsewhere (fn 41) that $30'$ misargs are common in Tycho's star math. Assuming that such occurred here in eq. 4, δ = $17°49'$ misargf $17°19'$ produces λ = $239°48'$, just the value in Table 23. S69 (D699 = η Oph) has by far the worst error in Table 23. Acc calc (via §I6) would give α = $253°20'.7$ & δ = $-15°17'$. A typical Tycho misinv (§M2) for α makes it $252°39'.3$, which is very close to the grossly erroneous Table 23 value, $252°40'$. For S71 (D509 = δ Her), acc calc (via §I6), would have α = $255°42'$. An ordinary $-10'$ slip suffices to account for the Table 23 value, $255°32'$.

[58] However, one could also argue that the 1701 S list was computed purely nondifferentially via straight spherical trig, starting at eq. 3. (Against this is the far greater labor involved per star. See also fn 56 & fn 57.) What has been established by §I7 is that Tycho's calc of equatorial Table 23 was not *purely* a differential extrapolation from the equatorial data of Table 22.

[59] From sample to sample, the steadiest error is $\Delta\delta$, which TB usually found most directly (see §B6).

J2 It has long been believed (e.g., Dreyer 1890 p.353) that the 1586 lists of Principal stars & Exceptional stars (OO 2:207&233 or §G&§H) are the immediate basis of cat D. Difficulties with this presumption:

[a] There are nontrivial discrepancies — some exceeding an arcmin[60] — in the Tycho positions for stars in his 4 samples of data (P, E, S, & D). These are from: [i] needless errors or roundings during precession-calculations and-or transformations (almost certainly the case for the slight discrepancies in α Ari's position), and-or [ii] creditable empirical attempts at position-improvement,[61] during the years following 1586.

[b] Examining the critical $\Delta\alpha$ sinusoid[62] for cat D (Table 9), we see that the greatest resemblance[63] is to the corresponding sinusoid (note θ in particular) for the Select (S) stars (Table 16), not the Principal (P) or Exceptional (E) stars (Tables 13 & Table 14). This therefore confirms the likelihood that the cat D positions are based directly upon the S list, for those quarry stars placed by the δ&g method (§B6). (The positions in cat D itself were used for quarry stars located by the less common two-g method: §B8.) The 3-unknown error α curve for the S list is weakly defined, but its phase & amplitude resemble[64] those of cat D (Zodiac, North, & Entire). The effects approximated by our error-sinusoids may have arisen from net effects of refraction upon g data, due to unintentional observing biases (favored side of the sky, time of day, time of year, etc)[65] — influences which were too tenuous to be statistically significant in a 100 star sample, but were so in the larger samples of cat D.

J3 Though the Principal stars seem not to mesh with cat D, it should be kept in mind that cat D's evolution was not one-step. One should follow the known chronological order, checking the sinusoids of P stars vs. E stars, then E stars vs. S stars, & finally S stars vs. cat D stars. Then, one sees that there is no statistically significant inconsistency at any of the three segues (from one sample to the next). And, as one might expect, $\Delta\alpha$'s rms error σ_0 steadily increases at each stage: $0'.53$ (P), $1'.27$ (E), $1'.62$ (S), $1'.93$ (D). However, σ_0 for the original nine stars does not steadily degrade (and the best figure is the final one, cat D): $0'.53$ (P-E), $0'.79$ (S), $0'.40$ (D). Moreover, the $\Delta\alpha$ systematic error-wave amplitude $A = 0'.31 \pm 0'.10$ for cat D is about as low as the earlier samples' A ($0'.33 \pm 0'.23$ for P & $0'.27 \pm 0'.24$ for S). By contrast, the E list indicates the worst A for $\Delta\alpha$: $0'.73 \pm 0'.35$. This

[60] In rt asc, the S values (OO 3:376-377) of δ Oph & α Peg disagree with the P values (OO 2:207 or Dreyer 1890 p.387) by $+1'1/3$ & $+1'1/4$, resp.

[61] We need not speculate on this point, since at D585-587 of §M4, we have shown that Tycho altered his pre-cat D position of β UMi (a common TB ref-star). Indeed, the star's original TB position is accurately reconstructed at *idem*, to $1'$ precision. See also (in §M3) the cases of D98 & D222, both of which were altered by ordmag $1'$ as they went from [a] the 1586.0 Exceptional star list, to [b] the 1589.0 catalog (OO 11:383f), to [c] cat D.

[62] Though our least-squares fits (§F) of sinusoids through the data have helpfully suggested correlations of data-sets (§J2), the curves are not very firm. E.g., note that in Table 9, the σ_i for α are pretty constant regardless of the selection of i. (We have $1'.93$, $1'.93$, & $1'.91$ for $i = 0$, 1, & 3, resp.) That is a symptom of an unconvincing, almost superfluous fit. The error waves in the Ancient Star Catalog are far more informative (see Rawlins 1982C & *DIO 2.3* ‡8 §C). But that is precisely because Tycho's cat D is so much the superior of the older Catalog: Tycho's mean errors are so tiny, and reflect so clearly the extreme care he took in eliminating errors, that one's disappointment at being unable to draw much information out of the small mean-error-trends in the data is counterbalanced by delight at the success of a unique scientist's passion for accuracy.

[63] When comparing a & b values ($\overline{\Gamma\alpha}$) of Table 9 vs. those of Table 13, keep in mind that the error in TB's slightly oversized precession ($51''$/yr vs. real 1601 precession $50''.19$/yr) creates a mean discrepancy of $+0'.2$ in lngtd (similar for mean rt asc) during the 15^{y} from 1586.0 to 1601.0. (I.e., one must add such an amount to the 1586 a or b, before comparing to the 1601 values.) Curiously, TB's fundamental star α Ari, was off by $-0'.21$ in 1586, but was almost perfectly accurate by 1601, due to his precession error.

[64] The least-squares results vary slightly with time. (However, not enough to melt those phase-incompatibilities noted in §J2.) To illustrate, we provide the last two rows of Table 14, computed at 1601.03, instead of 1586.03. For $\Gamma\alpha_{\mathrm{D}}$: $1'.00$, $-0'.08 \pm 0'.22$, $1'.02$, $-0'.04 \pm 0'.20$, $0'.73 \pm 0'.28$, $193° \pm 23°$, $0'.91$. For $\Delta\delta_{\mathrm{D}}$: $1'.60$, $1'.05 \pm 0'.27$, $1'.23$, $1'.10 \pm 0'.25$, $0'.87 \pm 0'.34$, $204° \pm 23°$, $1'.12$.

[65] If observers tended to work post-sunset more often than pre-sunrise, this would produce asymmetries in observations. Also, keep in mind that, in the Danish summer, it never gets completely dark (see Tycho's comments on this at Ræder & Strömgrens 1946 p.113, cited Rawlins 1992T §F3), a factor which produces further asymmetric difficulties in accessing certain constellations.

suggests[66] that the actual evolution of cat D was effectively: P-to-S-to-D.

J4 We find (contra previous commentators)[67] that accuracy was not much degraded by stellar dimness, so long as the star's μ was brighter than about 5[th] magnitude. Indeed, what our tables show is that from[68] 3[rd] to 5[th] magnitude, *there is no statistically significant decline in accuracy* — a startling finding for orthodox scholars, but one which is in fact quite consistent with what one ought to expect after examining[69] Tycho's raw stellar data. Note the case (see D95 in §M3), of the 6[th] magnitude Beehive ("Praesepe"), about whose position Tycho was so confident that he even put it on his Select star list (Table 22) — and, indeed, its accuracy is better than the average of the S list.

J5 A seeming peculiarity: the ratio, of $\Delta\beta$'s σ_0 to $\Delta\delta$'s σ_0, swings from unity-plus to unity-minus, as we go southward. The reason: in the north, where refraction is trifling near upper culmination, δ was nearly correct, while TB's error in obliquity ϵ vitiated rotation-transformation-calculated β. But, as we shift our attention to the zodiac and then into the southern part of cat D, refraction becomes more important. However, since TB's error[70] in ϵ is $+2'$, we find that, while many primarily refraction-caused errors in δ stand uncorrected,[71] the errors which they cause in calculated β are somewhat compensated for by the obliquity error, in the part of the sky around the winter solstitial colure. (See fn 71. However, around the summer solstitial colure, the errors tend to reinforce each other.)[72] The effect of refraction also makes itself felt in another surprising way: except for the north (trivial refraction), $\Delta\alpha$'s σ_0 is generally smaller than $\Delta\delta$'s σ_0.

J6 A final DR observation here concerns the $\Delta\beta$ sinusoidal results: all θ solutions are within σ_θ of 180°, except for the E sample (§H), where the discrepancy is nonetheless within $2\sigma_\theta$. Of course, this is simply a natural[73] byproduct of Tycho's erroneous obliquity ϵ. Also, in §F: Zodiac & North[74] A are within σ_A of $1'.5$ & $2'.0$, the errors $\Delta\epsilon$ in the obliquity ϵ adopted for these respective sections of the sky. (Similar correlations of $\Delta\epsilon$ with $\Delta\beta$'s A will readily be discerned in other tables here.)

[66] Another possibility: Tycho's use of large measured arcs (unlike Hipparchos: Rawlins 1982C p.373 & Rawlins 1991H §F-§G) somewhat melted A while (due to nonbias in the arcs' direction) keeping θ little changed. Comments: [a] the mean size of arcs g (roughly 30°) is not enough to cause this big a dent in A; [b] the $\Delta\alpha$ error-sinusoid for the cat D zodiacal (Table 10) & cat D northern (Table 11) stars is consistent with E (Table 14), though the cat D southern stars' sinusoid (Table 12) is nearer P's (Table 13). [c] The raw observations (OO 10-13) record use of so many ref-stars not on the P or E lists — but nearly all on the S list — that the relation already noted (§J2 item [b]) between the S list & cat D sinusoids (Tables 9&16) is perfectly reasonable.

[67] However, the table at Rybka 1984 p.202 presages our finding here, despite his using m (to 0.1 precision) not μ values: it reveals little difference between TB errors at m = 4 & 5. (Rybka would have found the same for 3[rd] magn, had he not merged these stars with all the brighter stars.)

[68] While for most samples the 2[nd] magn stars have more acc pstns than those dimmer, there is an anomaly in the North: in Table 7, the errors for the 2[nd] magn stars (16 stars) are outsize (compared to other samples' errors at 2[nd] magn). However, since (at 2[nd] magn, 18 stars), the North medians' size is not out of line (Table 3), the oddity in Table 7 is probably just due to a few large (& probably interdependent) errors in a small sub-sample. (Another peculiarity: in Tables 1-4, $\Delta\beta$ is smaller for μ = 2 than for μ = 1 — perhaps due to accid cancellation of refr & obliq errors. Note ignoring of refr for Sirius: fn 71.)

[69] Fn 37. On the other hand, note §N19.

[70] The error introduced, by TB's false oversized (ancient) adopted parallax plus his ignoring of polestar refraction, is about $2'.8$, which approximately accounts for the $+2'$ error in his ϵ. TB rejected [a] the *Almajest* 1.12 method (measuring double-ϵ between the solstices) in favor of [b] measuring the less refraction-affected complement of ϵ (the angle between pole & S.Solstice). (See Thoren 1990 pp.226-227.) I suspect that the ancient astronomer Hipparchos experienced exactly the reverse techniques: starting with method [b] (though crudely using a gnomon for the Sun, resulting in rounded ϵ = 23° 11/12 — roughly 1°/5 high in his era: see Rawlins 1982C pp.367-368), but later switching to method [a], which produced far better ϵ = 23° 2/3 (slightly shrunk by differential solar refraction).

[71] E.g., D933 = Sirius: $\Delta\delta = +3'.0$. This is precisely the refraction for $h = 17°55'$. Odd, because the $1'.3$ correction, found in TB's refraction table (OO 3:377) for this h, would have eliminated nearly half of the δ error. Clearly this correction was not applied to Sirius. (Presumably, Sirius' pstn was long-established for Tycho well before he began accounting for refr.) In connection with DR's observation at §J5, note that, for this southern star, $\Delta\beta = +1'.0$ is much smaller than $\Delta\delta$. Here, in the transf-calc, TB's $+2'.0$ ϵ error cancelled (full-impact, so near the winter solstitial colure) 2/3 of the $+3'.0$ error caused by refraction.

[72] Thus, since there are more stars around the summer solstitial colure in the northern portion of cat D, $\Delta\beta$ tends to be larger than $\Delta\delta$. But, there being more stars around the winter solstitial colure in the southern portion of cat D, the reverse tends to be true.

[73] See fn 39 here; also *DIO 2.3* ‡8 §C14. The expected latitude-error curve due to an obliquity-error $\Delta\epsilon$: $\Delta\beta = -\Delta\epsilon\sin\lambda = \Delta\epsilon\sin(\lambda - 180°)$.

Table 17: Mean Declination Errors' Dependence on Declination (761 Stars)

δ_1	δ_2	n	σ_1	a	σ_a	r_T	r	Δr	$\overline{h}$
75°	90°	7	3′.53	0′.79	1′.34	0	-0′.46	0′.46	65°58′
60°	75°	30	2′.15	-0′.16	0′.39	0	-0′.18	0′.18	79°38′
45°	60°	70	1′.85	0′.84	0′.22	0	0′.08	-0′.08	85°56′
30°	45°	91	1′.45	0′.67	0′.15	0	0′.34	-0′.34	71°03′
15°	30°	173	1′.69	0′.91	0′.13	0	0′.64	-0′.64	56°38′
0°	15°	182	1′.34	0′.83	0′.10	0	1′.02	-1′.02	41°39′
-5°	0°	32	1′.24	0′.98	0′.22	0	1′.56	-1′.56	31°47′
-10°	-5°	46	1′.16	1′.17	0′.17	0	1′.96	-1′.96	26°19′
-15°	-10°	46	1′.69	1′.53	0′.25	0	2′.46	-2′.46	21°27′
-20°	-15°	41	1′.99	1′.55	0′.31	1′.99	3′.15	-1′.16	17°01′
-25°	-20°	34	1′.53	1′.09	0′.26	4′.56	4′.52	0′.04	11°54′
-30°	-25°	8	1′.72	1′.04	0′.61	6′.92	6′.67	0′.25	7°53′
-31°43′		1	—	2′.90	—	13′.60	15′.48	-1′.88	2°38′

J7 To conclude this section, I provide Table 17: declination-error means $a = \overline{\Delta\delta}$, vertically stratified by declination bounds, using 15°-thick intervals for positive δ, 5°-thick intervals for negative. The solutions (based upon the same 761 stars used in §E & §F) are designated as were the 1-unknown least-squares results of §F: single-datum stdev σ_1, mean a, and its stdev σ_a. For the mean δ of each row, I also list (in the rightmost columns) for Hven culmination: Tycho's tabular refraction[75] r_T (interpolated from his table at OO 3:377), corresponding real refraction r, & their difference, $\Delta r = r_T - r$; the last column is the mean of the apparent altitudes h of all the stars in the row.

J8 Now, if all δ were based upon upper transit observations, corrected by Tycho's refraction table (fn 107), one would expect to find a resembling $-\Delta r$: varying from about $-0'.7$ at δ = 90°, to near-null at δ = 56° (Hven zenith), swooping to an absolute maximum of about $+2'.7$ at $\delta = -14°$ (h = 20°, where the TB refraction table's error Δr peaks at $-2'.7$), then quickly flattening-out further south, since the TB refraction table becomes accurate to about $1'$, from h = 17° until very near the horizon. (The error again becomes serious between h = 3° and 0°. But, in cat D, only one star lies in this range: D299 = Fomalhaut, with 1601.03 $\delta = -31°43'$. See last row of table.)

J9 However, a in the actual table here does not at all so behave, in the north. The 7 farthest north stars ($\delta > 75°$) of our sample have no consistent error, certainly not a negative one. Reason: not one of these 7 stars' places are based (even in part) upon observations for δ. If we include even stars with large errors & those marked in col.x, we have 33 stars whose $\delta > 70°$ — but the cat D position of only one of them (γ UMi = D342) appears to be based upon observations of h or δ. Moving away from the celestial pole: though the stars between δ = 60° & 75° show a very slight (utterly insignificant, statistically) negative mean error a, the zenith stars have a steady positive error of c.$1'$.

[74] And, for $\Delta\beta$, the southern stars' A is within $1.4\sigma_A$ of $2'.0$.

[75] Tycho's refraction r_T is computed for the mean apparent altitude, $\overline{h}$ (Table 17's last col), of the n cat D stars in the decl interval; real r is the mean of the real refractions of the n stars, computed (overprecisely, especially for low h) from DR's refraction formulae (Rawlins 1992T fn 17). Since refraction is not a linear function of h, these definitions are slightly inconsistent, but not at a level that will sensibly affect the present analysis.

J10 As we head south of the celestial equator, the behavior of a is more nearly what we expected (§J8): [a] Between $\delta = 0°$ (Hven $h = 34°$) and $\delta = -15°$ (Hven $h = 19°$), a is equal to about 60% of refraction. [b] The peak error indeed (§J8) occurs very near $\delta = -14°$ (Hven $h = 20°$), but again with about 60% of the expected strength. [c] Between $\delta = -25°$ & $-30°$, where one anticipates nearly null error (since the TB refraction tables are accurate in this range), we instead find steady $a = +1'$.

J11 In brief, then, vs. expectations (§J8), we find a: [i] off by $+1'$ for $h = 90°$ ($\delta = 56°$), [ii] off by $+1'1/2$ for $h = 20°$, [iii] off by $+1'$ for $h = 10°$. It is initially tempting to suppose that the sample was polluted by two-g stars. However, virtually no non-north stars were positioned in cat D by that method. (See §B8.) The most likely actual causes: instrumental pole-misplacement, too-frequent neglect of refraction-correction (prominent example at fn 71), and non-transit δ observations (by equatorial armillary) performed too far off meridian. (Note: no single one of these factors will explain the entire a profile of Table 17.)

J12 I conclude this section with a particularly surprising finding: The most accurate (smallest σ_0) of the 3 main sections of cat D is not the North or Zodiac section (as I would have expected), but the South part. (In the Ancient Star Catalog, the southern stars are the worst.) As a comparison of Table 12 to Table 16 shows, the southern ecliptical σ_0 are actually smaller (especially for β) than those of the elite S list. (Though, see §I3.) Likely reason: generally speaking, the order of (pre-Final-Fifty) observation was zodiac, north, south. So southern stars tended to be cataloged when TB's techniques & instruments were at their peak.

K Total Star Count

K1 Before *DIO*, perhaps only one scholar (Francis Baily)[76] had even attempted an accurate count of cat D's stars (§B2). *DIO* finds that the total is not 1000 (as commonly stated) but exactly 1004.

K2 The final 4 stars (D1001-1004), tacked onto cat D at the last minute, are those of Cen. (All 4 stars' longitudes λ are faked, as first pointed out at Rawlins 1992T Table 2 — where we also discovered that the first 6 stars of Oph, D675-680, are entirely faked.)

K3 Tycho was numerologically determined to complete his long-promised thousand star project. (Hipparchos & Ulugh Beg had each also cataloged just over 1000 stars.) Thus the vastness of the achievement. Thus also the motive to pad a bit at the very end, as Tycho was evicted from Hven just a few stars short of the magic desired total. (Details at Rawlins 1992T §C9 f.)

K4 A hitherto unknown number: how many separate stars did Tycho place in cat D? Not 1004. Not even 1000. First, 12 stars are listed more than once — two of them thrice; thus, 14 entries are repeated[77] stars (2 of them exact). Second, 11 further stars are fake or (D971) fishy. Third, D566&567 are nonexistent-hybrid disasters (§N8 & Table 19). So we subtract 27 from 1004 and conclude that cat D lists real attempted observations of 977 stellar objects. Fourth, dropping 12 hybrids[78] (cat D entries calculated via data not from the same star), we have 965 real, distinct stars cataloged (though not always with TB's intended accuracy).

K5 For our statistical investigations, we include non-identical repeats (fn 77), but delete fishy, fake, hybrid, or non-existent objects (§K4). We also eliminate (as in §C3, for §D) not only hybrids but lineup-calcs (§B9), here-restored scribal-errors (fn 42), wrong-choices-of-pair (WCP: fn 181), & the iffy Final Fifty, etc. — i.e., all the problem-stars cited in col.x of Table 21. The number remaining is then: 886 stars (§C4). Further weeding out (§E2) the stars with either implicit 1601.03 equatorial coordinate error exceeding $0°.1$, we are left with 761 stars for which Tycho gave reliable positions.

[76] In his *Mem.R.A.S. 13* (1843) version of cat D, Baily skips stars D94, D675, & D913, while appending 2 stars to Sgr and 2 novae to Cyg & Cas, resp, resulting in a total of $1004 - 3 + 4 = 1005$ stars. A more defensible candidate for a 1005th star is 24ω Her (HR6117, $m = 4.57$), which was cataloged at m = 5 (OO 13:76) in TB's Appendix to his 1596 observations, but (apparently inadvertently) omitted from cat D, a fact first remarked by Dreyer (OO 13:76 n.1). It is the sole Tycho star, previously cataloged by him, which is not in cat D. Its pstn is acc to less than $1'$ in both eqt coords. However, since it isn't in cat D, I don't include it in this edition of cat D. (Had its acc been awful, it would have been dropped; so it would be statistically improper to include it *post hoc*.) The cat D coords (& real coords for 1601.03): implicit $\alpha_D = 241°45'.8$ ($45'.7$) & $\delta_D = 15°00'.5$ ($00'.7$); explicit $\lambda_D = 235°58'.5$ ($59'.1$) & $\beta_D = 35°14'.8$ ($13'.3$); post-extinction magn $\mu = 4.75$.

[77] The repeated stars: D94 = D102 ($10\mu 2$ Cnc, HR3176), D256 = D257 (51μ Cap, HR8351), D345 $\equiv$ D600 (11-12 Cam, HR1622-3), D348 = D644 (A Cam, HR0985), D550 = D565 = D569 (13θ Cyg, HR7503-4), D554 = D568 (54λ Cyg, HR7963), D684 = D704 (53ν Ser, HR6446), D685 = D705 (55ξ Ser, HR6561), D686 = D706 ($56o$ Ser, HR6567), D687 = D707 = D696 (57μ Oph, HR6567), D699 $\equiv$ D701 (35η Oph, HR6378), D907 = D913 (26π Eri, HR1162). (Due merely to zodiac-sign misprints, D976 & D982 falsely appear to be repeats of D961 & D960, resp.) I have dropped cat D's two exact repeats, D600 & D701 (D345 $\equiv$ D600 & D699 $\equiv$ D701) from my samples because they are superfluous. (D600 was deleted on other grounds anyway: fn 191.) Note also that hybrid stars

L How Dim Was Tycho's Magnitude Limit?

L1 Of the 1004 stars of cat D, not one's pre-extinction[79] visual magnitude m unambiguously exceeds 6.00. I have checked[80] out several cases where it seemed[81] that Tycho perhaps had recorded a star dimmer than $m = 6.00$: D168, D194, D247, D257, D327, D408, D524, D598, D603.

L2 The cases of D257, D408, D598, & D603 turned out to be mere confusions engendered by cat D position-errors. D168 is a hybrid entry (see §M3), partly based upon observations of a triple star, HD121444 ($m = 7.6$) + HD121481 ($m = 6.8$) + HD121496 ($m = 6.85$): combined $m = 5.83$. The magnitude of D247 (HR8087, 25χ Cap) would at first seem to exceed 6.00. But the Yale *Bright Star Catalogue* (Hoffleit & Jaschek 1982) magnitude m of HR8087 is false ($m = 6.03$ vs. $m = 5.28$ in *SkyCat2000*; either a luminosity-error by a factor of 2 was made, or the magnitude & B−V of a variant of HR8086's data leaked into HR8087). The magnitude of D327 (65i Psc = HR230-1) is a binary of combined $m = 6.3$ according to the Yale *BSC*, but from the 1940 edition of the Yale *BSC* (p.6), we see that this is just Yale's Castor-Pollux gaffe (fn 87) in reverse: combined m confused with individual m (both 6.29), so true combined $m = 5.54$. (Amazingly, *SkyCat2000* 1991 follows this error, which may be corrected by a moment's eyeball exam of the real sky, comparing magnitudes of the stars in the little triangle formed by D325-7. It may seem incredible that, late in the 20th century, a naked-eye star's magnitude could be mistaken by a factor of *two* in *both* of the prime catalogs which astronomers consult for magnitudes. But this is in fact the case for 65i Psc. It is even more remarkable that this error was revealed by its conflict[82] with the magnitude limit which DR had found for Tycho's naked eye cat D. Indeed, DR was sufficiently confident, of the reality & nature of this error, that he distributed 2 copies[83] of the present edition of cat D before even checking the sky to confirm 65i Psc's magnitude — which he did at home, 1994/6/3 3:41 EDT. Note: while Yale University's *BSC* and the *SkyCat2000* both err on 65i Psc's m, by contrast the rough m indicated for this star is correct in the latest rendition of the popular *Norton's*, edited by Ian Ridpath.) Nonetheless,

(marked as such in col.x in Table 21) can contain pieces of data based on stars already listed (elsewhere in cat D). Such invasive hybrids include: D277, D566, D567, D854, and maybe D647 & D747.

[78] The twelve hybrids are: D73, D168, D224, D255, D277, D291, D358, D364, D484, D491, D854, & D938. See fn 170. D566-567 are hybrid-bungles (§N8), already dropped as nonexistent stars. D647 is a lineup-calc-bungle data-hybrid; it is eliminated from our statistically-analysed samples on several other grounds, anyway. A few other entries might be hybrid (e.g., D504); but, absent firm indication, §M treats each as just a flawed single-star position.

[79] The post-extinction magnitudes μ of several stars exceed 6.00. (See §L9 & Table 18.)

[80] Indeed, I have even examined the sky directly with my $5''$RFT refractor for D168, D194, D327, & D524.

[81] Yet another instance is the hybrid star D491, whose δ is of Com 22, which has $m = 6.29$; but, again, a nearby star enhanced the effective magnitude: see below at D491 in §M4.

[82] Were the modern catalogs' value ($m = 6.3$) correct for 65i Psc, then D327 would be by far the dimmest real star in cat D, with $\mu = 6.44$, more than 0.2 magns dimmer than any other. (See Table 18: D234.)

[83] To Curtis Wilson 1994/5/11 (from BWI Airport) & to Hanne Dalgas Christiansen 1994/5/28 (at the Tycho Brahe Museum, on Hven Isle, a few meters from where all cat D's fully genuine stars were observed).

two cat D entries still looked potentially dimmer than $\mu = 6$: D194 (HR5703, 29o Lib) and D524 (HR6641, Her). Both cat D positions agree well with those of actual dim stars.

L3 D194 was just $7'$ north of HR5703 (magn 6.30 in Yale Cat & *SkyCat2000*), and D524 was only $5'$ (great-circle) east of HR6641 (magn 6.43 in the same 2 sources). But a closer look muddies the situation. HR5703 is indeed listed as 6.30 by the Yale Cat & by *SkyCat2000* 1:371, but then *SkyCat2000* 2:94 (1985) says it is a double star (HD136407) whose components have magnitude 6.2 & 8.4 (combined magnitude 6.07), which is consistent with the older catalogs' magnitude 6.1 (SAO 159191, Albany 12396). Moreover, the 7.4 magn star HD136406 (SAO 159188 & Albany 12395 have it $m = 7.5$) was only $11'$ distant for Tycho; merging its magnitude with 6.07 yields[84] magn 5.8.

L4 As to D524: yes, HR6641 is $m = 6.43$ in Yale & *SkyCat2000*; but HD162299 ($m =$ 7.0) is just $9'$ (gt-circ) to the east. (That the 2 stars may have been seen together is suggested by the fact that for D524, Tycho writes "nebulous" instead of specifying a magnitude. There are a few other dimmer stars in the immediate neighborhood: e.g., SAO 46947.) Merging these two stars' m produces net $m = 5.93$ — which wipes the last 6th magnitude hopeful off our list.

L5 For both D194 & D524, the Tycho position is near the center of the actual pair, which suggests that the observer indeed saw both stars together.

L6 It should be noted that, for Hven transit, since the pre-extinction magn m of D194 was between 5.8 & 6.0 (§L3 & fn 84), post-extinction magn μ was between 6.2 & 6.4; thus, the possibility that Tycho recorded the unfaked δ of D1001-1004 ($\mu = 6.0$ to 6.5) from Hven (rather than Wandsbeck) cannot be said to have been utterly disproven here. However, Tycho's magnitude limit[85] is so consistent & reliable (see fn 83!) that the odds against Hven are convincingly high.

L7 A warning regarding cat D's published magnitudes m: they are crude[86] and often inaccurate. (Not that modern catalogs are always beyond reproach. E.g., it's official: Castor is brighter than Pollux! It says so, right there on p.119 of the authoritative 1982 Yale Catalog[87] [error preserved at Graßhoff 1990 p.292].) And, though a surprising number of Tycho's m are original, a few may occasionally[88] be derivative. E.g., TB follows Hipparchos in, oddly,[89] assigning magnitude m = 2 to Pollux (β Gem) = D66 ($m = 1.14$) and magnitude m = 1 to Denebola (β Leo) = D136 ($m = 2.14$). As with the modern *SAO Catalog*: the main goal was to determine stellar positions, not brightnesses.[90]

L8 For this edition of cat D (§P), it was decided to list not only each star's pre-extinction real magnitude m, but also its real[91] null-dust post-extinction magnitude μ, for culmination at Tycho's Hven observatory. The last (μ) is found by a 21-band integration of atmospheric extinction, stellar spectrum, & human ocular sensitivity curve, as described at Rawlins 1992T fn 18. The null-dust assumption (fn 45) for pre-industrial astronomy has been needlessly controversial. In the incomparable *Journal for the History of Astronomy*, Evans 1987 (64pp!) attacks, at astounding length, the Ptolemy star catalog analysis of Rawlins 1982C — charging that it didn't use modern skies' standard extinction model. This model entails 11 magnitudes[92] of extinction at a sealevel horizon, as perhaps first noted in Rawlins 1992T. So, to finally curb this odd debate, we here produce a surprise witness: Claudius Ptolemy. His *Planetary Hypotheses* 1.2.6 states[93] (as brought to my attention by an excellent new Springer book: Thurston 1994E p.173) that 1st magnitude stars were (in antiquity) visible on the horizon even during twilight. (When solar $h = -15°$. That is: sky 3° brighter than *JHA* refereeing.) Since 1 + 11 = 12, the esteamed *JHA* ($140/yr to institutions) has expended 64 of its extremely handsome pages on a Ptolemy-apology requiring that he saw 12th magnitude objects. (There will never be another *JHA*. Treasure it.)

L9 I now separately tabulate (without exclusions, even for fakery) those 14 stars in cat D whose null-dust post-extinction magnitudes were dimmer than $\mu = 6$. Four are fakes (D1001-1004), and three are dim parts of hybrid[94] cases (D168, D484, & D491).

[84] But from 1991 *SkyCat2000* p.410: 6.32 & 7.4; comb $m = 5.98$.

[85] This limit also bears upon one's natural initial hope that Tycho might have accidentally observed Uranus near the border between Aqr & Psc, during his 1589 (& 1590) Autumn sweeps (OO 11:363-371 & OO 12:79-80, 405-412) of that region, when the planet's $m = 5.7$. At the 1589/9 start of these observations, Uranus was retrograding near 20 Psc, a slightly brighter object. Other Psc stars in the vicinity which were a little brighter than Uranus: 27, 29, 30, 33. (All 4 are in Hipparchos' & Ulugh Beg's catalogs: PK708-711 & UK705-708, resp.) Yet, curiously, none of these 5 stars were observed by Tycho. In brief, Tycho did not observe Uranus. (When TB was observing the zodiac stars, he only very rarely — e.g., 67k Psc = D326 = PK700 — recorded a star as dim as Uranus. And, during this period, he was generally not intending to observe stars unlisted by Hipparchos-Ptolemy.)

[86] Largely integral m, though he occasionally adopted (Dreyer 1890 p.354), in effect, the ancient system — which used thirds of magnitudes.

[87] Lest one get the curious idea that flaws in star lists are strictly an oldtime problem, let's have a few words on the long-standard 1982 Yale *Bright Star Catalogue* — which contains so many glitches that even my spotty use of it (barely 10% of its stars) turned up roughly a score of slips. A compact list follows. HR230-1 p.13 (65i Psc = D327): see §L2. HR553 p.26 (D2): for 6ι Ari read 6β Ari. HR1592 p.449: 4 Aur not listed = ω Aur (as at p.66). HR2890-1 p.119 (Castor = D65): two prior estimates of comb m evidently taken as components' individual m, so 1.58 + 1.59 = 0.83, brighter than Pollux ($m = 1.12$, HR2990 = D66); again, Yale 1940 edition p.60 renders both m values correctly, 2.85 & 1.99, for comb $m = 1.58$, which we use here (Johnson has 2.95 + 1.97 = 1.60). HR3447 p.140 o Vel: $1'$ error in 1900.0 δ. (For $-52°34'00''$ read $-52°35'00''$. Obviously a rounding error permitted by the underlying computer program — suggesting that other such errors may lurk for rounded-up $00''$ endings.) HR4399 p.178 (D132): for 78κ Leo read 78ι Leo. HR4691 p.190: huge δ error. For 1900.0 $\delta = 1°37'11''$ read $-21°37'11''$. HR4729-4731 p.193 (α Cru). Error of +0.2 in comb m. (Rare miscue here in *SkyCat2000* 1982 p.311: HR4731 δ off by $+1°$.) HR5233 p.213: discrepancy of c.0.7 in m of HR5233. (Yale has $m = 6.19$; *SkyCat2000*, $m = 6.9$.) HR5264 p.214 (D181): for 93ρ Vir read 93τ Vir. HR5459-5460 pp.222-223 (α Cen). Pstns 1900.0 vs. 2000.0 inconsistent in 3 dimensions with motion & distance data. HR7254 (2 slips) p.294: for β CrA read α CrA; & p.466: for α Cra read α CrA. HR7730&5 p.312 (D558): for 30 Cyg read 30o1 Cyg (OK at p.451). HR7751 p.314 (D559): for 31 Cyg read 31o2 Cyg (OK at p.451). HR8087 p.327 (25χ Cap = D247): another brightness-error by factor of 2. (See above at §L2.) HR8402 p.340 (D261): for o Aqr read 31o Aqr (OK at p.448). HR8592 p.346 (59υ Aqr = D278): disastrous error of over 37° (gt-circ). (All HR8592 pstn coords are those of HR8593.) HR9045 p.364 (D582): for 71η Cas read 7ρ Cas. [HR339 p.16 (D330): for 81ϕ3 Psc read 81ψ3 Psc.]

[88] However, the m in cat D are frequently different from other catalogers'. According to a semirandom DR count of 74 stars, roughly 30% of Tycho's m do not equal the m of any of the earlier 1000 star catalogs (whose m are closely interdependent): Hipparchos-Ptolemy, Al Sufi, Ulugh Beg, Copernicus. Two comments: [a] The fraction of fresh m data is the highest in any catalog at least since Hipparchos. [b] Given that experienced astronomers — observing completely independently — will concur on most stars' magnitudes, 30% may be about the fraction of disagreement expected in a case of virtually zero dependence upon another naked-eye astronomer's starlist.

[89] Both stars are commonly visible simultaneously. The differential magnitude error here — Pollux's [m $-m$] minus Denebola's [m $-m$] — is precisely 2, which corresponds to a relative brightness error of 6.3. (More, if atm extinction accounted for.) Repeating such a gross error independently would be virtually impossible for an outdoor observer.

[90] There is one surely-nonderivative aspect to Tycho's recorded magnitudes m, namely his designation "ne. " for "nebulous". (We use just "n" in our §P edition of cat D.) Only 5 stars in cat D are designated "ne." They are: D95 (Beehive), D235, D236, D238, & D524. All are dim bunches of stars, not nebulae. (E.g., the Orion Nebula, D870, is not called nebulous but is just rated at m = 3. Rather bright, considering that Betelgeux, D841, is listed as m = 2 ! The HP values were, respectively 2 2/3 & 1 1/3: PK735 & PK764.) Evidently, the term "nebulous" referred primarily to *position*, not brightness — i.e., to star-patches that seemed so ill-defined (to the observer) that determining precise coords was problematical. However, it must be said that, of the 10 nonfake stars with $\mu > 6$ (Table 18), two are marked "ne": D236 & D524. (That's 40% of all the "ne" stars in cat D. And it's 20% of Table 18 — which is a fraction about 60 times higher than the 0.3% of the rest of cat D which is marked "ne".) Note that D236 has one of the dimmest μ in cat D.

[91] Actually, the standard 3 mm value for the ozone layer is not a rigid value: it varies around that average. (See B.Rensberger's anti-ozone-panic article, *Washington Post* 1993/4/15 pp.1,18-19.) But the effect is minor compared to that of the average amount of dust in the modern atmosphere.

[92] See Rawlins 1992T fn 18 (& fn 65). Same result: B.Schaefer "Astronomy & the Limits of Vision" *Vistas in Astronomy* 1994 (Table 3 and eqs.4b, 5b, & 6b for dry winter sealevel sky). For null-dust, horizon extinction = c.4 magns. Thus, the difference between the standard model & the *DIO* (null-dust) model is 11 − 4 = 7 magns, a factor of ordmag 1000 !

[93] The wonderful recovery of *Planetary Hypotheses* 1.2 was by (Muffioso) B.Goldstein 1967. See p.9 for Ptolemy on visibility of 1st magnitude stars at the horizon. [Some "defenders" of Ptolemy's honesty on the Catalog-authorship think his statements here and at *Almajest* 8.6 & (with diagrams) 13.7-8 were falsehoods: he didn't really see stars *at* the horizon. If one assumes his horizon-stars-dishonesty to prove his Catalog-stars-honesty, there is another problem: Ptolemy (*PlanHyp loc cit*) gives parallel acronycal rising&setting data for outer planets, and such cannot be defined *except* for planets (invisible by *JHA* atmosphere: fn 92) seen right on the horizon.]

[94] Note that, for each hybrid listed in Table 18, no more than one of the two listed pstn errors applies to it. For the δ&g method, usually one coord is nearly correct (especially δ), but for a star that is two-g-placed, there is no such guarantee — as the D484 errors in Table 18 dramatically attest.

Table 18: Cat D Stars with Hven Null-Dust μ Dimmer Than 6

D	m	m	μ	μ_J	$\Gamma\alpha$	$\Delta\delta$	x	δ	Name
157	6	5.79	6.04	6.17	-8′.8	4′.4		-1°.6	44k Vir
168	6	5.83	6.13	6.27	5′.6	11′.9	h	-7°.6	HD121481
194	6	5.80	6.19	6.38	0′.0	7′.7		-14°.0	29o Lib
234	6	5.85	6.23	6.42	12′.6	3′.1		-13°.7	2ξ2 Cap
236	n	5.52	6.06	6.33	1′.9	0′.6		-19°.8	12o Cap
326	6	6.00	6.16	6.24	-1′.8	-5′.8		25°.0	67k Psc
484	5	5.99	6.15	6.23	-55′.4	200′.7	h	23°.3	39 Com
491	4	5.92	6.08	6.15	-34′.4	2′.6	h	26°.5	22 Com
524	n	5.93	6.07	6.14	5′.1	0′.6		47°.8	HR6641
896	5	5.84	6.05	6.15	2′.3	1′.7		5°.1	12 Mon
1001	5	4.19	6.47	7.98	-59′.5	8′.4	f	-32°.4	2g Cen
1002	5	4.73	6.23	7.07	-71′.2	16′.4	f	-29°.9	4h Cen
1003	5	4.23	6.02	7.05	-58′.4	3′.8	f	-31°.0	1i Cen
1004	5	4.32	6.13	7.17	-73′.7	19′.6	f	-31°.0	3k Cen

Thus, only 7 stars (less than 1%) of cat D are entirely based upon stars whose $\mu > 6$. In Table 18, I list in columns each star's: catalog number D & catalog magnitude m, its actual pre-extinction magn m; its minimal post-extinction magn μ correctly computed; the same quantity computed (μ_J) according to the over-opaque[95] extinction formula basic to the disastrous J.Evans 1987 attack upon DR published by the jest-folks running the precious *JHA*; the gt-circ equatorial position errors ($\Gamma\alpha$ & $\Delta\delta$); the mark "x" (see §P4); the real 1601.0 δ (rounded to the nearest degree-tenth); & the star's Name.

L10 Even taking Wandsbeck (fn 95) for the Cen stars' observation-site, note that *JHA* extinction still puts the 6 dimmest stars in cat D (HD121481, 29o Lib, 2ξ2 Cap, 12o Cap, 2g Cen, & 4h Cen) low in the sky; by contrast, DR's null-dust extinction model requires no such curious δ-μ correlation. Unless we accept that Tycho's eyes got sharper at low altitudes, this again (as at §L8 & fn 95) confirms the preferability of the latter model, for evaluating older[96] observations.

L11 A fantasy as comment. If the *JHA* were an honest journal, it would acknowledge the unevadable: either [a] the extinction formula with which it hyper-attacked DR is, after all, not appropriate to (pre-polluted-sky)[97] early star catalogs, or [b] the case that Tycho faked the four Cen stars' longitudes (a shocker first announced in *DIO*: see Rawlins 1992T Table 2) is strengthened by the stars' great dimness (demanded by adoption of the *JHA* extinction formula instead of DR's: fn 95). The insuperable problem here is that agreeing to either [a] or [b] would require *JHA* admission that *DIO* contributes to academe. But even such a minimal, undeniable truth has long been verboten in that curious journal, where editorial integrity & impersonal equity still have the same priority they have always had.

[95] If the *JHA*'s formula is right, then Tycho saw to c.8th magnitude. (And Ptolemy to 12th: §L8!) See D1001 in Table 18 & fn 97. (This star's μ is given as 7.95, in Rawlins 1992T §H7 & fn 18 and *DIO 2.3* ‡8 fn 25, because I there adopted 271°K, mean Copenhagen T for Jan, as well as epoch 1591 and latitude 55°.91, following Evans 1987 p.168, to show what a continuation of his table there would have found for Cen.) DR proposed (Rawlins 1992T §C8&§G2) that declinations of the four Cen stars were observed at Wandsbeck, 1598.0. The respective μ would there have been: 5.66, 5.81, 5.46, 5.56. Reasonable values. However, the respective *JHA* μ_J are (again for Wandsbeck): 6.51, 6.38, 6.12, 6.23. [Nonsimplified computing with *JHA* presumed dustload makes it: 6.46, 6.35, 6.08, 6.19.] Thus, even assuming observations from the more southerly site (Wandsbeck), D1001 would be still be the dimmest star in cat D, by the *JHA* formula — and most of the Cen stars' μ_J would still rank in the dimmest 1% of cat D. (If the light of 1ξ1 Cap, 1°/3 distant at m = 6.34, is comb with that of 2ξ2 Cap, then comb m = 5.32 — and all four Cen stars would be in the dimmest 1% of cat D.) Not the case for DR's just-cited μ values. Which again speaks for adopting the null-dust model when analysing pre-industrial star data. See also §L10.

[96] DR has additionally analysed 30 far-southern stars in Hipparchos' catalog: those of Rawlins 1982C Table II (for nonexistent ν Car, read υ Car; error copied by Evans 1987 n.42) plus ι Car (PK887) & minus μ Vel (*DIO 4.3* ‡14). The results uncertainly suggest sparse aerosols on the clearest Rhodos nights, when Hipparchos rush-observed his most southern stars (during their slim daily above-horizon period). [Note: on ordmag 1/10 of clear nights, the nocturnal aerosol boundary layer is lower than hills at Lindos & Cape Prassonesi.] Taking modern standard dustload (Rawlins 1992T fn 18) as unity (& using Rawlins 1982C Table I), DR's formal CapeP sea-level result: 1/3 ± 1/6.

M Discussion of Individual Stars' Errors (& Occasional Oddities)

M1 We will now scrutinize every substantial position-error in cat D. This will be accomplished according to the same order in which the stars appear in cat D (OO 3:344f). All star positions with errors[98] greater than 0°.1 (gt-circ) in either α or δ will be analysed below. These limits are established in equatorial coordinates, in order to avoid the slight ecliptical position errors caused by TB's erroneous obliquity (usually ϵ = 23°31′1/2 — inaccurate by +2′.0, a remarkably large error for a TB fundamental constant: see fn 190). Below, one will note frequent errors in the arcmin tens place of coordinates. I take this to be the result of creditable concentration upon acquiring acc readings in the arcmin units & fractions.

M2 Abbreviations (besides standard IAU[99] 3-letter abbrevs for constellations) & terms adopted in §M (and elsewhere here):

"acc" = accurate(ly) to within c.1′ (gt-circ), limit 1′.5;
"accid" = accident(ly), inadvertent(ly);
α = right ascension;
"arcmin" = arcminutes;
"arg" = argument;
β = celestial latitude;
"C" = prefix of star's cat C number, e.g., "C153" is 153rd star in cat C (fn 2);
"calc" = calculate (calculated, calculating);
"comb" = combined[100] (magnitude of multiple star);
"config" = configuration (refers to angle of two g arcs at quarry star);
"coords" = coordinates;
"corr" = correct (corrected, correction);
"culm" = star's culmination (transit);
"D" = prefix denoting star's cat D number (Table 21), e.g., "D123" is 123rd star in cat D;
"dbld" = doubled or repeated (obs re-taken to check against error);
δ = declination;

[97] To justify applying a modern dust-factor to its formula for atm extinction, the *JHA* echoes Reagan's delightful trees-are-pollution-culprits fantasy: "Industrial pollution and automobile exhaust were not factors in Antiquity, but cooking over wood fires must have been a considerable source of haze." (Evans 1987 p.269. Look it up.) Note also that the *JHA* extinction formula breaks down for low h (where the Cen stars resided); for a normal 1.2 km-scale-hgt dust layer [of the same net 0.2 mags/atm opacity presumed by the *JHA*, the correct respective 1601.03 Hven Cen μ (integrated by DR for hgt = 50 m, with sealevel T = 283°K, P = 1013 mb) would be about: 7.99, 7.02, 7.01, 7.13, not the μ_J found] in the last 4 rows of Table 18. (While the numbers of atmospheres used to figure Rayleigh, ozone, & dust extinction are indeed roughly equal for high h, the problem is that this equality collapses near the horizon: Rawlins 1992T fn 18. Thus, the lower the star, the less applicable Evans' 1-dimensional formula becomes.)

[98] See discussions of Δ & Γ at: fn 185 & fn 103.

[99] I have attempted to assign the IAU constellation to each star, which in cases of contradiction, generally meant preference to Bayer over Flamsteed; e.g., Flamsteed numbers neglected in Table 21: 51 Lib = D203; 54 And = D806; 31 Mon = D958; 2 Crt = D978; 4 Crt = D979; 9 Crt = D982. (See fn 150 & fn 155.)

[100] I have not usually paid close attention to adding in very dim nearby stars' magnitudes unless the uncomb m exceeded 6 (since, at §L, I examine closely the question of whether any such stars were recorded). Thus, I expect that a few star-bunches are listed here with m a little dimmer than they actually appeared to the observer. (However, nearby stars of m = 6-7 will not add seriously to most stars' m.) For the Beehive, see D95 at §M3.

Δ = error or differential (not necess gt-circ: see fn 103 & at Γ below in this glossary);
"diff" = difference, different, or differential;
ϵ = obliquity (fn 190);
"E&E" = equator & ecliptic;
"ecl" = ecliptical;
"eq" = equation;
"eqt" = equatorial;
"err" = error, erroneous;
"esp" = especially;
"exagg" = exaggerate(d);
"flab" = ϕ = csc γ (see γ, below in this glossary), a crude[101] measure of error of pstn calc from two near-parallel g arcs (e.g., D440, D586, D836), which exagg (transversely)[102] errors of g & of ref stars' pstns (flab can also degrade standard δ & g method of §B6, when g too nearly north-south, e.g., D342);
g = gt-circ arc between quarry star & ref star (§§B6&B8);
γ = angle of intersection of two g arcs (see above at "flab" ϕ, also fn 176);
Γ = gt-circ differential or error (novel[103] notation, needed here only for α & λ diffs, since $\Delta\delta$ & $\Delta\beta$ are gt-circ);
"gt-circ" = great-circle, where (for non-gt-circ coords) gt-circ diffs are here denoted by using Γ (see fn 103) rather than the customary Δ;
h = altitude above horizon (at transit unless otherwise specified, in the present work);
"HD" = star's Henry Draper catalog number (primary numbering used by Sky Publ Corp's excellent *SkyCat2000*);
"HP" = Hipparchos-Ptolemy, i.e., Ptolemy's update-plagiarism of Hipparchos' Ancient Star Catalog: see below at "PK" & at fn 141;
"HR" = Harvard Revised Photometry star# (used by Yale Catalog);
"hybrid" = cat D star pstn inadvertently based upon measures from 2 distinct stars,[104] though believed by Tycho to be same star (e.g., D168, D854);
λ = celestial longitude;
"lineup" = calc ("u" in column x of Table 21) of quarry star pstn (e.g., D345-348) not by rigorous two-g math but merely by putting quarry star's catalog pstn on gt-circ between 2 ref stars (tempting to do this in flab cases);
m = star's magn according to cat D;
m = real pre-extinction magn;
μ = real post-extinction magn (see fn 45 & §L8);
"magn" = magnitude;
"misarg" = misperceived arg of (trig) tables, entering or leaving;
"misargf" = [was] misarg for;
"misinv" = confusion of $x^\circ + y'$ with $(x+1)^\circ - y'$ or (occasionally) $x^\circ - y'$, a common special[105] case of misarg (e.g., D348, D411, D523, D627, D832, S69) or misrd (see D353);
"misinvf" = [was] misinv for;

[101] The length of the g arcs is also obviously a factor in gauging flabbiness. To illustrate by extreme cases: [a] if both g are very short, flabbiness is effectively trivial, while [b] if both g are 90° & γ = 0° or 180°, then all points on the gt-circ locus of pts 90° from both ref-stars will satisfy both g.

[102] Problem similar to explorer attempting longitude-determination strictly via meridian sextant shots. See fn 172, *DIO 2.2*, *Wash Post* 1993/6/1 p.3, *Science 260*:1587 (1993/6/11). In a near-parallel two-g case (where the g are not tiny: fn 101), errors in either g will be exagg (in eventual calc pstn) by ordmag flab ϕ.

[103] Γ (fn 185) is a notation designed to bring long-awaited relief to the needy Historian-of-science, since certain Hist.sci archons are easily bewildered by undergrad math. See, e.g., the disastrous 1992 *JHA* confusion of Δ & Γ. Achievement suitably honored in the *Journal for Hysterical Astronomy* section of *DIO 2.3* (‡8 fn 31), 1992.

[104] List of all cat D hybrids at fn 78. For hybrids, the star listed in our *DIO* edition (Table 21) of cat D is generally the one whose δ corresponds to the cat D pstn. An exception can be: if that star has already been cataloged elsewhere. (See D854.) Specific instances are listed at fn 77 & fn 170.

[105] In trig cases, misinv would figure to be more common with small-angle cosine or large-angle sine.

"misrd" = misread instrument;
"misrdf" = [was] misrd for;
"miswr" = miswrite, miswritten;
"miswrf" = [was] miswr for;
"neg" = negative;
"nms" = no math solution (see §N16);
"obs" = observ(ed,er,ation);
"ordmag" = order-of-magnitude (ordmag agreement = to nearest power of 10);
"OK" = angular error in range $1'1/2$ to $5'$ (gt-circ);
"OO" = TB's *Opera Omnia* (e.g., "OO 11:399" = *Opera Omnia* vol.11 p.399);
"orig" = original;
"perp" = perpendicular(ity);
"PK" = star-number in Peters & Knobel 1915 edition of HP's Ancient Star Catalog;
"pstn" = position (mean E&E of date[106] unless otherwise stated);
"pos" = positive;
"prob" = probable(ly);
"quarry" = star whose pstn is being determined via ref stars;
"r" subscript denotes coord of ref-star;
"real" = modern-calc reconstruction (sign convention here: error = obs-minus-real);
"ref" = reference (as in ref star: §B5);
"refr" = atmospheric refraction;[107]
"resp" = respective(ly);
"restor" = cat D error ("r" in col.x, Table 21) restored here (in this edition) to orig;
"S" = prefix denoting star's number in Tycho's S list (Select stars: Tables 22&23), e.g., "S55" is the 55th star (α Vir or Spica) on the S list;
"SAO" = [star's no. in] *Smithsonian Astrophysical Observatory Star Catalog* 1966;
"screrr" = scribal error;
"screrrf" = [was] screrr for;
"*SkyCat2000*" = *Sky Catalogue 2000.0*, Sky Publ Corp 1991 (highly recommended);
"solst" = solstice or solstitial;
"sph trig" = spherical trigonometry(tric);
"SS" = Summer Solst;
"subseq" = subsequent;
"subtr" = subtract(ed,ing);
"transf" = transformation (rotational) calc of eqt pstn to ecl pstn or vice-versa;
"two-g" = pstn determination, or sph trig calc, based upon two arc measures g (§B8);
"TB" = Tycho Brahe;
"undbld" = not dbld, as best cat D obs regularly were (many late cat D obs undbld);[108]
"vs. " = wrt (usually) ref star cited, from which (usually) g was measured;
"WCP" = wrong choice between pair of solutions resulting from sph trig (§P4 & fn 181);
"wrt" = with respect to.

[106] Effects of aberration, refraction, & nutation are not included in real places provided here unless I explicitly so state, as, e.g., for the g of D370-371&379-380. For multiple stars, I generally list the pstn of the brightest component, though sometimes the mean pstn if the m of a pair are nearly equal. (I have not been systematic about this. See fn 174.) In our full §P edition of cat D, the 1st star in rt asc is listed in the HR column — while, in Table 20, the brightest component is listed in the HR column.

[107] Tycho's refraction table appears at OO 2:287 & OO 3:377. (Note alteration at $h = 19°$. Perhaps an earlier version of the table tailed off to nullity more gradually.) Tycho's 1598 statement seems (Ræder & Strömgrens 1946 p.114) to cast some doubt on the now-common perception that he believed refraction was zero for $h > 20°$. (See Thoren 1990 p.301 n.153.) A question in a different direction: is it coincidental that this, the first extant astronomically-useful refraction table, originated at a high northern latitude? (The much-later long-canonical Pulkovo tables raise the same question.) There are some advantages to making refraction-measurements in the far north — though, not too far: obviously, at the Pole itself, no stellar diurnal variation in refraction could be detected.

[108] Dreyer 1890 p.227 notes that most 1597 stars are undbld. Same true of much of 1596 stars at OO 13:61f.

M3 Zodiacal Star Errors:

D14 (43σ Ari). Acc α, δ, & λ; but (OO 11:384 n.1, 12:231) $-10'$ miscue in β. Restor.

D38 (106 l Tau). Unused OO 11:386 $\beta = 3°30'1/2$ screrrf $2°30'1/2$ (C38 & D38).

D39 (102ι Tau). Acc 1589.0 eqt pstn at OO 11:386, but misconceived transf. Evidently absolute magn of acc[109] calc[110] $\beta = -1°14'39''1/2$ (calc only off by $+2''$) accid added to $\alpha = 69°39'13''$, produced false $\lambda = 70°53'52''$, which is given to unusually overdone precision at OO 11:386. Acc $\beta = -1°14'39''1/2$ then perhaps miswr (losing 2 digits) $\beta = -1°49'1/2$.

D52 (23 Tau). At OO 12:78, acc measures of $g = 22°42'$ & $22°43'$ (vs. Hamal, real $g = 22°41'.4$); but latter value then accid repeated as δ. Ecl place (D052) then acc transf from this false eqt pstn.

D73 (64&65b Gem). Hybrid of acc $g = 40°26'3/4$ for 64b1 Gem (vs. Regulus) and acc $\delta = 28°45'$ (OO 12:233; epoch 1589) of center of pair 64b1 Gem & 65b2 Gem; both raw data at OO 12:76. (Arc g from Aldebaran to mean place of pair explicitly recorded at OO 12:75, $g = 41°34'$, tho never used.) Ecl-to-eqt transf calc acc.

D74 (27ϵ Gem). Orig obs δ (OO 3:412) & α both acc, but $\delta = 25°38'$ misarg by $+1$ in arcmin tens place before transf to ecl catalog. See 1589/1/3 & 2/9 obs (OO 11:348, 350, 390 n.1).

D82 (31ξ Gem). Acc α, δ, & β; but (OO 11:390-391 n.1, 12:234) λ misarg by -1 in arcmin tens place. Restor.

D95 (Praesepe). Beehive. Dreyer (OO 3:347) equates D95 with 41ϵ Cnc[111] = HR3429. This seems superficially reasonable, since HR3429 is the brightest bee in the hive, at m = 6.30. But the $+8'.4$ pstn discrepancy is serious, especially for a star on Tycho's S list (S38): D95 is $8'.4$ to the north of HR3429. However, $8'$ to the north of HR3429, there is a pair only $1'$ apart, HR3428 & HD73709, with a brighter comb $m = 6.44 + 7.70 = 6.14$. (Hevelius' position for Praesepe is also near HR3428 — indeed, his β agreed with D95's to ordmag $1'$. See Rybka 1984 p.64.) Tossing in $5'$ distant HD73785 ($m = 6.85$), we have total comb magn $m = 5.69$. Tho entire hive's comb magn $m < 5$, I will (in our tables) use the triplet's comb magn (5.69), and will use the pstn of HR3428. This is by far the dimmest star on the S list (marked "nebulous") — yet its pstn's accuracy is better than most S stars'.

D98 (43γ Cnc). C93 & D98 $\beta = 3°08'$ screrrf 1589.0 $\beta = 3°09'$ (OO 11:392), restor. However, another possible explanation: TB simply averaged his 1586.0 Exceptional-star list β ($3°07'$, OO 2:233) with the 1589.0 value ($3°09'$) for D98's $\beta = 3°08'$. The latter theory is lent credence by its success in also explaining D222's β (see below). Due to their shaky pasts, D98 & D222 have been marked "r" and dropped from the larger samples here, tho both are retained In §H&§J since we are there probing for the effects of just such shakiness.

D99 (47δ Cnc). Unused OO 11:392 (n.1) β "South" screrrf corr "North".

D125 (46 Leo). Obs (OO 11:355-356) & calc entirely acc,[112] except: acc calc $\alpha - \alpha_r = 43°24'-$ subtracted from α_r of δ Vir, not α Vir, causing hitherto unexplained (OO 11:394 n.1) gross $-7°1/6$ error in α. (Similar slip likely at D368-9 & D377-8.)

D137 (6h Leo). Slightly err α calc from acc g (OO 12:74) & δ (OO 12:395).

D138 (2ω Leo). Acc α but 1589.0 $\delta = 10°40'$ (OO 12:395) screrrf $10°50'$ (real $10°47'$).

D143 (41 LMi). Acc eqt pstn (OO 13:64), but then $+4°$ error intruded: $\delta = 29°18'$ misargf[113] $25°18'$ in transf-calc of ecl pstn. (Rybka 1st to know D143 = 41 LMi: fn 38.)

D157 (44k Vir). From β Lib, two discordant g records, acc $34°35'1/2$ (OO 11:359 & 396 n.1) 1589/3/14 & inacc $34°42'1/8$ (OO 12:177) 1591/1/23. (Actual 1591.1 $g = 34°33'$.) Acc calcs of α would yield (using β Lib coords of OO 11:399), resp (1589.0): $\alpha = 189°37'$ & $189°29'1/4$. OO 11:396 records two α: $189°26'$ & $189°30'$. Observed $\delta = -1°30'$

[109] Contra slightly erroneous calc ecl pstn at OO 3:412 & OO 11:386 n.2.

[110] From $\alpha = 69°39'13''$, $\delta = 20°56'1/3$, & $\epsilon = 23°31'$.

[111] Was Bayer's ϵ Cnc = 41 Cnc (HR3429) or D95 (HR3428 + HD73709)?

[112] OO 12:74 g vs. β Gem (1590/1/5) evidently not used.

[113] See §N15 for similar confusion.

(OO 11:396 & OO 12:177). For ecl pstn's acc transf-calc, this & $\alpha = 189°30'$ (OO 11:396 & OO 12:237) evidently used. Each's accuracy beneath TB's standards.

D164 (79ζ Vir). OO 11:358-359 (1589/3/11,14,&15) acc δ; acc g vs. β Leo & g vs. β Lib. Acc δ & OK α in first 1589.0 catalog (at OO 11:397); but, in transf, $\alpha = 198°23'2/3$ misarg by $+1$ in arcmin tens place, thus resultant ecl coords imperfect. Later (see OO 3:412), otherwise-OK re-calc of α used g (vs. β Leo) with $-1°$ misarg in g, producing α off by $-1°1/3$. Final cat D ecl coords then acc transf from these defective eqt coords. (See OO 12:239.)

D168 (95 Vir & HD121481). Hybrid, unsuccessful attempt to place HP's Vir #20. Acc 95 Vir $\delta = -7°19'$ recorded 1591/1/23 at OO 12:177 (real 1591.1 $\delta = -7°19'.3$), precessed for 1589.0 to $-7°18'$ (OO 11:398 & OO 12:237). (Real 95 Vir 1589.0 coords: $\alpha = 206°16'$ & $\delta = -7°18'.7$.) Yet, for determination of α, both recorded 1591.1 g are not of 95 Vir but are instead acc g of nearby dim star HD121481, whose real 1591.1 coords were: $\alpha = 203°34'.0$ & $\delta = -7°31'.1$. At OO 12:175, from β Vir, $g = 33°14'1/2$ (real 1591.1 $g = 33°14'.1$). At OO 12:177, from β Lib, $g = 20°00'1/2$ (real 1591.1 $g = 20°02'.0$). The former g was used with 95 Vir's $\delta = -7°18'$ for OK subseq calcs of α & then transf-calc of ecl coords appearing as D168. Three further oddities: [a] On 1590/3/31 (OO 12:76), $g = 21°55'1/6$ was measured from β Lib, and the star was "believed to be" HP's Vir #20 (see OO 12:76 n.1). (Datum not used.) This is actually an acc g of 90p Vir (D176 = HP's Vir #27), whose real 1590.3 g from β Lib was $21°55'.9$. [b] At OO 12:237, 1589.0 $\alpha = 203°37'$ of OO 11:398 is rendered as $206°37'$. This alteration may be screrr, but it chances to place the OO 12:237 eqt pstn close to (merely $18'$ east of) 95 Vir. Regardless, the pre-altered eqt pstn was input for transf-calc of disastrous final ecl pstn. [c] HD121481's pre-extinction magn $m = 6.8$, which is far dimmer than anything else in cat D. Yet both (astonishingly precise) g agreements with reality are proof that the star was seen. The answer to this seeming paradox appears to lie with two nearby stars,[114] HD121496 ($m = 6.85$) & HD121444 (m = 7.6). Trio's comb magnitude $m = 5.83$. Since HD121481 & HD121496 were then precisely as separated as Mizar & Alcor now are ($11'.8$), one may question how well the stars' light merged for the observer, but there is no other normal explanation for the strikingly acc two-g observation of such a dim star. (Tho not listed in the Harvard Revised or Yale catalogs, the star appeared in the 1959 edition of A.Norton's *Star Atlas*, for which its current tabular m is far too dim. By the 1989 edition, it had vanished from Norton.)

D187 (61 Vir). Error of 1 in δ arcmin tens place produced $\delta = -16°12'1/2$ at OO 13:70. Actual 1596.0 $\delta = -16°02'.4$.

D190 (7μ Lib). Error of $-12'$ in δ (OO 11:399); 1590/2/5 (OO 12:75) OK g vs. Spica, not used.

D193 (21ν Lib). Acc α & OK δ; OK β calc therefrom (OO 11:400), λ off by $-46'$ in calc, possibly from entering cos table at $9°14'$ instead of $1°14'$ when using eq. 4 to find λ.

D194 (29o Lib). For comb $m = 5.8$, see §L3.

D200 (45λ Lib). Acc α (from 29γ Vir = D156 & 13ζ Oph = D700, via eqt armillary) & acc δ & acc calc β at OO 13:75 (epoch 1596.0); but $\lambda = 234°59'$ screrrf acc calc $234°49'$: $+10'$ error, restor.

D210 (5ρ Sco). Prob error in tens place of $\alpha - \alpha_r$ during α determination.

D215 (23τ Sco). Acc eqt pstn (OO 11:401, 12:76), but $\delta = -27°14'$ misarg as $-27°04'$ for transf-calc of ecl pstn.

D216 (13c2 Sco). Undbld α determination (via 58η Ser = D724) off by $+5'$. See OO 11:401.

D219 (34σ Sgr). Eqt pstn OK at OO 11:401, but $\delta = -26°41'1/2$ misarg as $-26°51'1/2$ in transf-calc of ecl pstn.

[114] The pstns & magns of HD121444, HD121481, & HD121496 are taken from pp.375-376 of the 1991 ed. of *SkyCat2000*, by A.Hirshfeld, R.Sinnott, & F.Ochsenbein; this relatively recent publication of the semi-popular Sky Publishing Corporation is, it should be emphasized, generally much superior in accuracy to the famous *Bright Star Catalogue* issued for decades by Yale University. (See fn 87.)

D222 (39o Sgr). C193 & D222 $\beta = 0°59'$ screrrf $0°58'$ (OO 12:402), restor. But this may well be a case similar to D98 (see above). Both stars are on the small Exceptional star list (OO 2:233), and both's β can be explained as averages of the β of that list (1586.0) and the 1589.0 catalog (OO 11:383f). In this case: averaging $0°58'22''$ (precise transf-calc of eqt coords at OO 11:402) and $0°59'$ (OO 2:233) yields $0°59'$, which is D222's β.

D224 (43d Sgr & HR7249). Hybrid. Acc g twice (OO 11:402) of 43d Sgr ($m = 4.96$) for α. From 49δ Cap (D254), $g = 35°37'$ (OO 12:77), & real $g = 35°38'$. From 64ν Oph (D697), $g = 21°04'$ (OO 12:78), while real $g = 21°07'$. But acc $\delta = -19°50'$ (OO 11:402) was of nearby HR7249 instead ($m = 5.54$). Real 1589.0 δ: $-19°34'.8$ (43d Sgr) & $-19°50'.8$ (HR7249).

D230 (52h2&51 Sgr). Acc 52h2 Sgr g (vs. 49δ Cap = D254) & δ at OO 12:402. But 00 12:78 $g = 9°37'1/2$ (vs. 9ξ2 Sgr = D221) is for mean pstn of 51&52 Sgr (real mean $g = 9°37'.6$); & $+24'$ calc error produces poor α (error $+22'$) from latter g. Averaged with acc prior value to produce mean α, in error by $+10'$ ($9'$ gt-circ).

D232 (8ν Cap). Obs $\delta = -13°45'1/4$ (OO 11:403) affected by $+3'$ refr (unaccounted for, since TB did not apply refraction when $h > 20°$) & $+10'$ recording error. Real 1589.0 $\delta = -13°59'$.

D234 (2ξ2 Cap). See OO 12:403 n.3; α error $+1°/4$, largely from poor g obs vs. δ Cap (OO 12:79), error $-10'$. OO 12:77 OK g vs. ν Oph (D697) unused.

D235 (10π Cap). OO 12:77 δ misrd by $-10'$. OO 11:403 α from 64ν Oph (D697) OK, while α from β Cap off by $-1°/3$; crude adopted mean α off by $-10'$. (Note: HP's Cap star-numbering accid reversed by TB for D235&D236.)

D238 (7σ Cap). OO 11:403 g (vs. 64ν Oph) & δ acc, but OO 12:79 g vs. δ Cap is off by $-14'$ (star rated "nebulous"), main cause of mean α error $+8'$. OO 11:403 δ OK, but calc slip causes $-6'$ error in β.

D242 (18ω Cap). OO 11:404 δ off $-7'$, tho acc orig at OO 12:77 (1590/8/15, screrr as 1589 at OO 11:404 n.2): $\delta = -28°22'1/4$ (real $\delta = -28°23'1/4$). OO 12:77 g vs. π Sgr off $-13'$, & α off same. OO 12:79 g vs. δ Aqr off $-4'$, & α off $+7'$. (Note: this is one of the lowest stars in cat D.)

D243 (24A Cap). OO 12:77 δ OK; but OO 11:404 altered, so error = $-6'$. (For both D242&D243, it may be that refr-corr was unwittingly applied twice.)

D247 (25χ Cap). OO 12:404 δ OK. But α via β Cap off $-23'$; averaging with a later OK α (via δ Aqr) gave adopted α, off (as noted OO 11:404 n.4) by $-13'$ ($-12'$ gt-circ).

D248 (22η Cap). OO 11:404 δ OK, but both of two α hit within $1'$ of adopted $\alpha = 310°22'$, which is $+9'$ off. OO 12:79 g (vs. 76δ Aqr = D275) is off just $-3'$. Agreement strange. (Precessed twice?)

D251 (39ϵ Cap). As realized at OO 11:404 n.5, TB's eqt coords are acc, but calc (from them) of ecl coords err, esp in α.

D255 (48λ & 42d Cap). Hybrid. OO 11:405 $\delta = -13°13'$ acc for 48λ Cap (Dreyer's identification): real 1589.0 $\delta = -13°12'.8$. But 1590/10/7 (OO 12:79) $g = 20°23'1/2$ (vs. α Cap) acc instead for 42d Cap. (Real 1590.8 $g = 20°23'$ for 42d Cap; $21°40'$ for 48λ Cap.) All subseq calcs OK. Note: 42d Cap is HP's Cap #25 (TB's intended), while 48λ Cap is HP's Cap #27 (which TB confused with 51μ Cap: see below at D257).

D256 (57μ Cap). Simply D257 with δ diff by $1'$ (misrd by $-10'$, as noted OO 11:405 n.2)[115] & α miscalc twice from g vs. α Cap: 1589/10/30 (OO 11:363) $g = 23°15'1/8$ & 1590/10/7 (OO 12:79) $g = 23°09'1/2$. (Real $g = 23°11'$ then.) Common error perhaps due to accid use (in eq. 6) of β Cap's $\delta_{\rm r} = -15°58'1/4$ instead of α Cap's $\delta_{\rm r} = -13°42'$ (both 1589.0 data at OO 11:403) in both calcs of $\alpha - \alpha_{\rm r}$. (Nonetheless, agreement of two calcs to $30''$ curious, since founding g disagree by nearly $0°.1$: see above. Maybe accid used earlier g for both calcs of $\alpha - \alpha_{\rm r}$ & possibly in 2nd calc accid used β Cap's $\delta_{\rm r}$ for both ref & quarry stars' δ.)

[115] OO 11:363 δ recorded at about $-15°32'$ (1589/10/30); corr for $1'1/4$ TB refr & $1^{\rm y}$ precession gave $\delta = -15°34'$ (OO 11:405).

D257 (57μ Cap). OK λ, but β misarg by $+1°/2$. (Rejected OO 11:363 $\delta = -17°12'1/2$ prob D255 repeat with $-4°$ screrr. These 1589/10/30 records consecutive & both labelled "nebulous" in orig record, tho not in cat D's magn column.)

D277 (68 & 66g1 Aqr). Hybrid. OO 12:79 g OK of 68 Aqr (vs. ι Cet), not used in calc; OO 12:80 acc g of 66g1 Aqr (D279) vs. δ Cap input instead. OO 12:79 δ OK of 68 Aqr (h screrr by $-1°/2$, not used); but misarg by $+1°$ in transf-calc of ecl pstn.

D279 (66g1 Aqr). OO 12:79 g OK (vs. ι Cet), used for calc; OO 12:80 g acc vs. δ Cap, but misassigned to D277 (see above). OK δ at OO 12:79 & 241; α misarg by $+10'$ for transf-calc of ecl pstn. Note: at OO 12:79, g for D277-279 all said to be vs. β Cet, tho ref star actually ι Cet.

D282 (83h Aqr). OO 12:79 $\delta = -9°54'3/8$ acc 1590/10/8; but, in transf-calc of ecl pstn, TB instead adopted (OO 11:407 n.3, OO 12:242) 1589/11/20 $\delta = -9°35'$ (OO 11:367), misarg by $+20'$.

D291 (i Aqr). Hybrid; α OK for 107i2 Aqr, δ OK for 106i1 Aqr. (See OO 12:242.)

D298 (86c1 Aqr). OO 11:367 (later refr-corr) & 409 n.1 (also OO 12:242) 1589/11/16 $\delta = -25°07'$ screrrf acc $-25°57'$. Vs. δ Cap, OO 11:366 $g = 20°11'1/8$ OK 1589/11/1. (Real $g = 20°13'$.) OK calc $\alpha - \alpha_{\rm r} = 20°1/4$, added to δ Cap's 1589.0 $\alpha_{\rm r} = 321°1/6$ (OO 12:240) yields $\alpha = 341°1/3$, the false result recorded (OO 11:409 & OO 12:242). (Error $+50'$ in δ threw calc of α off by $+18'$.) Though $\alpha - \alpha_{\rm r}$ (OK) calc repeated after δ refr-corr (OO 11:409), OO 11:366 OK $g = 23°20'$ vs. β Cet unused (or silently rejected due to irreconcilable α produced).

D304 (17ι Psc). OO 11:409 (n.2) & 12:243 α or λ off by $+1$ in arcmin tens place.

D312 (86ζ Psc). OO 12:410 eqt pstn OK, but α misarg by $+2°$ in calc of β.

D329 (79ψ2 Psc). OO 11:411 & 12:243 δ prob screrr by -1 in arcmin tens place.

D334 (91 l Psc). OO 12:244 δ off $-7'.6$; obs prob screrr by $-10'$, as for D329.

M4 Northern Star Errors:

D340 (21η UMi). OO 12:166 g vs. α Per acc, g vs. γ Dra off $-5'$. Non-perp of these g exagg error, thus $\Gamma\alpha = -8'$.

D341 (7β UMi). Neither eqt coord error exceeds $0°.1$, but both too large for star sometimes used as ref star (even if not on S list). See below at D585-587 & fn 179.

D342 (13γ UMi). OO 12:81-8 δ obs acc. OO 12:166 g vs. γ Dra OK, but used instead (for calc of α) acc g vs. α Per (D621). (OO 12:166 screrr as g of β UMi.) This g too nearly north-south, so tiny errors exagg (flab situation): α off +12' (gt-circ). Acc calc from eqt coords (OO 12:244), but λ screrr by $-1°$, restor.

D343 (5 UMi). OO 13:76 g (vs. α UMa) off $+8'.4$, causing similar $\Gamma\alpha$.

D345-355. From Final Fifty. See Table 20 (which lists all g data). The pstns of D345-348 (all Cam) are mere lineup calcs (based on 1597.1 data of OO 13:98), using the g from α UMi in all cases. D347 is (as Dreyer was first to realize, OO 13:98 n.6) 9α Cam. Its g vs. α UMi was acc — but screrr by $+3°$. The g vs. α Aur was OK. D348 (intended to be HR1527, which in fact was not observed, evidently due to imperfect visibility) is actually just based (since lineup calc needs but a single g) upon one OK g (vs. α UMi). It's the same star (HR0985) later observed (OO 13:99) as D644, and whose coords are listed on same page (OO 13:98) as D348's g data. Calcs from lineup hypothesis & obs g fit all 4 cat D pstns (D345-348) to a precision of about $1'$. (For D348, $g = 23°18'$ misinvf obs $23°42'$.) The cat D pstns for these 4 stars fit best with use of $\beta_{\rm r} = 66°05'$ (not cat D's value) for α UMi — which is more consistent with acc obliquity[116] ϵ, than with Tycho's ϵ ($2'$ high). D349-355 are entirely two-g cases, based upon mixed-acc g data for semi-flab configs. Further discussions of a few individual stars of this set follow.

[116] Also more consistent with the pre-Tycho standard obliquity of $23°28'$ (used by, e.g., Copernicus 1543 2.2f). See Thoren 1990 p.226.

D345 (11-12 Cam). Identical to D600 (Tables 20 & 21): lineup calc. See §B8-§B9, fn 77, fn 133, §N11, §N16, fn 174, fn 191.

D350 (HR4646). OO 13:100 two-g: both g poorly observed; $g = 29^\circ 36'$ vs. η UMa (real 1597.2 $g = 29^\circ 43'$), but taken to be $39^\circ 36'$ in two-g calc ($+10^\circ$ misarg).

D351 (HR285). OO 13:100 two-g: obs $g = 42^\circ 13'$ vs. α Aur & obs $g = 44^\circ 21'$ vs. η UMa; both OK. But for two-g calc, former g taken as from α Per, latter was accid taken as $g = 39^\circ 36'$, which was the η UMa-based g not of D351 but that already used for D350.

D353 (HR8702). OO 13:100 $g = 44^\circ 46'$ (vs. α Aur, 1597.2) may be misinv of acc $g = 45^\circ 14'$ — or just a confusion of g with its complement. After two-g calc of pstn, resulting $\lambda = 67^\circ 22'$ & $\beta = 67^\circ 43'$ were reversed — just possibly after glance at sky and-or observer's diagram (OO 13:100) revealed mixed-up pstn to be more acc than orig calc pstn!

D356 (1o UMa). Evidently two-g-based pstn (no eqt coords at OO 12:245): g from α Aur & from η UMa, with resp g errors $+5'$ & $-4'$. Flab: δ off $-10'$.

D358 (3π1 & 2A UMa). Hybrid. OO 12:174 g of 3π1 UMa vs. α Umi, & OO 12:172 g of 2A UMa vs. α Aur; both acc. But of diff stars.

D361 (24d UMa). OO 12:174 g vs. α UMi & vs. α Gem. Both OK except both screrr by -1° & input thus for transf-calc of ecl pstn.

D362 (16c UMa). OO 12:172 g vs. α Aur (acc) & η UMa (OK). But flab: δ off $-17'$.

D363 (23h UMa). OO 12:172 OK $\delta = 64^\circ 47' 3/4$, OK $g = 38^\circ 36' 5/8$ vs. α Aur, & acc $g = 36^\circ 22' 1/3$ vs. η UMa. First two data used for pstn, but either [a] with g screrr as about $36^\circ 31'$, or [b] with g of 14τ UMa (D364) vs. η UMa confused with (proximate) g of 23h UMa (D363) vs. α Aur. Causes most of $-7'$ α error (gt-circ).

D364 (14τ & 5 UMa). Hybrid. OO 12:172 entirely accurate 14τ UMa δ and g vs. both α Aur & η UMa. But both these g ignored; g of 5 UMa vs. η UMa instead used as if g vs. α Aur.

D367 (25θ UMa). For all 3 stars D367-9, δ acc or OK. But α low by c.$1^\circ 3/4$ (non-gt-circ): $-106'.7$, $-109'.7$, & $-97'.5$, resp. Common error evidently due to $-1^\circ 3/4$ slip in α of ref star g measured from. Presumably ζ Leo (not far distant, & listed as Select star at OO 3:375, immediately next to Regulus) was used for g & its δ for calc; but $\alpha - \alpha_{\rm r}$ then added to Regulus' $\alpha_{\rm r}$, which differed (1589.0) from ζ Leo's α by $-109'$ ($-107'$ on OO 12:235). (Similar mixup at D125, and likely at D368-9 & D377-8.)

D368 (9ι UMa). See D367.

D369 (12κ UMa). See D367; evidently additional $+1$ error in α arcmin tens place.

D370-371 (15f UMa & 18e UMa) & D379-380. These four are the only pre-1597/3/15 cat D stars for which DR found no data[117] in OO. Indeed, there are no pstn data for these stars even in the epoch 1589.0 catalog appended to Tycho's 1592 obs. (See OO 12:245.) They appear in posthumous cat C, at OO 2:267, as stars C328-329 & C337-338. (It would require a search of the orig mss of his long-evolving *Progymnasmata* to determine when these four stars were entered.) All four cat D places have error vectors of roughly the same direction & (for 3 of 4) the same size; since these relate to the odd error of α Per, we can reconstruct all eight of the observations on which these four cat D pstns are founded. The four errors are consistent with two-g placement via arcs g measured vs. ref stars α Per & α CMa. The eight reconstructed obs[118] arcs g follow, expressed to the nearest quarter-arcmin. From α Per: $51^\circ 04' 1/2$ (D370),[119] $50^\circ 45'$ (D371), $80^\circ 51' 1/2$ (D379), $82^\circ 03'$ (D380). From α CMa: $74^\circ 59' 1/4$ (D370), $77^\circ 34'$ (D371), $81^\circ 50' 3/4$ (D379), $81^\circ 10' 3/4$ (D380). For the four stars (with D370 restor: fn 119), the close agreement of real[120] g

[117] The orig data could be among those missing from c.1596.0, remarked at OO 13:59 n.1 & 61 n.2. I suppose that the four stars were obs sometime between then & TB's 1597.2 departure from Hven. But the analyses that follow are pretty epoch-insensitive, since they are based largely upon g data, whose secular variation is entirely due to stellar proper motion — a minor factor in ordmag a decade.

[118] The reconstructions assume TB's two-g math acc.

[119] This g miswrf $51^\circ 14' 1/2$.

[120] I use 1597/1/1 local Hven midnight, when h of α Per & the four UMa stars all exceed 45°, and α CMa's h is

(real four stars vs. real α Per) and reconstructed g (cat D pstns vs. highly erroneous D621) is gratifying: the mean (O−C) discrepancy is $+1'.1 \pm 0'.7$. (To understand how neatly indicative this confirmation is, note[121] that D621 = α Per has the 2nd largest gt-circ ecl[122] error of any of TB's 100 Select stars: $13'$. The finding here, that our four UMa quarry stars' errors mimic[123] α Per's peculiar cat D error, suggested the connection to α Per.) For the four g vs. α CMa (whose δ error is $+3'$): there is an admirably consistent systematic mean discrepancy (O−C) of $+1'.7 \pm 0'.1$. Thus, the two discrepancies (mean error of four α Per g & mean error of four α CMa g) are both slightly positive (between $+1'$ & $+2'$) and are statistically compatible. Note: six of eight g are greater than 60°; thus, these data were observed (not with a sextant, as usual, but) with an instrument whose arc was larger than a sixth of a circle, presumably Tycho's nonazimuthal semicirculus.[124] Use of nonstandard (seldom-used) instrument may be the cause of the data's misfiling.

D377 (34μ UMa). Similar to D367-9: acc δ, but α off $-44'$ (not gt-circ). Perhaps $\alpha - \alpha_{\rm r}$ calc from g (vs. ζ UMa) & δ but then added to Spica's $\alpha_{\rm r}$ (adjacent OO 3:376), which differs (1589.0) by $-53'$ ($-50'$ at OO 12:237 & 245) from ζ UMa's $\alpha_{\rm r}$.

D378 (52ψ UMa). Acc δ, but α off $-52'.1$. Presumably same process as D377.

D379-380 (54ν UMa & 53ξ UMa). See above at D370-1.

D384 (12α CVn). OO 12:226 acc δ and g vs. α Leo & α Boo. Last unused. OO 12:245 acc α and OK (unprecessed) δ; β OK, but λ miscalc.

D392 (21 LMi). OO 13:73 acc g vs. α UMa, but g vs. η UMa off $+46'$; subseq two-g calc OK.

D394 (30 LMi). OO 13:73 OK g vs. α UMa & η UMa; errors $-1'.5$ & $-2'.9$, resp. Two-g miscalc by just $+10'$ in λ, but $-164'$ (perhaps partly from 3° misarg) in β. (Precise 1601.03 two-g calc would yield: $\lambda = 139^\circ 47'$, $\beta = 22^\circ 15'$.)

D396 (42 LMi). OO 13:73 acc g vs. α UMa & OK g vs. η UMa; errors $+0'.4$ & $+2'.3$, resp. Two-g miscalc by $+50'$ in λ, $-19'$ in β. (Precise 1601.03 two-g calc would yield: $\lambda = 145^\circ 19'$, $\beta = 21^\circ 03'$.)

D399-D410. From Final Fifty. See §N, Table 20 (which provides all g data). All calcs two-g & WCP. Extreme confusion as to ref stars used for obs *and* for calc: see §N20. (Also, calc of D408 used misinv g: fn 180.)

D411 (26 UMa). See §N4.

D416 (33γ Dra). Error $+2'.9$ in δ, not exceeding $0^\circ.1$, but nonetheless curiously overlarge for ref star. Cause: finding $\delta = 51^\circ 37'$ (OO 3:377, OO 12:246) from non-refr-corr lower culm, e.g., OO 11:300-301, OO 12:84-85, 164-165. (Note -1 error in arcmin tens place at OO 12:84.) In TB's day, actual $\delta = 51^\circ 34'$.

not far from its culmination value. I here include effects of aberration & refraction. (Nutation is too epoch-dependent to be assigned, and it has no effect upon g anyway — beyond a supertrifling influence upon refraction.) On this basis, real g were as follows. For α Per: $51^\circ 13'.7$ (15 UMa = D370), $50^\circ 46'.6$ (18 UMa = D371), $80^\circ 48'.1$ (54 UMa = D379), $82^\circ 01'.0$ (53 UMa = D380). For α CMa: $74^\circ 57'.5$ (15 UMa = D370), $77^\circ 32'.4$ (18 UMa = D371), $81^\circ 49'.0$ (54 UMa = D379), $81^\circ 09'.0$ (53 UMa = D380). (Again: these DR-calc g are not very sensitive to assumed epoch.)

[121] See below at fn 136.

[122] The eqt pstn for α Per is acc. (See §I7, & see contrasts at D621 in §M4.) Thus, we have independent confirmation that two-g sph trig underlies the cat D pstns of the four stars D370-371&379-380, since the standard δ & g method operates with ref star's eqt coords — which, for α Per, would not carry the large $0^\circ.2$ error (of D621) that here solved the mystery of our four quarry stars' $0^\circ.2$ pstn-errors.

[123] Not that there are no alternate explanations. E.g., it is possible that the four stars were observed & placed in the usual δ & g fashion, the latter vs. α CMi, and the former affected by $+10'$ systematic error (as that found, e.g., for 1591/11/11 obs of several UMa stars, OO 12:173). Obviously, such a δ error is rather *ad hoc*, and the ultimate fit is less neat than that here primarily proposed — but the δ & g scenario cannot be utterly ruled out.

[124] Ræder & Strömgrens 1946 p.96 (not pp.40-43). A universal mounting would be required for these obs. The size of most of the eight reconstructed g superficially suggest use of a quadrant. Comments: [a] The quarry stars would probably be taken at high altitudes. (At least 60°; D370-371 likely near zenith.) So, since ref stars' h were seldom low, g could hardly much exceed 90° (and, in these 4 cases, fell short of even that). [b] I do not believe that TB ever possessed a quadrant universally mounted. But his infrequently-used semicirculus was. It was constructed c.1588 (Thoren 1990 p.177), indicating that the four stars' g data were probably not observed before that date.

D428 (31ψ1 Dra). Two-g. OO 12:167 acc $g = 34°19'$ vs. η UMa, & OO 12:168 acc $g = 18°19'1/3$ vs. α UMi. But latter misarg by $-1°$ in two-g calc, causing effectively $-1°$ error in δ. Calc acc. Indeed, acc modern two-g calc yields $\lambda = 96°35'$ & $\beta = 83°06'$, very close to listed D428 pstn. (If g_b restor to $18°19'1/3$, acc two-g calc yields $\lambda = 97°42'$ & $\beta = 84°06'$. Real coords: $\lambda = 98°01'$ & $\beta = 84°07'$, so potential placement acc = ordmag $1'$.) Note: OO 13:98 acc but unused $g = 32°40'$ vs. ϵ UMa. See Table 20.

D429 (44χ Dra). Screrr λ by $+20°$, restor.

D436 (14η Dra). OO 12:102 OK δ, OO 12:166 acc g vs. η UMa; calc OK except δ misarg by $+10'$.

D437 (13θ Dra). OO 12:101 OK δ, OO 12:168 acc g (vs. γ Dra) except -1 error in arcmin tens place; δ misarg by $-1°/2$ in calc. Two errors virtually cancel effects on α, which ends up OK.

D440 (11α Dra). OO 12:170 acc g vs. α UMi & η UMa; but very flab (also wrt acc OO11:382 lower transit), so ordmag $1'$ errors explode into error $\Gamma\alpha = +1°/3$.

D441 (5κ Dra). OO 12:170 acc g vs. α UMi & η UMa; but flab, so ordmag $1'$ errors trigger error $\Gamma\alpha = -1°/6$.

D448-D454 are entirely two-g cases (in Cep). Individual comments follow.

D448 (23ϵ Cep). OO 13:63 OK g vs. β Cep off $-4'.7$; acc g vs. γ Cas misarg with -1 slip in arcmin tens place. Combined effect of both errors pulls pstn $+12'$ off in λ.

D449 (27δ Cep). OO 13:63 acc g vs. α UMi, thus acc δ. But OK g vs. β Cas screrr by $-1°$ (error $-61'.6$); thus, $+64'$ gt-circ error in α.

D450 (3η Cep). OO 13:63 acc g vs. γ Cas; OK g vs. β UMi, but latter's $0°.1$ error is prime cause of $+0°.1$ error in δ. All calcs acc.

D451 (2θ Cep). OO 13:63 acc g vs. γ Cas; OK g vs. β UMi, but latter's $0°.1$ error is prime cause of $+7'$ error in δ. All calcs acc. (Virtual repeat of D450.)

D454 (35γ Cep). OO 13:63 acc g vs. β Cas & β UMi, OK g vs. α Cep. But first g screrr by -1 in arcmin tens place (and last g not used); thus, $-7'.5$ error in δ. All calcs acc.

D460 (42β Boo). OO 12:171 δ acc & several g acc or OK. OO 12:247 1589.0 eqt pstn OK, but implicit cat D 1601.0 α poor.

D464 (25ρ Boo). OO 12:167 OK δ, acc g vs. β Leo, but latter misarg by $+1$ in arcmin tens place for transf-calc of ecl pstn, causing similar $\Gamma\alpha$.

D481-482. Members of Final Fifty. See §N, Table 20.

D484 (36&39 Com). Hybrid. OO 12:228 36 Com $g = 37°41'1/3$ vs. γ Leo 1592/3/7 (real 1592.2 $g = 37°41'.4$); 39 Com $g = 34°12'1/4$ vs. α CrB 1592/3/21 (real 1592.2 $g = 34°12'.3$). Inadequate two-g sph trig calc (entirely ecl). Acc two-g calc: $\lambda = 177°48'$, $\beta = 29°11'$. (The cat D pstn is nearly $5'$ further from each ref star than the OO 12:228 recorded values for g.) Even if all obs & math acc, flab would vitiate outcome, esp in δ (where D484's errors are indeed much worse than in α). The implicit eqt errors of D484 wrt 36 Com (Table 21): $+52'$ ($\Gamma\alpha$) & $+425'$ ($\Delta\delta$); wrt 39 Com (Table 18): $-55'$ ($\Gamma\alpha$) & $+201'$ (δ). However, while criticizing the failures connected to D484, one must note the astonishing successes: recording the g arcs of two (moving) dim stars — one of them 6$^{\text{th}}$ magnitude! — down to a fraction of an arcmin in both cases, lasting testimony to the skill & dedication to correctness of the Tycho school at Hven.

D486 (16 Com). OO 12:227 δ either screrr by $+2$ in arcmin tens place or result of confused differential result vs. 14 Com. (Record shows 14&16 Com were being observed together & comparatively.) OK g vs. γ Leo. All calcs OK. Errors: $\Gamma\alpha = -6'$ & $\Delta\delta = +18'$.

D487 (17 Com). OO 12:227 δ screrr by -1 in arcmin tens place, then misarg by $+1°$ in transf-calc of ecl pstn; $g = 30°09'7/8$ vs. γ Leo. (Real 1592.2 $g = 30°15'.8$. So error = $-6'$.) All calcs OK. Eqt errors: $\Gamma\alpha = -11'$ & $\Delta\alpha = +48'$.

D491 (21-22 Com). Hybrid. OO 12:228 g vs. γ Leo acc of Com 21, while δ is OK of Com 22; latter's $m = 6.29$, but within $10'$ is HD109282 (SAO 82377), $m = 7.26$ (*SkyCat2000* 1991 p.348), so comb $m = 5.92$.

D493 (23k Com). OO 12:228 δ 1592.2 error $-5'.3$, but $+1'.1$ precession-corr ignored when entered into 1589.0 catalog at OO 12:265; thus, net D493 δ error = $-6'.4$.

D494 (43β Com). OO 12:228 (1592.2) α acc & δ OK. But precession again ignored (OO 12:228 δ same as 1589.0 δ at 12:265); λ OK, but large calc error left net $+18'$ error in β. OO 12:265 $\beta = 32°46'$ tho acc calc $\beta = 32°25'$.

D495 (41 Com). OO 12:265 α at least OK, but OO 12:228 δ off by $-7'$, an unusually high obs error for TB. Note: [a] 41 Com is just west of 43β Com, & [b] the next cat D star (D496) is 31 Com. It is possible that the δ of the latter's just-west neighbor, 30 Com ($m = 5$), was observed (instead of 41 Com). In that case, the 1592.2 discrepancy in $\delta = -4'$, size more credible (for TB obs error).

D499 (4θ CrB). OO 12:95 δ acc 1590/10/7, but g vs. α Her off $+1$ in arcmin tens place. This slip & calc error result in α off by about $-1°/2$.

D500 (9π CrB). OO 12:170 δ acc 1591/9/29, but calc based on slips of $-1°/2$ in this, as well as $+1°$ in α.

D504 (14ι CrB). OO 12:95 $g = 27°36'3/4$ vs. α Oph 1590/10/9 & OO 12:99 $g = 26°11'$ (uncertain) vs. α Boo 1591/12/18. (Resp errors $-4'$ & $+10'$.) Serious subseq error, since while D504 pstn is $27°40'$ (acc, perhaps accid) from D688 (α Oph), it's $25°21'$ from D469 (α Boo), disagreeing by $-50'$ with obs (& by $-40'$ with real 1591.0 g). OO 12:95 record incomplete & OO 12:99 marked doubtful (dawn-light).

D512 (103o Her). OO 12:169 δ off $+2'$ (1591.4) & miscopied by $+1'$ at OO 12:249; OO 12:169 g vs. α CrB (D497) off $+2'$. Using D497's OO 12:248 eqt coords, D512's $\alpha = 38°32' + 229°18'$. Arithmetical error in arcmin tens place produced $268°00'$ for 1589.0 (OO 12:249). Ecl calc acc from there. (OO 12:94 g vs. α Aql acc 1590.8, but unused.)

D523 (82y Her): OO 12:171 acc δ (error $+1'$), tho g vs. α Lyr off by $+11'$. Eqt pstn 1589.0 at OO 12:249 repeats acc δ, and provides $\alpha = 261°04'1/4$, calc to ordmag $1'$ precision from δ, g, & α Lyr's coords ($\alpha_r = 275°46'$ & $\delta_r = 38°27'1/2$, precessed from OO 3:377). This α in error by $-0°.4$. Subseq transf-calc (1589.0) of D523 ecl pstn acc until β misinv as $71°13'1/2$ instead of acc calc = $71°46'1/2$. (Making this corr at OO 12:249 gels all four D523 coordinates there.)

D524 (HR6641 & HD162299). Comb magn $m = 5.93$ (overprecise). Table 21 lists pstn of HR6641. D524 α within $1'$ of center of pair, slightly ($5'$ gt-circ) east of HR6641 ($m = 6.43$), evidently affected by HD162299 ($m = 7$),[125] $9'$ gt-circ east.

D530 (30g Her). OO 12:171 1591/10/8 δ acc, & g vs. α Lyr OK. But α misarg by $1°/2$: $\alpha - \alpha_r = -31°34'-$ (instead of acc calc $-32°04'-$). Added to Vega's $\alpha = 275°47'1/2$ (precessed for 3^y after OO 12:250 1589.0): $\alpha = 244°14'$ (α & δ entered into 1589.0 catalog at OO 12:250 without backward precession-corr).

D541 (14γ Lyr). OO 12:96 g vs. β Peg acc (1590.9), & OO 12:250 δ acc 1589.0. But α miscalc by -1 in arcmin tens place. Acc calcs thereafter. Note oddity (also for D542) that TB was so looking ahead to epoch 1601.0 that he precessed OO 12:250 eqt pstn to then, tho this catalog is 1589.0 (& the D541 ecl pstn is 1589.0).

D542 (15λ Lyr). OO 12:171 (1591.8) δ acc, & g vs. ϵ Cyg acc but misarg (in calc of α) with -1 slip[126] in arcmin tens place. Remaining calcs acc, tho one finds the same mixed-epoch situation as for D541.

D555 (64ζ Cyg). Screrr λ by $+1$ in arcmin tens place, restor. (See OO 12:251 for corr 1589.0 λ.)

D562 (78μ Cyg). OO 13:61 OK g vs. γ Peg, & OK $\delta = 27°$; but δ misarg by $-1°$ in calc of α. All calcs acc.

D564 (16 Lyr). OO 13:61 g vs. γ Cyg off by $-3'$, & δ off by $+2'$. Combined gt-circ effect on $\alpha = +4'$, which accounts for most of error $\Gamma\alpha = +6'$.

D565-569. See §N (§N5-§N10 & Table 19).

[125] Pstn & m from *SkyCat2000*.

[126] Note also that α Cyg (D548) is off in the degree units place for both eqt coords at OO 12:251, tho the cat D place is acc.

D585-587 (50, 48A, & 46ω Cas). These 3 stars (& D345-348, D611-613, & D836) are among the flabbiest two-g configs anywhere in cat D; esp D587. The real g pairs intersect at angles γ equal to: 7°, 7°, & 6°, resp. For the cat D coords of these stars & the ref-stars α Ari (Hamal) & β UMi (Kochab), γ_{D} equals:[127] 4°, 2°, & $14'$, resp. (For the reconstructed orig Kochab pstn, the last γ_{D} obviously becomes $0'$ in this lineup instance.) For such flabby cases, rigorous sph trig two-g calcs would have to be performed[128] to ordmag $10''$ acc, for $1'$ pstn precision to be achieved.[129] These 3 stars appear on a 1573.0 list (OO 11:238) of all Cas pstns. (Cas' stars having already thus been provided separately, Cas is the sole TB observed constellation which is not included in TB's 1589.0 catalog at OO 12:231-265.) The obs data are given nearby. OO 11:231 (1587/2/17) g vs. α Ari: $48^\circ53'7/8$ (D585), $47^\circ23'1/4$ (D586), $45^\circ10'1/2$ (D587). OO 11:233 (1587/2/21) g vs. β UMi (mislabelled[130] as Capella): $33^\circ15'7/12$ (D585), $34^\circ43'5/12$ (D586), $36^\circ54'$ (D587). (Note $36^\circ15'7/12$ screrrf $33^\circ15'7/12$ at OO 11:233, where the order of the records is also confused.[131] The six real g were, resp, $48^\circ56'.5-$, $47^\circ26'.0$, $45^\circ14'.3$, and $33^\circ14'.7$, $34^\circ44'.3$, $36^\circ53'.5-$ (1587.2). The resp six errors (O$-$C) were: $-2'.6$, $-2'.7$, $-3'.8$, and $+0'.9$, $-0'.9$, $+0'.5+$. The six resp diffs (O$-$D) between obs g & cat D g, resp: $-2'.6$, $+0'.6$, $-0'.1-$ and $+4'.1$, $+4'.3$, $+3'.7$. Impressive. However, despite the TB school's wonderful observational consistency and scrupulously precise sph trig calcs, the D585-587 results are all mistaken by ordmag 1°. The prime[132] reasons: both cases D585-586 are WCP, and D587 is simply a lineup-calc[133] (which can only be corr by a fluke — & there was no fluke in this case), in which the pstn is just $g = 45^\circ10'1/2$ from α Ari, along the gt-circ connecting α Ari to β UMi (neglecting the datum g vs. β UMi). (Thus the inevitable near-null O$-$D for D587's g vs. α Ari.) The foregoing data enable us to place TB's pre-cat D pstn for Kochab (β UMi). We merely find the intersection of two loci, both determined purely by the coords in cat D: [a] the gt-circ containing D003 (α Ari) & D587 (46ω Cas), and [b] the locus of points $33^\circ15'7/12$ distant from D585 (50 Cas) or $34^\circ43'5/12$ distant from D586 (48A Cas). (The two loci cited under [b] are nearly parallel, separated merely by ordmag $10''$; so the intersection of [a]&[b] will be virtually identical regardless of the [b] option selected.) For epoch 1587.2, that intersection is (within $1'$): $\lambda = 127^\circ25'$ & $\beta = 72^\circ59'$. (Eqt pstn: $\alpha = 223^\circ28'$ & $\delta = 75^\circ49'$.) For cat D's epoch (1601.03): $\lambda = 127^\circ37'$ & $\beta = 72^\circ59'$. (Eqt pstn: $\alpha = 223^\circ26'$ & $\delta = 75^\circ46'$.) This completes our reconstruction of TB's pre-cat D pstn for Kochab. As a check, we perform two-g calcs of D585-586 & lineup calc of D587, with both Kochab places. For cat D Kochab: $\lambda = 51^\circ06'$ & $\beta = 56^\circ34'$ (D585, two-g), $\lambda = 50^\circ35'$ & $\beta = 55^\circ02'$ (D586, two-g), $\lambda = 52^\circ07'$ & $\beta = 52^\circ06'$ (D587, lineup from Hamal). For D585&586, the λ discrepancies (vs. cat D) are ordmag a degree. By contrast, for orig Kochab we find: $\lambda = 52^\circ23'$ & $\beta = 56^\circ13'$ (D585, two-g), $\lambda = 52^\circ28'$ & $\beta = 54^\circ29'$ (D586, two-g), $\lambda = 51^\circ58'.2$ & $\beta = 52^\circ08'.4$ (D587, lineup from Hamal). The agreements with the cat D places of D585-587 are within $3'$ (gt-circ) for all 6 coords — roughly 10 times better fit than the places we just calc using the cat D pstn for Kochab. I display the last pstn to the nearest tenth-arcmin — deliberately to highlight the perfect match with D587 (to its precision, half an arcmin). Note that the orig Kochab pstn's α error is not much diff from D341's (tho of diff sign), but the δ error is far smaller (fraction of $1'$) than D341's δ error ($+6'$).

[127] Since 4° & even 2° may seem superficially unflabby, I must comment on a stimulating oddity here, namely: if either of D585's implicit cat D g (i.e., the g between cat D places, not obs or real g) had been just another $5'$ on the low side of reality, the star's two-g placement would not have been solvable. For D586, the margin was even narrower: merely $1'$ difference (slightly less in fact) would destroy the two-g solution. Note: for D587, a two-g solution (using cat D's D003 & D341 as ref-star coords) would have failed, had either g been only $1''$ shorter! (To be precise: about 2/3 of an arcsec.) In a context of ordmag $0^\circ.1$ errors, this is obviously ludicrous — and was the symptom which proved to DR that D587 was a lineup-placed pstn (see fn 133), and (since the gt-circ from D003 extended through D587 did not hit D341) thus verified DR's already-waxing suspicion (fn 129 & fn 179) that the β UMi pstn formerly used (by the 1587 computer of D587's pstn) was not the same as the eventually published pstn (D341). (The occasional mutability of TB's ref-star pstns is basic to understanding their relation to the quarry stars that largely comprise cat D. See §J2 & §J12.)

[128] It is possible that the D585-586 calcs were not done by rigorous two-g math (see fn 34), but instead by merely shooting a short perpendicular (at the point given by lineup solution) off the gt-circ between the two ref stars. In such flabby cases as D585-586, this ploy can achieve all needed acc via $1'$-precision math. Indeed, despite the simplicity of the approach, the resultant acc will be better than will be yielded by the rigorous two-g approach, unless (fn 25) the latter is taken to an ordmag higher precision.

[129] Before finally locating the raw g data in OO, DR determined the ref stars (tho leaving open the outside possibility that γ And might be the one on the vernal side of the pole) and reconstructed all 6 of the g observations. These DR-reconstructed g follow. From α Ari: $48^\circ54'$ (D585), $47^\circ23'$ (D586), $45^\circ11'$ (D587). From β UMi: $33^\circ11'$ (D585), $34^\circ39'$ (D586), $36^\circ50'$ (D587). Comparing the 1st three reconstructed values' close agreement with the actual obs g (§M4 at D585-587) inspires increased admiration for the pre-1597 Hven computers' scrupulous dedication to precision. (Had the work been at the level of the Final Fifty, DR's reconstructions here could not have worked — see, e.g., the sloppy math even in simple lineup calcs at D611-613 in Table 20.) And the consistency of the latter reconstructed trio's $-4'$ disagreements with the obs merely show that (as suggested in fn 127 and as we are about to see in detail): in 1587, TB was using a different & more acc pstn for β UMi (Kochab) than later ended up in cat D as D341. (On D341's curious inacc, see fn 179.)

[130] For another (nonsuperficial) TB mislabelling ref star Kochab (as Alkaid in that case) in a two-g situation, see fn 179.

[131] Note: the numbering of some Cas stars at OO 11:235 differs from that at OO 11:238.

[132] Other reasons: flabbiness & errors in ref star pstns.

[133] See also, e.g., D345-346. If the sum of the two observed quarry-to-ref g data is less than the g between the cat D places of the two ref stars, then clearly no rigorous two-g sph trig solution is possible. Such situations obviously invited the lineup-solution approach. See §N16.

D590 (28υ2 Cas). Precession-corr[134] evidently neglected, thus -1 error in λ arcmin tens place, while β very acc. (D596 is similar case.)

D595 (20π Cas). Cat D screrr β by -1 in arcmin tens place; corr in cat C (C487), so restor.

D596-614. From Final Fifty. See §N, Table 20 (which imparts all g data and acc thereof). OO 13:98-99 (1597.1-1597.2). All are two-g calcs. Remarks on individual cases follow:

D596 (HR743). Similar to D590.

D597 (HR932). Error $+13'$ in g vs. α Aur.

D598 (γ Cam). Large error in two-g calc.

D599 (HR1138). Screrr -2° in λ, restor.

D600 (11-12 Cam). Identical to D345 (Tables 20 & 21): lineup calc.

D601-610. Mostly OK g, but two-g calcs mostly not OK. See Final Fifty, Table 20.

D607 (M Cam). Screrr $+10'$ of g vs. γ Cas at OO 13:99, but OK two-g calc used orig value ($32^\circ03'1/2$). Screrr resultant β by $+1^\circ$, restor.

D611-613. Among flabbiest configs in cat D: $\gamma_{\mathrm{D}} = 30'$, $109'$, & $75'$, resp. Impossible two-g calcs, since (for all 3 stars) sum of both g = less than cat D gt-circ angle ($57^\circ11'.4$) between the two ref-stars. Thus, TB's computer was forced to use lineup calcs.[135] Accurately done (using fn 36 method), the results for cat D's 1601.03 epoch would have been the values listed in Table 20. The discrepancies wrt cat D are ordmag $10'$, which is not out of line for the Final Fifty, of which these stars are part.

D614 (HR4892-3). Both obs g poor. WCP.

D619 (18τ Per). OO 12:98 misobs h produced δ off $+0^\circ.1$, which in turn threw off α (in δ&g calc) by similar negative error. Acc transf-calc, but λ misarg by $-1^\circ/2$.

D621 (33α Per). Spectacularly large[136] error for a member of TB's Select stars (S list): $\Delta\lambda = -14'$ for 1589.0 catalog (OO 12:252) & cat D; virtually same ($\Delta\lambda = -13'$) for S list 1701 (Table 23, star S15). Yet, $\Delta\alpha$ of 1589.0 catalog & S list for 1601 are both rather trivial ($-1'$ & $-3'$, resp). By contrast, implicit 1589.0 catalog ecl coords $\Delta\alpha = -19'$, & S list 1701 $\Delta\alpha = -18'$ (Table 23). Orig error in 1589.0 catalog: presuming $-20'$ α slip ($43^\circ31'$

[134] By TB's $51''$/yr, precession from 1589.0 to 1601.0 would be $+10'.2$.

[135] It is also possible that instead of doing lineup calc, the computer just quietly stretched the obs g data in order to make a standard two-g calc possible. But, why go to so much trouble to get a result that will be no better than that given by far simpler lineup calc?

[136] However, this large error luckily permits our reconstruction of the founding data for the only 4 stars in cat C where these data are missing: see fn 121.

misargf $43^\circ 51'$) in transf-calc produces ecl pstn $\lambda = 56^\circ 07'$ (precisely that at OO 12:252) & $\beta = 30^\circ 08'$, while acc calc yields $\beta = 30^\circ 03'$. (The $\beta = 30^\circ 05'$ at OO 12:252 may be an average.) See §I7.

D627 (28ω Per). Acc 1589.0 eqt coords & β at OO 12:252, but (during transf-calc) misinv λ error: $50^\circ 39'$ read as $50^\circ 21'$.

D641 (HR1314). OO 12:163 (1591.0) acc $h = 86^\circ 33' 1/2$ wrongly taken as north culm (actually south); with $30'$ screrr, yields $\delta = 59^\circ 50' 1/2$ (OO 12:253), instead of acc calc & real $\delta = 52^\circ 28'$. Calc used this δ & evidently crude $g = 39^\circ$ from α Ari to calc 1591.0 α after precessing δ to $59^\circ 51'$ and (using OO 3:375 diffs) precessing α Ari's OO 12:231 coords (1589.0) to $\alpha_r = 26^\circ 04' 2/3$ & $\delta_r = 21^\circ 30'$. Calc gave $\alpha - \alpha_r = 9^\circ 59' 1/2$. Adding to α Ari's α & subtr $2' 1/4$ precession yielded $36^\circ 01' 11/12$ (OO 12:253), off (1589.0) by over -20°. Acc transf.

D644-647. From Final Fifty. See §N16 & Table 20 (which lists all real g and corresponding TB errors). OO 13:99 (1597.2): D644[137] was OK two-g calc. But, since flab config, other 3 are lineup calcs, OK in precision but crude & confused in execution. (The evidently inadvertent order at OO 13:99 is D646-647, D645, [D647], D644.) D645&646 are on gt-circ between α UMi & D644: D645 is $20^\circ 24' 2/3$ from former; D646 is $19^\circ 01'$ from it. (OO 13:99 corr has both these g as distances from α Aur, not α UMi.) D647 is on gt-circ between α UMi & β Per,[138] $14^\circ 51'$ ($33^\circ 52' - 19^\circ 01'$)[139] from former. All g data misused[140] for D645-647. (These three pstns fit best for α UMi's $\beta = 66^\circ 00'$, the Hipparchos[141] & Copernicus value.[142] But Table 20 computes them, in all 3 cases, using the cat D coords of the adopted ref stars, and the misbegotten g values cited above in this paragraph.)

D651 (34β Aur). OO 12:97 OK $g = 41^\circ 48' 3/4$ vs. γ And (real 1590.9 $g = 41^\circ 46'.1$) & $\delta = 44^\circ 50'$ (real $\delta = 44^\circ 48'$); calc gave OK 1590.9 $\alpha = 82^\circ 28'$. (Precession to 1589.0: $82^\circ 26'$ at OO 12:253.) But $\alpha = 82^\circ 32'$ (misinvf $83^\circ 28'$) into transf, resulting in subpar λ.

D652 (37θ Aur). OO 12:253 OK 1589.0 eqt pstn, but $\alpha = 82^\circ 55'$ misarg by $-1^\circ/2$ in transf to ecl pstn. See §I7.

D653 (7ϵ Aur). Calc $\alpha = 68^\circ 10' 1/2$ (1589.0) misarg by -1 in arcmin tens place at OO 12:253.

D657 (35π Aur). OO 13:65 $\beta = 27^\circ 27'$ screrrf $22^\circ 27'$, restor.

D659 (15λ Aur). OO 13:65 OK δ; OK g vs. α Per & acc g vs. α Gem. Calcs yield $\alpha = 72^\circ 40'$ & $72^\circ 36'$, resp, mean $72^\circ 38'$ at OO 13:65. (Real 1596.0 $\alpha = 72^\circ 43'$.) Then α precession to 1601.03 neglected, so D659 pstn based upon 1596.0 α (OO 13:65).

D666 (24ϕ Aur). Oddity. OO 13:65 δ and g vs. α Per & g vs. α Gem. All acc except last, misrd by -1°, causing similar error in λ, since ecl pstn from it & δ. But eqt pstn from δ & other g. All calcs acc.

137 For the same star's prior appearance in cat D, see above at star D348.

138 The observer's scrawl (on his sketch of these 4 stars, reproduced at OO 13:99), identifying the bright star near HR1046, was probably intended to say "lucid. lat. Per" (i.e., α Per). It looks instead like "lucid. lalg Per" & so evidently was later taken to refer to Algol. (In the depiction at OO 12:99, the "t" is not crossed, though it is faintly semi-crossed in the orig TBmss: see Gl. kgl. Samling 316 fol., microfilm 546, p.127b.)

139 I.e., the difference between the two D646 g data (vs. α Aur & vs. α UMi, resp)! See fn 140.

140 If the reconstruction here of D647 is corr, then the g data for the 3rd star at OO 13:99 were never used in cat D (thus the brackets in the foregoing text), while the data for the 1st star were used twice. See fn 139.

141 The Ancient Star Catalog, C.Ptolemy's massive (amateurishly fumbled) plagiarism of c.1000 stars from Hipparchos, is found at Ptolemy's *Almajest* 7.5-8.1. For summary of proofs that Hipparchos was the true observer, see e.g., *DIO 2.3* ‡8 §C, and more to come in *DIO 4*. The 1st public charge that Ptolemy had stolen ("usurped") Hipparchos' star catalog was right in the preface to Tycho's own cat D, at OO 3:337. Note: Historians-of-science often mention Tycho's epochal discovery of the constancy of precession — but they do not tell their readers the blunt truth: this discovery would never have occurred without *the discovery it was squarely based upon*, namely, Tycho's realization of Ptolemy's catalog-thievery. (See fn 29.) I.e., it is no coincidence that both discoveries were made by the same astronomer. Just another instance of horrified modern Ptolemists' promulgation of skewed history, in order to suppress public awareness of their hero's dishonesty & scientific ineptitude.

142 *Almajest* 7.5 (PK1) & Copernicus 1543 2.14 (p.46b).

D675-680. Utter fakes.[143] See Rawlins 1992T (§C1-§C5, §F, & Table 1).

D681-687. Rawlins 1992T §F argues that all 7 pstns were from frantic final (eviction-eve) Hven obs session (1597/3/15-16), the record of which has been destroyed. (Record would have revealed failure to obs D675-680, a lapse which had necessitated later faking all 6 stars indoors.) Onset of dawn ruined D681, and haste degraded D684, D686, D687. Individual-star comments follow.

D681 (45d Oph). Evidently calc from crude $\delta = 30^\circ$ and equally-crudely-adopted $\lambda = 256^\circ 5/6$ from α Oph. All calcs acc: on the nose. Same β sign-screrrf-restor as D682.

D682 (3 Sgr). Sign β north screrrf south, restor. See Rawlins 1992T §E4.

D687 (57μ Oph). Sloppy pstn of same star very acc recorded (1596.0) at OO 13:76 (& thus acc pstn at D707).

D696 (57μ Oph). Ditto. OO 12:170 (1591.8) OK obs $g = 34^\circ 50'$ vs. β Lib; but misidentified as ref star in Ser, so later computer — finding one Ser star yielding near-fit to D696's known vicinity — assumed it was γ Ser. OK subseq calcs proceeded on this premis, using acc 1591.8 δ, with misarg g (deliberate or no) by $+1^\circ$, as $35^\circ 50'$. Only acc coord: δ.

D699 (35η Oph). Identical to D701: fn 77. See §C3, fn 55, fn 57, fn 157, fn 191.

D701 (35η Oph). Identical to D699.

D714 (38ρ Ser). Screrr δ by $+1^\circ$ (OO 12:254).

D717 (35κ Ser). OO 12:169 acc 1591/9/7 $g = 47^\circ 18' 1/12$ vs. ζ Aql, & OO 12:94 OK 1590/10/6 $\delta = 19^\circ 30' 1/3$. Latter misarg (by -1 in degree-tens place) as $g = 9^\circ 30' 1/3$, so calc $\alpha = 233^\circ 28'$. Otherwise, all calcs acc. (Transf acc to within $0'.1$ in both ecl coords.)

D722 (32μ Ser). Obs $\delta = 2^\circ 02' 2/3$ & obs $g = 30^\circ 04' 5/6$ vs. γ Oph (real $30^\circ 10'.6$) both at OO 12:89. And both vitiated by $5' 1/4$ of refr at $h = 11^\circ 25'$. The δ component is $4'$; TB tried removing this from δ, rounded & left $\delta = 2^\circ 00'$ (OO 12:254). But he applied wrong sign since δ orig (OO 12:89) screrr north (really south). (Otherwise would have been acc, since real 1590.6 $\delta = -2^\circ 06'.7$.) Refr also artificially affected g by $-2' 1/2$, but this not removed by TB. Subseq calcs acc.

D723 (57ζ Ser). Poor OO 12:171 1591.8 $\delta = -3^\circ 28' 1/2$ used for 1589.0 δ at OO 12:255 (where $\alpha = 26^\circ 43' 48''$ screrrf $264^\circ 43' 48''$). Precession no problem, but some of $+6'$ error in δ is from $2'$-$3'$ of uncorr refr. Without refr: obs, calcs, & pstn OK. (No mention of low h in 1591/10/10 record at OO 12:171. By end of twilight at 18:44 Uraniborg Mean Time, star was only 1^h past culm.)

D737 (54o Aql). OO 12:255 screrr λ by -1°, restor. (OO 12:169 notes clouds interrupted obs.)

D739 (61ϕ Aql). Screrr -2° in otherwise acc α; δ & calcs OK. Data at OO 12:169-170.

D747 (41ι Aql or Ani).[144] Misrd δ by $+10'$ or hybrid (D746's δ). See OO 12:88&256.

D756 (6β Del). OO 12:88 acc 1590.6 $\delta = 13^\circ 13'.9$. OO 12:91 $g = 35^\circ 07' 5/6$ (vs. α Lyr) evidently screrrf OK $g = 35^\circ 57' 5/6$. (Real $g = 35^\circ 52'.8$, so: less than $5'$ off. But err exagg by steep angle of g wrt E-W direction, thus α off by over $+0^\circ.1$.) As confirmed by perfect check with math of D762, TB used at this time α Lyr 1589 eqt coords compatible with final D533 ecl pstn; eqt pstn: $\alpha_r = 275^\circ 44'.7$ & $\delta_r = 38^\circ 27' 1/2$. (Later, α altered by $+1'.3$, tho ecl pstn unchanged.) Calc with this & above δ (only precessed later) & g gave 1589 $\alpha = 304^\circ 41'.6$, conventionally rounded to $304^\circ 41' 1/2$ at OO 12:256. Transf acc.

D758 (11δ Del). The $\lambda = 13^\circ 36' 1/2$ screrrf $12^\circ 36' 1/2$, restor.

D782 (68υ Peg). OO 12:257 (1589.0) $\lambda = 356^\circ 56'$ screrrf $356^\circ 16'$ (not acc calc via usual[145] eq) but acc calc via eq. 4 (surprising to find latter eq used so near null λ); adding

143 Rawlins 1992T §F7 proposes that a star record of about 1597/3/15 was destroyed, since it showed failure to observe the eventually-faked stars D675-680. I note that there is a -1 alteration of pagination in the (not consistently chronological) Final Fifty section of the original TBmss. (See altered numbers in upper-right corners of leaves in Gl. kgl. Samling 316 fol., microfilm 546.) This occurred before or during Dreyer's 1923-1926 publication of the mss, since he uses the post-alteration pagination. (See, e.g., OO 10:XVIII.)

144 Tycho used two constellations, Antinoüs & Argo (see below at D954&955), which are not (presently) recognized by IAU convention. (See *DIO 1.1* ‡8 §F2.)

145 See below at star D908 in §M5.

12^y precession gave $\lambda = 357^\circ06'$ for cat D's 1601.0 epoch. Restor to $40'$ less.

D788 (2 Peg). OO 13:62 δ acc, but (this being a late TB obs), g undbld; $g = 23^\circ44'1/2$, off by over $0^\circ.1$ vs. α Peg (real 1596.0 $g = 23^\circ50'.6$) — which causes α error exceeding $+0^\circ.1$. All calcs acc.

D789 (9 Peg). OO 12:485 δ OK (& see OO 13:62 n.1); acc $g = 19^\circ20'1/2$ vs. α Peg. (Real $g = 19^\circ21'.7$.) But WCP produced α off by over $+15^\circ$! (Sole instance in cat D of WCP for any but two-g-based star. See fn 32.) All calcs acc.

D795 (27ρ And). Either bad 1590.7 obs $\delta = 35^\circ35'1/3$ (complaint in OO 12:93 record) or accid arcmin repeat of degree arg. Real 1590.7 $\delta = 35^\circ41'.8$. All calcs acc.

D796 (17ι And). OO 12:92 $\delta = 40^\circ00'1/4$ screrrf acc $41^\circ00'1/4$. (Real 1590.7 $\delta = 41^\circ00'.6$.) So, two-g calc of necessity, using OK $g = 31^\circ14'3/8$ vs. α Cyg (OO 12:92) & $g = 26^\circ36'5/12$ vs. γ And (OO 12:93). Real 1590.7 g, resp, $31^\circ17'.6$ & $26^\circ32'.3$. An oddity: these real g more closely equal the g between the real ref stars & the cat D pstn, than do the reported g. This may reflect ref-star pstns subseq alterations, or slightly imprecise math. Regardless, $-0^\circ.1$ δ error partly function of: [a] $-3'$ error in γ And's α, & [b] some flab in config.

D798 (20ψ And). OO 12:93 acc 1590.7 δ & g vs. γ And. OO 12:257 acc 1589.0 calcs but $\beta = 42^\circ8'$ screrrf $42^\circ58'$, restor.

D800 (34ζ And). OO 12:91&93 acc 1590.7 δ & g vs. α Ari. OO 12:258 acc 1589.0 calcs but used $\delta = 22^\circ15'$ screrrf $22^\circ1'5''$.

D803 (37μ And). OO 12:89 1590.7 $\delta = 37^\circ16'11/12$ screrrf acc $36^\circ16'11/12$; $\delta = 37^\circ17'$ & OK 1590.7 OO 12:93 g (vs. α Cyg) used in OK 1589.0 calcs at OO 12:258.

D808 (50υ And). OO 12:258 (1589.0) $\lambda = 4^\circ55'1/2$ screrrf $\lambda = 2^\circ55'1/2$, restor.

D811 (1o And). Final cat D pstn awful (despite all obs & calcs acc), due to 2 huge, separate[146] screrrs. OO 12:93 acc 1590.7 $h = 74^\circ12'2/3$ (yielding OO 12:258 acc 1589.0 $\delta = 40^\circ07'1/3$), & acc $g = 25^\circ17'5/8$ vs. α Cyg (real 1590.7 $g = 25^\circ18'.9$). Using these data & ref star's 1589.0 eqt coords (at OO 12:251 — & each misprinted there in degrees unit place), acc calc gave $\alpha = 340^\circ45'1/3$, which OO 12:258 reverse-digits-screrrs into: $\alpha = 304^\circ45'1/3$. Acc transf-calc of this & δ into false ecl pstn, λ = Aqr $23^\circ49'2/3$ & $\beta = 57^\circ18'5/6$. Then, Psc screrrf Aqr at OO 12:258 & cat D — perhaps just a clumsy late patchup-attempt to get D811 back somewhere roughly near where it belonged. Not restor. (This is Ptolemy's And #23, so its approx pstn was pre-known.)[147]

M5 Southern Star Errors:

Header for Southern Section of 1589.0 catalog reads (OO 12:258): "On the South Side of the Equator" — screrr for "Ecliptic".

D822 (87μ Cet). OO 12:259 λ miscalc. From OO 12:105 δ and from mean of α based upon g vs. α Tau & g vs. γ Peg, 1591.0 $\alpha = 35^\circ44'2/3$ (acc, as is 1589.0 α at OO 12:259). If acc transf gave 1591.0 $\lambda = 36^\circ12'1/2$ (real $\lambda = 36^\circ12'.1$), & $15'2/3$ (screrrf $1'2/3 = 2^y$ precession) subtracted, then false 1589.0 $\lambda = 35^\circ56'5/6$ ensued (OO 12:259).

D832 (31η Cet). OO 12:182 δ OK, & OO 12:259 α & calcs acc — except $\beta = -16^\circ55'$ misinvf $-16^\circ05'$, restor.

D836 (53χ Cet). OO 12:103 acc $g = 22^\circ19'$ vs. ι Cet & OO 12:176 OK $g = 50^\circ34'7/8$ vs. β Ori. (Real g, resp, $22^\circ18'.1$ & $50^\circ32'.1$.) Flabby two-g calc imperfect (D836 is $22^\circ19'.2$ & $50^\circ36'.1$ from D833 & D874, resp). Since both g are virtually E-W & no obs for δ was taken (see comments at §B8), the pstn is flabby in the N-S direction. The two

[146] Which is why Dreyer was mystified by D811, merely quasi-proposing it might be 81π2 Cyg (OO 3:368).

[147] In the entire period before TB's final 1595-1598 rush to complete cat D, this is virtually (though see D971) the only pstn, uncovered by DR, involving possible undue-influence of previous scholars upon TB. (Pretty mild.) Which is perfectly reasonable, according to the hypothesis that TB only deceived when he felt his career & livelihood threatened. He is not the last scholar so to behave. Would that his present-day counterparts, in such desperate resorts, possessed a fraction of his talent & productivity.

g intersect at D836 at an angle $\gamma = 1^\circ$, but the cat D bulge in this two-arc-join is so great (from the slight excess of each obs g over real g) that the cat D implicit angle (γ_D) is 6°.

D844 (61μ Ori). In transf, $\delta = 8^\circ34'2/3$ misargf $9^\circ34'2/3$ OO 12:260.

D845 (74k2 Ori). In otherwise acc transf, $\delta = 12^\circ01'1/12$ misargf OK $12^\circ21'1/12$ OO 12:260.

D854 (33n1 & 23m Ori). Hybrid. OO 12:176 g vs. α CMi is for 33n1 Ori; but, despite obs's description, δ is for 23m Ori (D879). (Compare acc raw δ data OO 12:177 vs. 178.) Which accounts for apparent $-9'$ discrepancy in δ.

D878 (48σ Ori). OO 12:177 OK g vs. γ Eri off $+2'.5$ (obliquely), & ref star α off same, so D874 total error ($\Gamma\alpha$) slightly exceeds $+0^\circ.1$.

D887 (18 Ori). OO 13:67 OK 1596.0 δ & $g = 35^\circ56'1/4$ vs. α CMi, but misarg from screrr $35^\circ50'1/4$ (& g's obliqueness) threw α calc well off to east.

D889 (14i Ori). OO 13:67 very acc 1596.0 δ & not-quite-OK $g = 11^\circ06'$ vs. α Tau. (Real $g = 11^\circ11'.4$.) Obliqueness of g exagg effect on $\Gamma\alpha$ to $-7'$, which accounts for most of α error.

D890 (5γ Mon). OO 13:67 OK δ (& α) but $\beta = -29^\circ31'1/3$ screrrf acc $-29^\circ41'1/3$ (1596.0), restor. (Also: β slightly misrounded to whole-arcmin instead of to expected standard half-arcmin.)

D891 (11β Mon). OO 13:68 α very acc 1596.0 & δ OK — except, in (acc) transf, $\delta = -6^\circ18'5/6$ misargf $-6^\circ48'5/6$.

D893 (8ϵ Mon). OO 13:68 acc 1596.0 δ & OK $\alpha = 90^\circ37'5/6$. Transf gave acc β, but $\lambda = 91^\circ03'3/4$ (off by $+0^\circ.4$ gt-circ). Perhaps just a simple yet unrecoverable math slip (tho the result is patently incompatible with α). However, it instead may be an outrageously-freakish error. (Acc calc $\lambda = 90^\circ36'37''$. Real 1596.0 $\lambda = 90^\circ35'.5$.) Weird hypothesis follows. Computer, confused in problem very messy so near solst (where $\tan$ & $\sec$ explode), ended up accid equating[148] λ with $\sec\alpha$ or $\tan\alpha$ (virtually identical here), for α interpolated (interpolation error $-5''$) from table at effectively $90^\circ37'3/4$, the $\sec$ of which is -91.0625 (& $\cos$ of which is $39''32'''$, sexagesimally). Abs mag of resulting trig function confused for angle, so 91.0625 taken as $91^\circ03'3/4$. This hypothesis agrees with OO 13:68 false λ, within a small fraction of an arcsec. (Note: if x is taken literally in degrees, then $90^\circ37'56''$ is the smallest possible positive solution to the highly sensitive transcendental eq: $x + \tan x = 0$.)

D904 (57μ Eri). Similar to D836 (except less flab): OO 12:180 (1591.1) two acc E-W g used for pstn, but not δ. Two-g solution imperfect calc leaves $+3'$ slack, so bulge pushes D904 southward over $0^\circ.1$. Computer later noticed OK δ obs after all at OO 12:180, & so calc eqt pstn. No transf of this, since already possessed (non-acc) two-g-based ecl pstn. (OO 12:262 ecl & eqt pstns thus incompatible.)

D908 (23δ Eri). OO 12:262 eqt pstn acc 1589.0. Calc β OK, but $\lambda = 44^\circ57'1/3$ screrrf $45^\circ07'1/3$, result of precise calc via $\tan\lambda = \cos\epsilon\tan\alpha + \sin\epsilon\tan\delta/\cos\alpha$ (fn 148). Restor. An odd $-10'$ error, unless made in epoch 1601.0 list — which suggests that, as early as 1591 (OO 12:179), TB was arranging some results with that round epoch in mind.

D914 (39A Eri). OO 13:62 eqt pstn OK (δ obviously influenced by non-corr for refr $2'.4$), & λ calc OK. But err calc gave $\beta = -30^\circ25'$ (tho real $-30^\circ57'.5$), either $1^\circ/2$ slip or possibly as follows: $\sin\beta = \cos\epsilon\sin\delta - \sin\epsilon\sin\alpha\cos\delta = -(0.171181 + 0.335052) = \sin(-30^\circ25')$, where 0.171181 screrrf 0.179181.

D920 (3ι Lep). OO 12:176 $h = 21^\circ54'$ misrf OK $21^\circ44'$ (off by 1 in arcmin tens place); net positive δ error, largely from this & non-corr for refr $2'.5$: $\delta = +14'$.

D922 (7ν Lep). OO 12:176 $\delta = -12^\circ43'1/2$ OK obs (off $+2'.6$), sullied by uncorr refr $2'.6$; & β calc off by $+3'$. These slips account for most of implicit δ error in D922 ecl pstn: $+8'$.

D934 (14θ CMa). OO 12:263 eqt coords & acc calc β OK, but λ miscalc by $+0^\circ.3$.

[148] Eqs for λ: $\sec\lambda = \sec\alpha\sec\delta/\sec\beta$ (eq. 4), or $\tan\lambda = \cos\epsilon\tan\alpha + \sin\epsilon\tan\delta/\cos\alpha$.

D937 (20ι CMa). OO 12:263 δ 1589.0 miscalc by 1 in arcmin tens place from 1592.2 $h = 17^\circ 33'$ at OO 12:227; used in transf.

D938 (8ν3 & 7ν2 CMa.). Hybrid. OO 12:180&227 acc h data for 8ν3 CMa, while OO 12:227 g (vs. β Ori) acc for 7ν2 CMa. The 2 stars plainly confused at OO 12:180&227. Acc calc produced OO 12:263 eqt pstn (1589.0); tho ecl pstn discrepant, possibly based upon flawed separate reduction: for finding α (via §B6 method), 7ν2 CMa g (vs. β Ori, OO 12:227) = $22^\circ 55'$ misargf $22^\circ 45'$, then transf-calc $\delta = -18^\circ 48'$ misargf $-18^\circ 58'$. (Acc OO 12:180&227 obs of 8ν3 CMa's h unused.)

D941 (16o1 CMa). OO 12:263 α acc; but δ off $+12'$, due to 1591/2/9 $h = 10^\circ 34' 2/3$ (OO 12:179), prob misrdf $10^\circ 24' 2/3$.

D944 (1ζ CMa). OO 12:179 acc 1591/2/9 g vs. α Hya. Acc $h = 4^\circ 21' 1/4$, with $-11'$ TB-refr-corr, should've led to acc $\delta = -29^\circ 55'$. Instead, TB accid used $\delta = -28^\circ 15'$, perhaps a refr-uncorr version of previous star, D943 (OO 12:263). Because g (this low in sky) was nontrivially tilted wrt the preferred E-W direction, δ error severely affects (otherwise OK) calc of α as well.

D945 (31η CMa). OO 12:263 δ acc & OO 12:180 g vs. α Hya OK; errors $-1'.5$ & $-2'+$, resp. Ref star's α off $+1'.2$ & δ off $+1'.5$. (As for D944, δ error affects calc α, due to tilt of g.) Sum effect of these errors accounts for over $5'$ of the $+6'.2$ error in D945's α.

D954 (19 Pup or Arg).[149] OO 13:72 α OK & δ acc 1596.0. However, OO 13:72 $\lambda = 124^\circ 02' 1/3$ screrrf $123^\circ 02' 1/3$. Restor.

D955 (16 Pup or Arg). OO 13:72 eqt pstn acc 1596.0. But δ in acc transf: [a] refr-uncorr & [b] misarg by 1 in arcmin tens place.

D959 (29ζ Mon). OO 13:72 λ = Leo $29^\circ 21' 2/3$ screrrf[150] Cnc $29^\circ 21' 2/3$, restor; α OK & δ acc except for $-0^\circ 51' 1/2$ screrrf $-1^\circ 51' 1/2$. Transf acc.

D960 (C Hya). OO 13:72 α OK, δ acc, & acc transf. But in cat D, λ = Vir $4^\circ 20' 1/2$ screrrf Leo $4^\circ 20' 1/2$, restor.

D961 (26α Mon). OO 13:72 Leo $23^\circ 40' 1/4$ screrrf Cnc $23^\circ 40' 1/4$, restor.

D971 (31τ1 Hya). Fishy[151] λ. OO 12:104 (1590/11/25) reports obs of δ and g; δ acc for 1590.93, but three reported g obs[152] *from 2 different directions* (vs. 2 distinct ref stars) consistently place D971 west[153] of real 31τ1 Hya by $1^\circ/8$, four standard deviations! Dbld[154] obs g (vs. α CMi) = $28^\circ 22' 3/4$ (tho real $g = 28^\circ 30'.8$). Undbld obs g (vs. γ Vir) = $48^\circ 18'$ (tho real $g = 48^\circ 11'.3$). Acc calcs.

D978 (ϕ3 Hya).[155] OO 12:264 entirely acc obs & calcs, except 1589.0 $\lambda = 162^\circ 31' 1/3$ screrrf $162^\circ 21' 1/3$, restor.

D984 (45ψ Hya). OO 13:69 δ off $-7'$ 1596.0 (prob accid repeat-measure of D983's δ), & $\alpha = 192^\circ 11'$, off $+19'$. But acc transf used OK $\alpha = 191^\circ 56'$ & (prob) pre-refr-corr $\delta = -20^\circ 59'$. This α acc calc from OO 13:69 $g = 48^\circ 45' 1/2$ vs. δ Oph. Thus, after this eqt pstn transf to ecl pstn, former later recalc — with $+1^\circ/4$ error in α, 2nd time around.

[149] See fn 144.

[150] All three zodiac-sign errors here (D959-961) were restor by Dreyer. (See OO 13:72 nn.1-3.) Dreyer's names for D958&960 were, resp, Flamsteed's 31&30 Mon, where we use Bayer's names, resp, F&C Hya, since both stars are well within the modern IAU bounds for Hya. (I.e., there is no Dreyer misidentification here, merely a difference of naming-convention.) See also fn 99 & fn 155.

[151] Oddity 1st noted 1994/4/6. (See also the oddities at D248 & D256.)

[152] At the predawn time of the TB obs, 31τ1 Hya ($m = 4.60$) had $\mu > 5$, & solar $h > -15^\circ$: not total darkness.

[153] Hipparchos' λ error for same star PK903 (PK p.93) is in the same direction by (within $1'$) the same amount — whether figured absolutely, or differentially: $2^\circ 1/6$ west of previous star, D970 (PK902 = 35ι Hya). Direct consultation of the original manuscript record, by DR & Hanne Dalgas Christiansen (Royal Library, Copenhagen, 1994/5/26), reveals that the latter g ($48^\circ 18'$ vs. γ Vir) has been altered. (In TBmss, see: Gl. kgl. Samling 312b fol., microfilm 539.2, p.299a.) The final "8" has been anciently written in, over another digit (which is not now reliably recoverable). The least awful explanation of D971: after the D971 pstn was computed (by the Hven team) from the false 1st $g = 28^\circ 22' 3/4$ (vs. α CMi), the 2nd g was forced to accord with this place.

[154] Individual data: $28^\circ 23' 1/4$ & $28^\circ 22' 1/4$.

[155] Dreyer (OO 3:373) designates D978&9 as 2&4 Crt, resp. These are just the Flamsteed numbers of Bayer's ϕ3&ν Hya, resp. See fn 150.

D988 (12δ Crt). OO 12:182 (1591.3) δ (slight refr error) OK & g (vs. α Hya) acc; OK 1589.0 eqt pstn OO 12:264. Calc of α acc; but β miscalc by $+8'$, presumably from $-\sin\epsilon\cos\delta\sin\alpha = -0.1005$ screrrf -0.1025 in sph trig calc (eq at D914, above) of $\sin\beta$.

D1000 (8η Crv). OO 13:70 acc δ & OK α, acc transf; but $\beta = -11^\circ 27' 3/4$ screrrf $-11^\circ 37' 3/4$, restor.

D1001-1004. All λ faked;[156] δ evidently obs (crudely), presumably Wandsbeck. See Rawlins 1992T §C8, §G2, & Table 2. Hven post-extinction $\mu > 6$ for all 4 of these stars (Table 18), but at Wandsbeck $\mu < 6$ for all 4 (fn 95). See also here at Table 21.

N The Final Fifty Stars: Complete Sph Trig Reconstructions

N1 I have made a special examination (see further details at Rawlins 1992T §D) of the last fifty[157] stars Tycho recorded, since these have posed some hitherto-unsolved problems for earlier investigators. (At least 20% of these stars have never before been correctly identified.)[158] Additionally, I note that prior scholars have not completely understood the two-g observational technique used for Tycho's last stars (Table 20), nor the complexity of the sph trig employed for proper reduction. (See §B8. And, of course, we have seen that the two-g method was used aplenty prior to the Table 20 stars, largely in the northern part of cat D.)

N2 In September of 1596 (Dreyer 1890 pp.230-231, Thoren 1990 p.367), Tycho learned that his fiscal throat was being slit by the new kinglet. Almost immediately, Tycho returned to recording stellar positions, in hopes of reaching the millennial mark he had set for himself. He was able to observe about 50 objects before leaving Denmark. Below, in Tables 19 & 20, we will identify every one of them. Thus, henceforth, all 1004 of cat D stars' identities will be known.

N3 The first set of Tycho's Final Fifty stars occurred on 1596/10/5. (See OO 13:59-60. Original TBmss data at: Gl. kgl. Samling 316 fol., microfilm 546, p.163b. An atypically messy page.) These data, set out here in Table 19, produced 8 star places in cat D: D411, D550, D554, & D565-569 — this despite the fact that observations of merely 3 quarry stars were involved! The first object (D411) was correctly identified (OO 3:356) by J.Dreyer as 26 UMa, a star of pre-extinction magnitude $m = 4.50$. As for the other seven 1596/10/5 places (D550, D554, & D565-569), there are no correct identifications at OO 3:360 or OO 13:59-60. (Though, see fn 158.)

N4 An example will assist in understanding Table 19. The cat D ecliptical position for D411 is: longitude $\lambda = 121^\circ 41'$, latitude $\beta = 35^\circ 40'$. Subtracting $3'.6$ from λ (for TB's $51''$/yr: fn 29) precesses[159] the position in cat D (1601.03) to the observations' epoch, 1596.79 (1596/10/5). Then, by rotational transf-calc, using obliquity $\epsilon = 23^\circ 31' 1/2$, we find that this corresponds to the implicit equatorial coordinates: rt asc $\alpha = 136^\circ 41'$, decl

[156] Only if performed at Wandsbeck could obs have been even partially real. So, it says something for how proud was the party responsible for them, that: the record is missing. (This is highly exceptional. See §P4 under "m" & see fn 136.) The extant Wandsbeck observations before 1598/1/2 (when cat D was first distributed) are published at OO 13:105-113. They contain no data whatsoever for adding stars to cat D — neither in Cen nor in any other constellation. As to why the λ were faked (while δ obs via cross-staff): Tycho had no fixed instruments mounted at Wandsbeck before 1598/1/2. (See Dreyer 1890 p.258.) See Rawlins 1992T §G2 & Table 2 for fuller discussion.

[157] Due to repeats, the Final Fifty stars (starting 1596/10/5) produce fifty-six cat D places, not counting D428 but counting both D345 & D600 (identical): 8 places (3 stars) on 1596/10/5 and 48 places (47 stars) in 1597.

[158] The previously-unidentified or incorrectly-identified stars of Tycho's Final Fifty (in temporal order of observation): D565 (13θ Cyg, tho this possibility is suggested at OO 3:415), D566 (hybrid-nonexistent), D567 (ditto), D568 (54λ Cyg), D569 (13θ Cyg), D596 (HR743), D597 (HR932), D603 (12 Lyn), D403 (15&17 CVn: see fn 174), D407 (HR5110), D408 (25 CVn), D409 (HR5186), D410 (HR5214-5215). Considering the relative resources available to Tycho-editor Dreyer, compared to those astronomers have at hand today, I think he did a creditable job in his attempts at star-identification. See fn 16.

[159] The TBmss record (Gl. kgl. Samling 316 fol., microfilm 546, p.163b) suggests that at least some Table 19 TB calcs here were either orig done for E&E 1601.0, or were not later precessed. E.g., the rt asc for D569 is there displayed as $\alpha = 291^\circ 26' 1/2$, which agrees precisely with the implicit cat D value. (See at D569 in Table 21.)

Table 19: Tycho Stars 1596/10/5 (Mean E&E of Date)

catD#	Star	m	catDδ	Obsδ	Realδ	r*	Obs$g$	Real$g$	catDα	Obsα	Realα
D411	26 UMa	4.50	$54^\circ10'$	$53^\circ52'$	$53^\circ47'$	α Aur	$41^\circ17'$	$41^\circ19'$	$136^\circ41'$	$136^\circ38'$	$136^\circ39'$
D567	26 UMa	4.50	*53°52′*	$53^\circ52'$	$53^\circ47'$	η UMa	$38^\circ51'$	$38^\circ51'$	*137°36′*	$136^\circ32'$	$136^\circ39'$
D550	13θ Cyg	4.48	$49^\circ23'$	$49^\circ23'$	$49^\circ19'$	α Cyg	$11^\circ56'$	$11^\circ57'$	$291^\circ26'$	$291^\circ27'$	$291^\circ24'$
D554	54λ Cyg	4.53	$35^\circ05'$	$35^\circ05'$	$35^\circ03'$	β Peg	$29^\circ50'$	$29^\circ50'$	$307^\circ56'$	$307^\circ57'$	$307^\circ56'$
D565	13θ Cyg	4.48	$49^\circ18'$	$49^\circ23'$	$49^\circ19'$	α Lyr	$15^\circ29'$	$15^\circ34'$	$291^\circ36'$	$291^\circ11'$	$291^\circ24'$
D566	nonexistent		$11^\circ40'$	*11°56′*		α Cyg	*35°05′*		$322^\circ08'$	$323^\circ46'$	
D567	nonexistent		$11^\circ56'$	*11°56′*		α Cyg	*35°05′*		$321^\circ40'$	$323^\circ46'$	
D568	54λ Cyg	4.53	$35^\circ05'$	$35^\circ05'$	$35^\circ03'$	α Lyr	$25^\circ46'$	$25^\circ49'$	$303^\circ04'$	$307^\circ53'$	$307^\circ56'$
D569	13θ Cyg	4.48	$49^\circ23'$	$49^\circ19'$	$49^\circ23'$	β Peg	$44^\circ43'$	$44^\circ42'$	$291^\circ25'$	$291^\circ25'$	$291^\circ24'$

$\delta = 54^\circ10'$. Actual 1596.79 place of 26 UMa: $\alpha = 136^\circ39'$, $\delta = 53^\circ47'$. (See the "Real" columns in Table 19.) The α match ($\Gamma\alpha = +1'$) is acc, and D411's discordant δ must be merely a slip (see §M2 at "misinv"), since the observed & recorded $\delta = 53^\circ52'$ (OO 13:59) is also an OK match (O$-$C = $\Delta = +5'$) to that of the real 26 UMa for 1596.79. The g obs were taken vs. reference stars ("r*" in Table 19) α Aur & η UMa. Acc DR calcs from these data give D411's rt asc $\alpha = 136^\circ38'$ (acc) & $136^\circ32'$ (poor), so these values are placed under the column-heading "Obsα" in Table 19.

N5 The other seven 1596/10/5 places (D550, D554, & D565-569) are largely or entirely (see at D567 in §N9) based on observations of just 2 stars, 13θ Cyg ("upper wing of Cygnus") & 54λ Cyg ("lower wing of Cygnus"). D569 is the same star as D550 & D565. (All three cat D places are near-identical.) D567 may be a miswr repeat of nonexistent D566. And D568 (despite a nearly -5° misarg[160] in α) is the same star as D554. Thus (adopting option [a] in §N9), we appear to have but 3 distinct cat D places; taking the last cat D pstn in each case, these are: D567, D568, D569. We convert D567-569 (as in §N4) from cat D to 1596.79 eqt coords ($-3'.6$ precession in λ). For declination δ, we find: $11^\circ56'$ (D567), $35^\circ05'$ (D568), & $49^\circ23'$ (D569). The data $11^\circ56'$, $35^\circ05'$,[161] $49^\circ23'1/4$ are found right in the brief 1596/10/5 record (OO 13:59-60).

N6 These stars are based upon data taken by Tycho's common method (§B6): [a] measure δ (we note that the 1596/10/5 declinations exhibit a systematic positive error of c.$4'$); then, [b] find α by sextant observation of the quarry star's gt-circ distance g from a well-fixed ref star. E.g., 13θ Cyg was observed (OO 3:59) to be (mean)[162] $g = 44^\circ43'1/8$ (acc) from Scheat (β Peg). (Real g then = $44^\circ42'$.) Using $g = 44^\circ43'1/8$, quarry star $\delta = 49^\circ23'1/4$, & the S list (Table 22) eqt pstn (precessed) for ref-star Scheat ($\alpha_\mathrm{r} = 341^\circ06'$, $\delta_\mathrm{r} = 25^\circ54'2/3$), sph trig computation via the standard equation (from law of cosines)

[160] The error in D568's α occurred as misarg during calc of ecl place, since its α is written as $307^\circ56'$ (the 7 distorted & the 6 obscured), a nearly corr value, in the pre-calc TBmss record: Gl. kgl. Samling 316 fol., microfilm 546, p.163b. But this datum was probably misrd there as $303^\circ05'$, which is within $1'$ of the implicit cat D α for D568. (See at D568 in Table 21.)

[161] Also $35^\circ06'$. The average ($35^\circ05'1/2$) is rendered as $35^\circ05'$ in Table 19, tho $35^\circ05'1/2$ was used in the table's underlying computations. Similarly, the mean obs g for D565 was $11^\circ55'7/12$, which was obviously rounded by the computer to $11^\circ55'1/2$ — and is rounded in Table 19 to $11^\circ56'$.

[162] The g of 13θ Cyg from Scheat was observed twice: $44^\circ43'$ & $44^\circ43'1/4$. Here, throughout, we average such repeated values into one datum, for purposes of tabulating and counting. The exact mean was used in calculations for Tables 19&20, but the values entered into those two tables are uniformly rounded to the nearest arcmin. Occasional $1'$ apparent discrepancies (compared to the g of OO 13:98-100) are merely due to rounding of real g and Δ before listing in Table 20 here.

$$\cos[\alpha - \alpha_\mathrm{r}] = [\cos g - \sin\delta\sin\delta_\mathrm{r}]/[\cos\delta\cos\delta_\mathrm{r}] \qquad (6)$$

gave Tycho's computer $\alpha = 341^\circ06' - 49^\circ41' = 291^\circ25'$. (This result is found in the last row of Table 19, in the cat Dα column.) Transf-calc of this eqt pstn to ecl pstn, adding 4^y of precession to λ, produced $\lambda = 313^\circ18'$, $\beta = 69^\circ42'$. These are precisely the λ & β of D569. (Other Final-Fifty stars were similarly computed — only rarely this accurately.)

N7 An explanation of some of the headings in Table 19: "catDα" & "catDδ" are the mean E&E-of-date implicit equatorial coordinates corresponding (see §N4) to the ecliptical position in cat D (epoch 1601.03); and "Obsα" refers to the rt asc α *accurately* deduced from the observed δ, the observed g, and Tycho's own[163] equatorial coordinates (precessed at $51''$/yr from 1601.03 to 1596.79) for the chosen ref star (Select ref stars' 1601.0 eqt coords listed at Table 22). It will easily be seen from Table 19 that the main source of error in these cat D places is not observational but computational. (Remember: the work was last-minute and done without logs.) Whereas not one of the numerous 1596/10/5 observations' errors exceeds $5'$, the calc & scribal slips produce errors as high as c.5° in the deduced pstns.

N8 The strangest errors by the antique computer of these places: D566 & D567 are not outdoor stars at all. Rather, they are merely the issue of inadvertent data-inversion: the observed g between 13θ Cyg[164] and Deneb (α Cyg) was taken to be an observed δ, while the δ of 54λ Cyg was taken to be g measured from Deneb! (In Table 19: for D566&567, the "Obs" data for δ & g are listed exactly as the mixed-up computer would have listed them, and italics distinguish the data misunderstood & thus mis-classified by Tycho's computer.)

N9 We will next attempt[165] to speculate-reconstruct a few of the other, less gross errors in D565-D568.

D565 is based (badly) upon OK $g = 15^\circ29'$ vs. Vega. Computer started by conventional calc (§B6 & eq. 6), using obs $\delta = 49^\circ23'$ & TB-precessed Table 22 eqt coords for S75 = Vega (OO 3:377), $\alpha_\mathrm{r} = 275^\circ50'$ & $\delta_\mathrm{r} = 38^\circ28'$. He acc got $\alpha = 291^\circ12'$, & acc transf-calc then yielded $\beta = 69^\circ45'$, miswr as $69^\circ35'$. Unchecked (unusual for TB) use of eq. 4 gave $\lambda = 312^\circ27'$, misarg (by $+1^\circ$) as $313^\circ27'$, which (after adding 4^y of TB precession) became $313^\circ31'$.

For nonexistent-hybrid D566, the first slip was $-1^\circ/4$: $\delta = 11^\circ41'$ (perhaps $1^\circ/2$ miswr of D567's $11^\circ11'$), permanently misargf $11^\circ56'$ (which is actually 13θ Cyg's g vs. Deneb here & in transf). Assuming $g = 35^\circ05'1/2$ (actually 54λ Cyg's δ) vs. Deneb (Table 22's S85, 1596.79 TB: $\alpha_\mathrm{r} = 306^\circ55'$, $\delta_\mathrm{r} = 43^\circ52'1/2$), the computer found (via eq. 6) $\alpha = 306^\circ55' + 16^\circ12'$, which he misadded by -1°, getting $322^\circ07'$. Acc transf-calc upon this & $\delta = 11^\circ41'$ produces (to $1'$) the ecl coords of D566.

As for D567, two different explanations ([a]&[b]) produce pstn. Possibly both contributed. (Table 19 exhibits both, while Table 21 adopts [a].) [a] Latitude $\beta = 35^\circ35'$ screrrf $25^\circ35'$, restor. Similar to D566, but δ temporarily misarg (arcmin confused for degrees) in eq. 6 (but not in transf) as $11^\circ11'$. Acc subseq calc yielded $14^\circ46' + 306^\circ55' = 321^\circ40'$. (See 7th row of Table 19.) Acc transf-calc upon this & $\delta = 11^\circ56'$ yields D567's ecl coords to $1'$. [b] Latitude $\beta = 35^\circ35'$ is from calc[166] for 26 UMa (D411) found in TBmss at Gl. kgl. Samling 316 fol., microfilm 546, p.163b ($35^\circ34'1/2$). The $\lambda = 328^\circ22'$ got its arcmin from same calc ($122^\circ21'2/3$), while the degrees were from λ of D566.

[163] See fn 171.

[164] Consultation of the data-record's verbal text leaves no question about what occurred. Right after several g data for 54 λ Cyg ("lower wing of Cygnus"), OO 13:60 states that measures of $35^\circ05'$ & $35^\circ06'$ are "declinations of same". Then, immediately following these data, the observer says he returns to measure the g of 13θ Cyg ("upper . . . wing again") from Deneb. Note that the places of D566 & D567 make no sense as they stand, since they are entirely outside of Cygnus, in Pegasus!

[165] The several explanations attempted here are based on the assumption that the computer's detailed sph trig steps were OK. The premis is far from solid, at this point in the history of TB's school.

[166] Explanation [b] appears in the 2nd row of Table 19, with the TBmss ecl pstn's implicit eqt coords in italics. Coords in TBmss: $\alpha = 136^\circ35'$ (precise rendition: $136^\circ34'50''$) & $\delta = 53^\circ52'$, $\lambda = 122^\circ21'2/3$ & $\beta = 35^\circ34'1/2$. Obvious -1° slip: $\alpha = 136^\circ35'$ misargf $137^\circ35'$.

D568 is based on calc from OK g (vs. Vega) & δ; but very poor $\alpha = 303°05'$, based upon misrd (fn 160).

N10 The upshot: [a] All the 8 places (D411, D550, D554, & D565-569) have been traced here, even though [b] only 3 actual outdoor stars are the basis of these data. I will leave the reader to judge whether or not this was deliberate data-padding. (Given the sloppy math exhibited throughout these reductions, I don't find it absolutely necessary to assume anything conscious about the process. But, given the rarity of such TB-school mass-bungling, it is suspicious that this occurred at the very time when unique pressure was on, to produce as many stars as possible.) Regardless, these places' accuracy is far below the high standard of Tycho in his heyday.

N11 We turn now to consider the star data taken in 1597 (OO 13:98-100). The dates are 1597/2/8,[167] 2/10, 3/3, 3/4, 3/5, 3/9, 3/10. At the head of these data appears the statement (OO 3:98; see also OO 10:xviii), "Need 60 [more stars] to complete the thousand." But only 47 stars are recorded. (How the deficit of 13 was made up has been analysed in Rawlins 1992T §D4-§F7.) The 6th object in Table 20 is a repeat entry: D345 ≡ D600. (Thus, its cat D & HR numbers are italicized in Table 20.) And the 5th observation in Table 20 is an incomplete[168] record of 31ψ1 Dra (HR6636-6637). (The observation may have been left incomplete when it was realized that this star had been earlier fully observed & recorded as D428.) Thus, including 31ψ1 Dra, there were 48 stellar objects recorded in 1597, all listed here in Table 20.

N12 For the 1597 stars, Tycho switched over to his alternate observing procedure: instead of (as usually before: §B6 & §N6) taking, for each quarry-star, a declination δ by transit instrument (or eqt armillary) and a great-circle arc g (from a ref star) by sextant, he began taking two g arcs (from two different ref stars) by sextant (§B8). The procedure-alteration of switching to two-g observations was not due to loss of ability to make transit or declination observations. (Many such data for the Sun, Moon, & planets date from the same time period, as we see from OO 13:78-98.) I suppose that the two-g star-taking process was simply less complicated (observationally) and less subject to misidentification[169] of now-uniformly dim (thus more easily confused)[170] quarry stars. See also fn 33's remark that the two-g method was frequently applied to northern stars. (All Final Fifty stars are northern.)

N13 However, the §B8 reduction of stars from such data is far more complex, mathematically, than the usual process. In Tycho's day, before log tables' general availability, the work would have been formidable. As we will see, it is too much (given TB's rush) to expect that each of these stars would be computed via rigorous sph trig.

N14 In only one sense would the math be easier than the usual: there was now no reason to revert (at any stage of reduction math) to the equatorial frame. Thus, the computer was spared the customary final equatorial-to-ecliptic transformation process.

N15 In Table 20 here, I provide the 1597 Tycho stellar data, in the ecliptic frame (longitude λ & latitude β). The main Table 20 data are: the "catD" coordinates, the "Obs"

[167] Misprinted as 1597/2/4 at OO 13:98. (Error revealed by direct 1994/5/27 Dennis & Barbara Rawlins exam of microfilm of original TBmss: Gl. kgl. Samling 316 fol., microfilm 546, p.127a.) The ecl places listed there for 2/8 & 2/10 are (except for D644) merely reductions of observed 2/8 & 2/10 data, respectively, printed on the same page. Thus, they do not add to the star-total.

[168] One cannot of course compute a place from a single g datum (which is all that was recorded for the 5th star of Table 20), but the cat D & real positions for D428 are included here anyway so that the accuracy of all the 1597 sextant g data can be comprehended together. (However, the position of D428 in cat D is not based upon 1597 observations; indeed, this star appears in cat C as C359.) Note that there is obviously a $-1°$ error in D428's β. (See under D428 in §M4.) And note that the apparently huge $-86'$ error (CatD−real) in λ is merely $-9'$ in great-circle measure.

[169] Thoren 1990 p.295 describes the process: g one night, δ another. For dim objects, the possibilities of confusion causing hybrid catalog "stars" are obvious — and became real on occasion (fn 170).

[170] Cat D has some stars which I call "hybrid". (See fn 78 for list of all.) Most of these are based upon δ of one star, g of another. But, for two-g based stars, such errors are rarer (D358, D484, & perhaps D647), since the two data were taken consecutively on the same instrument by the same observer.

Table 20: Tycho Stars 1597/2/8-1597/3/10 (Mean E&E 1601.03)

catD#	HR	γ_D	r*	Realg_a	Δ	Realg_b	Δ	catDλ	Obsλ	Realλ	catDβ	Obsβ	Realβ
D596	0743	57°	0,1	16°27′	−02′	32°15′	+06′	061°46′	061°58′	062°02′	53°16′	53°19′	53°15′
D597	0932	45°	0,1	14°53′	−02′	31°27′	+13′	066°12′	066°26′	066°49′	53°32′	53°38′	53°29′
D598	1148	60°	0,1	17°59′	−03′	27°18′	+02′	060°11′	069°07′	069°05′	52°04′	49°36′	49°34′
D599	1138	40°	0,1	18°26′	+03′	26°59′	+01′	066°45′	068°35′	068°43′	49°08′	49°09′	49°10′
D428	6636		7	32°40′	−00′			096°34′	nms	098°00′	83°04′	nms	84°07′
D345	*1622*	25′	0,1	30°28′	−03′	13°01′	−03′	077°17′	*077°19′*	075°55′	35°50′	*35°48′*	35°53′
D346	1603	15′	0,1	28°59′	−04′	14°32′	−04′	077°28′	*077°31′*	075°42′	37°20′	*37°17′*	37°23′
D348	0985	20′	0,*1*	23°38′	+04′			078°03′	*078°08′*	062°20′	42°56′	*42°30′*	45°12′
D347	1542	18′	0,1	23°04′	−*01*′	20°31′	−03′	077°45′	*077°50′*	075°25′	40°13′	*40°09′*	43°22′
D646	1046	46°	0,*1*	33°50′	+02′	19°08′	−07′	064°41′	*064°50′*	059°27′	49°27′	*49°30′*	35°10′
D645	1040	48°	0,*1*	30°25′	+05′	20°29′	−04′	064°02′	*063°58′*	060°44′	48°07′	*48°13′*	38°26′
D647	1035	45°	0,*1*	29°21′	+02′	21°04′	−03′	066°15′	*066°21′*	061°02′	53°37′	*53°39′*	39°29′
D644	0985	53°	0,1	23°38′	+04′	25°05′	−02′	062°18′	062°18′	062°20′	45°10′	45°08′	45°12′
D601	2238	17°	2,3	37°59′	−05′	34°20′	+01′	087°19′	087°21′	087°32′	35°48′	35°27′	35°34′
D602	2560	24°	2,3	42°03′	−03′	31°33′	−07′	092°33′	093°18′	093°34′	34°49′	35°07′	35°24′
D603	2470	17°	2,3	40°19′	−04′	33°01′	−09′	093°00′	091°18′	091°41′	30°22′	35°51′	36°15′
D604	2490	37°	2,3	35°49′	−04′	40°23′	−01′	090°45′	091°06′	091°11′	44°10′	44°19′	44°23′
D605	2511	40°	2,3	35°19′	+02′	41°34′	+01′	090°57′	091°27′	091°18′	45°32′	45°46′	45°43′
D606	2209	35°	2,3	32°23′	−07′	43°11′	+10′	086°15′	086°46′	086°49′	45°43′	46°01′	45°53′
D607	2527	54°	2,3	31°59′	+*05*′	49°15′	−02′	090°10′	090°16′	090°05′	53°43′	53°46′	53°47′
D608	2401	58°	2,3	30°28′	−06′	51°59′	+06′	087°45′	088°04′	088°10′	56°15′	56°21′	56°18′
D609	3082	62°	2,3	33°45′	−06′	51°30′	−02′	094°13′	094°17′	094°27′	56°55′	57°00′	57°05′
D610	2742	65°	2,3	31°15′	+07′	54°24′	+00′	089°58′	090°28′	090°11′	59°18′	59°25′	59°23′
D611	3751	30′	1,4	40°55′	−05′	16°24′	−13′	097°54′	*097°44′*	098°53′	60°47′	*61°03′*	60°38′
D612	4084	02°	1,4	42°59′	−16′	14°19′	−13′	100°14′	*100°11′*	099°41′	62°04′	*62°49′*	62°52′
D613	4062	75′	1,4	43°06′	−13′	14°23′	−08′	099°37′	*100°00′*	096°31′	62°46′	*62°41′*	63°48′
D614	4893	21°	*1,4*	46°51′	−10′	10°41′	+29′	110°58′	111°08′	101°07′	63°17′	63°22′	67°03′
D399	5154	56°	*4,6*	20°41′	−02′	51°19′	+13′	111°29′	111°43′	163°39′	53°08′	53°16′	57°50′
D400	5023	52°	*4,6*	26°22′	−07′	46°11′	−01′	113°55′	113°59′	164°39′	47°14′	47°19′	51°47′
D401	5112	59°	*4,6*	26°26′	−01′	48°25′	−00′	109°49′	109°50′	168°45′	47°30′	47°39′	52°52′
D402	4943	58°	*5,9*	46°27′	−07′	15°32′	−*15*′	143°17′	143°02′	172°46′	46°50′	46°46′	38°54′
D403	4971	39°	*5,9*	48°11′	+00′	12°44′	−04′	153°58′	153°45′	171°59′	47°55′	47°56′	41°40′
D404	4997	37°	*5,9*	49°27′	−03′	10°57′	+06′	156°00′	155°47′	171°39′	48°40′	48°50′	43°27′
D405	5017	41°	*5,9*	50°17′	+07′	10°13′	−02′	156°30′	156°24′	172°13′	49°42′	49°46′	44°12′
D406	5032	41°	*5,9*	50°38′	−18′	10°21′	−05′	156°19′	156°18′	173°08′	49°42′	49°42′	44°07′
D407	5110	55°	*4*,5	38°05′	+*40*′	52°26′	+37′	169°05′	169°12′	178°34′	49°00′	48°58′	43°00′
D408	5127	53°	*4*,5	38°53′	−*03*′	52°45′	+19′	168°01′	169°04′	179°49′	49°27′	49°03′	42°30′
D409	5186	64°	*4*,5	36°24′	+21′	55°07′	−07′	175°42′	176°04′	180°32′	48°11′	48°06′	45°24′
D410	5215	52°	*4*,5	40°08′	+01′	55°08′	−03′	166°02′	165°59′	184°09′	52°25′	52°27′	42°27′
D349	4126	19°	1,9	43°15′	+00′	32°37′	+08′	111°38′	109°58′	110°36′	57°55′	58°54′	58°34′
D350	4646	48°	1,9	48°08′	−12′	29°43′	−*07*′	081°55′	082°09′	113°54′	70°42′	70°39′	64°12′
D351	0285	56°	1,9	42°18′	−05′	44°23′	−02′	084°31′	075°59′	075°53′	69°08′	65°03′	65°10′
D352	8546	60°	1,9	45°09′	+01′	43°05′	−02′	075°07′	075°03′	075°06′	68°04′	68°00′	68°00′
D353	8702	64°	1,9	45°14′	−28′	45°44′	+01′	067°22′	067°43′	067°01′	67°43′	67°17′	67°44′
D354	8748	62°	1,9	44°48′	+00′	44°56′	−13′	069°57′	070°39′	070°08′	67°22′	67°30′	67°29′
D355	2609	48°	1,9	41°35′	+03′	40°52′	+15′	086°30′	086°19′	087°18′	63°55′	63°56′	63°47′
D481	5618	23°	0,8	43°05′	−04′	29°53′	+07′	191°49′	192°33′	192°12′	60°40′	60°46′	60°35′
D482	5627	24°	0,8	42°35′	+22′	30°26′	−19′	192°33′	192°43′	192°02′	60°57′	60°54′	61°07′

coordinates (deduced by DR via precise sph trig from the raw two-g data, combined with the ecliptical cat D positions for the chosen ref stars),[171] and the real coords (computed by DR from modern tables). All pstns are given for E&E 1601.03, cat D's epoch. Several obvious whole-degree scribal slips are accounted for or restor (indicated by italics in Table 20's Δ column). E.g., for D402, g = 19°17′ (vs. Alkaid) screrrf 15°17′. (See D143 in §M3 for another case of 5 mistaken for 9.) For D347, g = 26°03′1/2 (vs. Polaris) screrrf 23°03′1/2. And, in the two-g calc of D350's pstn, a $+10°$ error occurred: g = 39°36′ (vs. η UMa) misargf 29°36′. Similarly, for D407&D408, evidently 36° screrrf 38°. In the Δ (O$-$C) entries of Table 20, the above-cited restorations are adopted (denoted by italics). However, in all such cases, the unrestor g were used for DR's sph trig computation of the "Obs" coordinates, in order to permit meaningful comparison of these positions to the adjacent "catD" column. (See also §N20.)

N16 For some cases, the "Obs" coordinates were impossible to compute via two-g math, because (fn 133) the sum of the two g values was a trifle less than the great-circle distance between the two ref stars. For these cases (also high-flab cases D347-348 & D645-647), TB resorted to lineup calcs. Our acc lineup calcs for these cases are provided in the "Obs" column. The use of lineup math is indicated by italics there. For single-g D428, Table 20 simply lists "nms" (no-math-solution) in the column for "Obs" coords. For such objects as D348, Tycho gives a cat D position, nonetheless. (See under "u" or "U" at §P4.) This set of cases provides several valuable insights: [a] It confirms the use of lineup calc since there is no other way to calc a pstn from a single g. [b] For some quarry stars, the 2 ref stars were so badly chosen (quarry star virtually on their great circle) that a mere few arcmin of observational error rendered rigorous sph trig solutions either [i] flabby in the direction roughly perpendicular to the gt-circ connecting the two ref stars, or [ii] mathematically impossible. Item [b] indicates that the observer was lacking[172] in scrupulousness and-or providentiality. Item [a] is verified by the obvious use of the "lineup" method (see above at §B9 & fn 36) for several sets of these stars: D345-348, D611-613, D645-647. (Each set is discussed in §M4.) Stars D644-647 are an especially curious bunch. D644 is based upon initial careful two-g calc of pstn — and then D645&646 were supposed to be just lineup-placed with respect to Polaris along the gt-circ connecting Polaris to the D644 anchor, with D647 placed likewise except using β Per instead of D644. But, in this revealing case, the extrapolator got confused about the order of the 4 stars. (Note that their listing in cat D is, exceptionally, not in the same order in which they were observed.) So, when using the rough observer's diagram (reproduced at OO 13:99), he went in the wrong direction with his differential placements. (Thus, D644 is the only star of the four that is accurate. See full details in §M4 at D644-647. The g used in the calcs for placing D645-647 are there reconstructed; these g are adopted here in our lineup calcs, whose results are listed — *italicized* — in the "Obs" columns of Table 20.)

N17 Several devices are used here to save space in the already-overdense Table 20. E.g., the cataloged[173] stars (some of which lack Bayer or even Flamsteed tags) are uniformly identified by Harvard Revised Photometry ("HR") number. For each multiple[174] star,

[171] Same approach as at §N7: the "Obs" coordinates computed here (α in Table 19, λ & β in Table 20) are those which Tycho himself would have deduced (assuming perfect mathematics), from his observed data for the quarry star & for the ref star(s).

[172] Choosing ref stars on the same great circle through the quarry star is analogous (both mathematically & follywise) to steering for a geographical pole with nothing but meridian (noon-or-midnight) observations. (See fn 102 & *DIO 2.3* ‡8 §B.) And this is centuries before National Geographic. . . .

[173] An instance of the insanity of English-language convention: according to the indications (under "catalog" & "catalogue") of one of the Big modern dictionaries, it is prahpah to use "cataloger" (u optional) but not "cataloged" or "cataloging", where the u is demanded. If my universal to-hell-with-u attitude on this point offends anyone, I refer said superpedant to my wife, a professional cataloger, who hasn't used the u in decades.

[174] Multiple stars in Final Fifty: D345 (same as D600) = HR1622-1623 (Cam 11-12), D428 = HR6636-6637, D614 = HR4892-4893, D403 = HR4967&4971, D410 = HR5214-5215. E.g., D403 is CVn 15&17, where m_1 = 6.28, m_2 = 5.91: thus, comb m = 5.33. At OO 13:100 n.1, Dreyer set D403 = just CVn 15, which (at magn 6.28) is too dim for Tycho to have bothered with it, if it were a lone star.

Table 20's Realλ Realβ columns list only (see fn 106) the position of the brightest component. (And its HR# alone is cited there.) The ref stars ("r*") — most of them found on Tycho's list of Select stars — are specified (in the order a, b, corresponding to the measured gt-circ arcs g_{a}, g_{b}, respectively), according to the code: 0 = Polaris (α UMi), 1 = Capella (α Aur), 2 = γ Cas, 3 = Pollux (β Gem), 4 = Kochab (β UMi), 5 = Regulus (α Leo), 6 = Algieba (γ Leo), 7 = Alioth (ϵ UMa), 8 = Arcturus (α Boo), 9 = Alkaid (η UMa). Also, instead of repeating here Tycho's mean observed g data (which are printed at OO 13:98-100), I list in Table 20 just real g and obs g's error Δ (O$-$C).[175] Table 20 also lists γ_{D}, the angle[176] of intersection of Tycho's two cat D g arcs. Note that flabbiness ϕ = csc γ (fn 102). Thus, if γ is a small angle, severe pstn inaccuracy is expected. For cases of single g, "nms" indicates the obvious: no-math-solution possible. For cases of lineup calcs by Tycho, the "Obs" coords are in *italics*: these coords are precisely what acc sph trig lineup calcs[177] would have given. (For details of individual lineup calcs, consult entries for those stars, in §M4. For D348, see also fn 177, here. Note: in Table 20, D348's italicized 2nd ref star was supposed to be Capella, but the intended g did not materialize.) It will be seen from Tables 19&20 that most of the Final Fifty raw observed Tycho star data (δ & g) constitute OK naked-eye measurements of dim objects.

N18 The samples displayed in Tables 19&20 are difficult to study statistically, given the nonuniform conditions governing the work, both indoor & outdoor. But a few general observations can be made without sophisticated analysis. One surprising result: a few of the Table 20 stars (particularly D644 & D352), taken in such notorious haste — and by evidently inexperienced observer(s) — are comparable in accuracy to the main body of Tycho's cat D. And for both Tables 19&20, we see that by far the greatest source of errors in these stars' positions was computational, not observational — the inverse of the usual situation in cat D. Indeed, under the panic-circumstances, the observational accuracy is impressive more often than not. Though there are indeed a few gross misfires,[178] the median Δ is 4′ — and for dim stars, averaging fifth magnitude, recorded with rapacious rapidity in the bare-eyeball pre-telescopic era. This supplies yet another (unexpected) testimony to the accuracy-advance Tycho's school had made, beyond every one of several millennia of prior astronomers. Ancient astronomers' single-datum mean error of first magnitude stars' δ (a simpler measurement) is no better.

N19 Another surprising feature of the Final Fifty: every one of the (pre-extinction) magnitudes m is in the modest range 4.03 to 5.60. Not one of these 50 stars' post-extinction magnitudes was greater than about 5 3/4. (Four stars of the set have $m \geq 5.50$: D613, D406, D409, D482. None has both g accurate.) This refutes the natural expectation that Tycho went after very dim stars during his last desperate weeks at Hven. Which argues powerfully against the Hven team having tried for 2g Cen (D1001), since its post-extinction magnitude was μ = 6.47 at Hven (Table 18) or μ_J = 6.51 at Wandsbeck (fn 95). By

[175] Δ = O$-$C = Observed-minus-Calculated, where "O" is TB-observed g & "C" is real g, the latter modernly-Calculated for 1601.03. I here neglect the tiny differential effects upon g due to refraction, aberration, & nutation.

[176] See definitions of γ and "flab" ϕ (= 1/cos γ) in §M2. (See fn 101-fn 103.) For Table 20, we calc γ_{D} purely from Tycho data: the observed g and the cat D coords of the two ref-stars.

[177] See fn 36. Acc two-g calc of D347 pstn would yield (λ & β, resp): 75°58′ & 43°18′. If D348's g misinv (§M4) not restor to OO 13:98 obs value (23°41′19/24, used in Table 20), then acc lineup calc (§B9) would yield (λ & β, resp): 78°08′ & 42°53′, which is close to the cat D pstn.

[178] The large errors are unrandomly clumped in time. Some are presumably from bad weather which, under less strained circumstances, would have caused the observer to cease. (Perhaps cloud-obscuration was a cause of what appears to be mere data-repetition in the series D407-409. Another possible interpretation: all the data D407-409 are of HR5214-5, with 55° sometimes miswritten as 53°, and the record augmented by repeated transit observations of this star's declination; its real δ was 36°43′.) It is apparent that the number of large Δ tends to grow, as the day of departure from Hven approaches. It does not require a psychologist to guess that the observations were increasingly rushed and thus became less reliable. Alternate explanation: some of the observations were perhaps made by a single person — contra Tycho's proper explicit specification (fn 28) that its accurate use required 2 observers working cooperatively. (Note the problems with errors in the records of 18th century astronomer P. Lemonnier, who did massive positional astronomy by himself: Rawlins 1981L.)

contrast, DR's atm model yields a much more credible Wandsbeck $\mu = 5.81$ (fn 95) for 4h Cen (dimmest of the 4 stars, there).

N20 The oddest 1597 cases are D399-410. From Tycho's crude diagrams, Dreyer turned out an admirably flawless set of identifications of D399-406. He was prevented from going further only because the data-record neglects to state that the g data for D407-410 are not from the same ref stars as those immediately preceding (D402-406), which were measured from Alkaid (η UMa) & Regulus (α Leo). After observing D406, the observer just (continuing to use Regulus as his other ref star) quietly exchanged Alkaid for Kochab[179] (β UMi), though making no note of this in the record. (See concluding suggestion in fn 178.) Worse: the contingent pstns (D407-410) were then computed[180] as if the g_a observations were measured from Denebola (β Leo) instead of Kochab! (Thus, in Table 20, for these four observations, the Kochab star code is italicized. In Table 21, the obs are marked "c" for confusion.) Worst: for all the other stars (D399-406) of this dozen, as well as for the preceding star (D614), the computer took the wrong member of the pair[181] of solutions one inevitably obtains (via pure math) from such data. (Which is why both ref-star-codes are italicized in Table 20 for these nine stars: D614-406. Such wrong-choice stars are called "WCP" in §M, and the two-g instances are marked "w" in col.x of our Table 21.) Thus, not one of the star places D399-410 corresponds to a real star. In Table 20, for D614 & D399-410, I have listed the wrong[182] solutions under both "Obs" & "catD", in order that one may gauge the accuracy of the math, which (for pre-log work) is the most historically interesting part of the process. (E.g., Table 20's "Obs" coordinates for D407-410 are calculated by DR on the false assumption that the 2nd ref star was indeed Denebola. Policy similar to that of §N15.) Note that some of these misbegotten solutions are accurately computed (e.g., D405, D406, & D410). They are among the class of excellent calculations here (see also such examples as D644 & D352) which prove positively that at least some of these swift, final-days, two-g-based star positions were computed by rigorous sph trig. The computation of such a sizable sample of stars thusly at this late, confused stage of Tycho's career shows that a remnant of its prior crest's skills & drive lived yet.

N21 However, one cannot evade the fact that very few of the Final Fifty stars here considered (1596/10/5-1597/3/10, Tables 19&20) are up to Tycho's standard, when cat D coordinates are compared to the real coordinates — which is naturally the crucial test. Only three cat D places of Tycho's Final Fifty stars were accurate to within $5'$ of great-circle distance: D596, D644, & D352. (And two potentially accurate stars were apparent victims of whole-degree misprints: D599 & D607. Also, D410 would have been accurate to c.$5'$ gt-circ, but for the computer's use of a wrong ref star.) Thus, Longomontanus' decision to omit the last-gasp stars is vindicated, though (as noted at Rawlins 1992T §E5), he went too far in also jettisoning the less-hastily gathered 156 stars of Tycho's 1596 Appendix, which DR has found (*idem*) are roughly as accurate as the rest of cat D.

[179] Not Kochab's 1st appearance as improperly-identified ref star. (See fn 130.) Actually, it is peculiar that Kochab would be used as a ref object at all: [a] Its equatorial cat D position (D341) is off by $7'$ (gt circ): $\Delta\alpha = -16'$ ($-4'$ gt circ), $\Delta\delta = +6'$. (The gt circ error is $9'$ in the ecliptic frame. In cat D, ecliptic errors are generally larger than equatorial, due to the $+2'$ error in Tycho's adopted obliquity.) This is an astonishingly large error for a Tycho ref star (tho α Per's ecl error is larger yet), and the $7'$ error naturally affects all the stars measured from it, e.g., in Table 20. [b] Kochab is not on the list of 100 Select-stars whose eqt coords (& Tychonic precession rates) are appended to cat D. (See here at §I & Table 22.) This may be due to its negative α precession. (See §I2.) [c] Moreover, despite exceedingly numerous Kochab meridian & declination measures (e.g., OO 11:102-3, 106-9, 117&119, 216-222, 12:81-88, 100-102, 163), its eqt coords were never published by Tycho. (See OO 3:376 & 12:244. TB's old pre-cat D Kochab pstn, reconstructed here at D585-587 of §M4, was probably eqt, but it was not recorded in a catalog.) This suggests that the cat D position (D341) was calc from 2 gt circ arc-measures g. And this two-g hypothesis turns out to be correct; the data are: $g_a = 29°36'1/2$ vs. γ Dra (D416) and $g_b = 25°45'1/4$ vs. η UMa (D383). (Both g are found at OO 12:166. The OO 12:84 g vs. Schedar was not used.) To within $3''$ (an astonishing testament to math skills at Hven!), each of the two obs g arcs fits its respective implicit cat D g (the D341-D416 arc g & the D341-D383 arc g). Thus, the unusually large error in D341's pstn arises, not from sph trig miscues, but from $+3'$ obs errors in g_a and in the tabular δ_r of both D416 & D383.

[180] Despite these confusions, the two-g sph trig turns out to have been pretty good for all four pstns. The D408 calc's poorness is simply due to (two-g) calc use of $g = 37°10'$ misinvf $36°50'$ obs.

[181] Remember (from fn 32) that, whether one's outdoor technique is standard (§B6 for Table 19) or the swifter two-g method (§B8 for Table 20), the raw data will mathematically produce 2 solutions later, indoors. (That is, eq. 6 has two solutions, just as does the §B8 technique.) To avoid the wrong-choice-of-pair (WCP) pitfall, the observer must record sufficient information, additional to arc-angles, which will later enable the computer to choose the correct one. Thus the regular use of diagrams, of the sort displayed by Dreyer at OO 13:98-100. In truth, these are not photocopies of TB's diagrams, as close comparison to the TBmss shows: see Gl. kgl. Samling 316 fol., microfilm 546, p.127a-130b. Presumably, the published diagrams are Dreyer's hand-copies, based upon the TBmss originals. (The same is true for the drawings of constellations. E.g., the Aries depiction at OO 11:340 is not quite the same as the original: Gl. kgl. Samling 312b fol., microfilm 539.2, p.211a.))

[182] For each of these 13 cases, the correct "Obs" place accurately computed (from the observed g and the Tycho α_r & δ_r of the actual ref stars used) has been found by DR (λ & β, resp): $097°40'$ & $67°36'$ (D614), $163°53'$ & $57°59'$ (D399), $164°18'$ & $51°52'$ (D400), $168°36'$ & $52°54'$ (D401), $176°50'$ & $35°32'$ (D402), $171°49'$ & $41°45'$ (D403), $171°39'$ & $43°22'$ (D404), $172°21'$ & $44°15'$ (D405), $172°20'$ & $44°10'$ (D406), $177°55'$ & $44°18'$ (D407), $178°02'$ & $44°15'$ (D408), $180°40'$ & $45°07'$ (D409), $184°02'$ & $42°28'$ (D410). All for epoch 1601.03.

O Tycho's Rank

I conclude this extended introduction to *DIO*'s rendition of cat D by citing 3 thoughts which succinctly sum up my own view of Tycho and his achievements:

O1 Dreyer 1890 (p.363) ends his devoted account of Tycho's life with an appraisal by no less than F.Bessel, setting Tycho high upon a throne as "a king among astronomers".

O2 Tycho's grand successes were based upon an intertwining of extraordinary ability & intensely hard work; a TB credo, printed on the wall of the modern Tycho Museum at Hven, was pointed out by Hanne Dalgas Christiansen (during our 1994/5/28 family visit to Hven): it's not what you seem, but what you are.

O3 Finally, I return, for deliberate emphasis, to the apt Tycho motto (Thoren 1990 p.184) which prefaced this *DIO* volume and which has long been DR's guide:
"Neither wealth nor power, but only knowledge, alone, endures."

P Preface to Tabulation of Cat D's 1004 Stars & 100 Select Stars

We now turn to *DIO*'s 42pp Table 21 edition of cat D itself which — with Tables 22&23 for the Select Stars — follows a few brief comments & aids-to-the-user.

P1 All coords are provided in arcmin, to tenth-arcmin precision. Errors (Γ or Δ) likewise; following[183] modern convention, they are rendered O−C (obs-minus-calc, i.e., cat D-minus-real). On facing pages, I provide ecl (even page) & eqt (odd page) coords & errors. The ecl page also assigns marks for special cases, while the eqt page lists magnitudes. Note: rows (at the same vertical position) on facing pages correspond to the same star — thus, in effect, each pair of facing pages are a joint single table, with a row (for each star) extending across both pages, in one long horizontal line of data (19 columns wide).

[183] Note: Rybka 1984 uses C−O.

P2 Each even (ecl) page's columns are, in order (left to right):

$\lambda_{\rm D}$ = cat D celestial longitude.
$\beta_{\rm D}$ = cat D celestial latitude.
$\lambda_{\rm S}$ = Select Star celestial longitude.
$\beta_{\rm S}$ = Select Star celestial latitude.
λ = real (i.e., modern-calc[184] for 1601.03) mean celestial longitude.
β = real mean celestial latitude.
$\Gamma\lambda$ = gt-circ[185] error of λ in arcmin.
$\Delta\beta$ = error[186] of β in arcmin.
x = mark of exceptional entry (see §P4 for x codes).
Name = Flamsteed number and-or Bayer[187] letter, and IAU constellation.
D = number in cat D.

P3 Each odd (eqt) page's columns are, in order (left to right):

HR = "Harvard Revised" number (used by, e.g., Yale Catalog).
m = real pre-extinction magn (from Yale Catalog and-or *SkyCat2000*).
μ = real Hven culmination post-extinction magn.[188]
m = Tycho's assigned magn (note: §L7), where "n" stands for "nebulous".
$\alpha_{\rm D}$ = cat D right ascension.[189]
$\delta_{\rm D}$ = cat D declination.
$\alpha_{\rm S}$ = Select Star right ascension.
$\delta_{\rm S}$ = Select Star declination.
α = real right ascension.
δ = real declination.
$\Gamma\alpha$ = gt-circ error of α (see fn 103) in arcmin.
$\Delta\delta$ = error of δ in arcmin.
(Note: adopted Zodiac stars' $\epsilon = 23°31'$, North & South stars' $\epsilon = 23°31'1/2$.)[190]

[184] Mean E&E pstns, generated from data of Yale Catalog (Hoffleit & Jaschek 1982) — with occasional help from the superior *SkyCat2000* (Hirshfeld, Sinnott, & Ochsenbein 1991), e.g., for D278 (see fn 87) — using Newcomb's traditional precession constants. One could improve slightly upon the places thus found, but not to a degree appropriate to analysing a naked-eye catalog.

[185] Setting $\lambda_{\rm D} - \lambda = \Delta\lambda$ (not gt-circ), we have gt-circ $\Gamma\lambda = \Delta\lambda\cos\beta$. Similarly, setting $\alpha_{\rm D} - \alpha = \Delta\alpha$ (not gt-circ), we have gt-circ $\Gamma\alpha = \Delta\alpha\cos\delta$. (See fn 103.) Note that this differential approach breaks down for large differentials (where sph trig must be used to gauge the actual $O - C$ disagreement) — see, e.g., the apparent gross contradiction of the ecl & eqt error-vectors for D401. (This is most obviously due to, e.g., use of δ — ignoring $\delta_{\rm D}$ — in our definition of $\Gamma\alpha$. The distinction is trivial in most cases — but not when $\Delta\beta$ and-or $\Delta\delta$ are ordmag $10°$, as for D401 & a few other stars in this messy little corner of cat D.)

[186] Again, sign is O−C, or: cat D pstn minus real pstn.

[187] I have depended heavily upon Dreyer & PK for minor stars' Bayer letters.

[188] §L8 summarizes how μ is calc. For full details, see Rawlins 1992T fn 18. Both m & μ here calc for cat D epoch 1601.03. Zero dust presumed, for reasons discussed here at §L8 & at Rawlins 1992T fn 18, fn 65, fn 66.

[189] Remember (see fn 190): Table 21 eqt coords are implicit. (Likewise: ecl coords are implicit in Tables 22&23.)

[190] Recall from fn 39 that what is here taken to be the "obs" eqt pstn is that implicit in cat D, i.e., transf-calc by *DIO* (using the above-cited appropriate TB value for obliquity ϵ) from $\lambda_{\rm D}$ & $\beta_{\rm D}$. And keep in mind that the obliquity ϵ used in these transf-calc is slightly different for the zodiac (D1-D335) than for the northern & southern stars (D336-D1004). Again, see fn 39. According to Thoren 1990 p.298 n.138, an unpublished study by K.Moesgaard finds that, despite publicly adopting $\epsilon = 23°31'1/2$, Tycho actually used $23°31'$ for cat D. To check the matter, I computed rigorously the implicit ϵ for over 50 ordinary stars (Tau, Gem, Cnc, Sco, Sqr, Dra, Her, Lyr, Cyg, Aur, Oph, Ser, Aql, Ori, Lep, CMa, & Pup) where TB provides both eqt & ecl coords — and repeated the test on all 37 Select stars (of TB's OO 3:375-7 list: our Tables 22-23) whose α was within $30°$ of the solstitial colure. The findings: both ϵ values are used frequently, but there are statistical correlations, revealing which ϵ was generally used for eqt-to-ecl transf: $23°31'$ for zodiac & much of Ori & Oph, $23°31'1/2$ for pretty much the remainder of cat D. (There are, however, numerous individual & regional deviations. Moreover, the fact that Ori & Oph were each eqt as well as ecl suggests that use of $23°31'$ may be as correlated to eqt proximity as to zodiacal.) Since the zodiac was observed first, it seems that TB did indeed switch over to the latter figure for his post-zodiac cat D calculations, as he stated. The Thoren 1990 p.298 remarks on TB's alleged pretense to scrupulousness thus seem unjustified in this instance. But the sunnier Thoren 1990 p.226 n.16 evaluation is completely confirmed. The present DR edition of cat D will be consistently based upon $\epsilon = 23°31'$ for the Zodiac section of cat D, $23°31'1/2$ for the North & South sections.

P4 The meanings of column x codes are provided in this section.

Confusion of ref star = "c".
Duplicate[191] place = "d" or "D".
Fishy, forced, or partially fraudulent = "f".
Totally fraudulent = "F".
Accid obs-hybrid = "h". Calc-bungle-hybrid = "H". (See fn 78.)
Member of the set of 21 stars for which DR found no obs data in OO = "m". Note that every single one of the 10 stars (1% of cat D) which were surely faked resides in the mere 2% of cat D which is marked m.
Restor = "r". H&r combined = "R".
Lineup-calc = "u"; u&d (or u&D) combined = "U".
WCP (§M2) = "w" for two-g ecl case, or "W" for δ&g eqt case.[192]
Member of the Final Fifty[193] places = "z".

P5 The order of the catalog is much like that of Hipparchos-Ptolemy & Ulugh Beg, except that (instead of their North-Zodiac-South sequence) cat D's order is: Zodiac-North-South. (This is, crudely[194] speaking, the order of TB's observation of the stars, a point which affects the accuracy of the data & the accuracy of their reduction.)[195] Since the following table contains no breaks (except between pages), I will point out that the first star of the northern section is D336, and the first star of the southern section is D817. Note that TB expressed all[196] his cat D pstns either to arcmin or half-arcmin precision (Ræder & Strömgrens 1946 p.112); however, outside the zodiac (Gem 5 stars), all separately-headed lists of *informes* or *pertinent* places exhibit strictly whole-arcmin precision: UMi (11), UMa (13), Boo (2), Cyg (5), Cas (19), Per (4), Oph (13). All 67 of these pstns are northern. (There are no unformed-star lists attached to cat D southern constellations.) All 47 of the 1597 late-rush pstns (purely unformed), Table 20, have whole-arcmin coords. So do all 10 of those fake stars whose alleged data are missing. (By contrast: every other reasonably definable set of stars in cat D — even Crt & Crv — includes at least one star with at least one coord expressed to half-arcmin.)

P6 Our 42pp-tabulation of the entire catalog D now begins.[197] Following it, 8pp more are devoted to the 1601.03 (Table 22) & 1701.03 (Table 23) versions of Tycho's equatorial Select Star list (S list: 100 stars) which he appended to cat D (OO 3:375-377). The column headings are the same as for Table 21, except that: [a] we also give (last column of ecl page) the star's number (S) on the Select stars list, while [b] dropping the x column, (since not one of the 100 Select stars suffered a mark). Note: the Tycho implicit ecl pstns (even pages), of Tables 22&23, are calc from the eqt pstns of the S list (odd pages), using, as before (in the reverse case, fn 39), the appropriate value of the obliquity ϵ in the transf. (Again: for the zodiacal stars, adopted $\epsilon = 23°31'$; for the northern & southern stars, $23°31'1/2$.)

[191] Repeat stars are listed in fn 77. Note that only 2 repeats are precise duplicates: D345 ≡ D600 & D699 ≡ D701. The code here for such cases is: mark the 1st appearance as "d" (in col.x) and all later appearances as "D" — and drop all "D" cases from the samples analysed here. But, this scheme was only required for one case: D699 is "d" and D701 is "D". (Same procedure would have been applied to D345 & D600 — however, both these (identical) stars had already been previously eliminated from the samples anyway, on 2 other grounds each.) See §C3.

[192] As noted at fn 32, D789 is the sole "W" case in cat D.

[193] OO 13:59-60 & 98-101 (1596/10/5 & 1597/2/8-3/10). See §N.

[194] However, note that Tycho's most unreliable class of real stars (the Final Fifty of §N) were entirely northern.

[195] Recall that the obliquity adopted later in TB's career differed from his earlier (25% better) value. See fn 190.

[196] At OO 3:350, D218's β is printed $2°27'1/3$. However, at OO 2:262, the same star (C189) has $\beta = 2°27'1/2$. (Identical β at OO 11:401.) So I've corrected this trifling misprint & left D218 in the sample of stars analysed.

[197] I am confident that, whatever the initial reception of this edition of cat D, it will ultimately assist in establishing permanent appreciation, at last, of Tycho's long-underestimated star labors. (Note that I merely say: assist. See fn 13.) An irony: DR does not pretend to be a scholar specializing in Tycho studies. However, far from wishing to obscure that fact, I am stressing it here — precisely because this edition of cat D illustrates that scholars can make lasting contributions to scientific history without going the orthodox History-of-science route. There are certain Historians of science who could attain medically beneficial calm by coming to accept this.

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
27°37′.0	7°08′.5	27°37′.1	7°08′.8	-0.1	-0.3		5γ Ari	1
28°23′.0	8°29′.0	28°24′.2	8°28′.2	-1.2	0.8		6β Ari	2
32°06′.0	9°57′.0	32°05′.2	9°57′.2	0.7	-0.2		13α Ari	3
32°34′.0	7°23′.0	32°32′.9	7°22′.5	1.1	0.5		17η Ari	4
33°20′.0	5°42′.5	33°18′.6	5°43′.2	1.4	-0.7		22θ Ari	5
27°57′.0	5°24′.0	27°57′.0	5°26′.0	-0.0	-2.0		8ι Ari	6
38°36′.0	6°07′.0	38°34′.5	6°07′.8	1.5	-0.8		32ν Ari	7
42°57′.0	4°08′.5	42°56′.1	4°08′.0	0.9	0.5		48ε Ari	8
45°15′.0	1°46′.5	45°16′.2	1°47′.2	-1.2	-0.7		57δ Ari	9
46°24′.0	2°50′.0	46°22′.9	2°51′.3	1.1	-1.3		58ζ Ari	10
47°50′.5	2°36′.0	47°49′.6	2°34′.1	0.9	1.9		61τ1 Ari	11
41°22′.0	1°12′.0	41°20′.3	1°10′.2	1.7	1.8		46ρ3 Ari	12
39°35′.0	1°07′.0	39°34′.2	1°06′.0	0.8	1.0		42π Ari	13
39°23′.0	-1°20′.0	39°22′.4	-1°19′.8	0.6	-0.2	r	43σ Ari	14
37°52′.0	-0°39′.0	37°50′.7	-0°37′.0	1.3	-2.0		37o Ari	15
38°46′.0	4°01′.0	38°45′.9	4°01′.5	0.1	-0.5		34μ Ari	16
31°41′.0	9°13′.0	31°41′.0	9°13′.1	-0.0	-0.1		12κ Ari	17
40°35′.0	10°50′.5	40°34′.2	10°51′.2	0.8	-0.7		33 Ari	18
41°23′.0	11°16′.0	41°22′.4	11°16′.4	0.6	-0.4		35 Ari	19
42°40′.0	10°24′.0	42°38′.3	10°25′.3	1.7	-1.3		41 Ari	20
42°51′.0	12°25′.5	42°47′.7	12°27′.5	3.2	-2.0		39 Ari	21
48°00′.0	-5°57′.0	48°01′.2	-5°57′.6	-1.2	0.6		5f Tau	22
47°30′.0	-7°29′.0	47°31′.2	-7°29′.0	-1.2	-0.0		4 Tau	23
46°18′.0	-8°49′.5	46°20′.1	-8°50′.2	-2.1	0.7		2ξ Tau	24
45°35′.5	-9°22′.5	45°36′.0	-9°22′.3	-0.5	-0.2		1o Tau	25
51°46′.0	-8°41′.0	51°46′.5	-8°41′.1	-0.5	0.1		30e Tau	26
55°01′.0	-8°03′.0	55°03′.9	-8°00′.4	-2.9	-2.6		35λ Tau	27
57°59′.0	-12°13′.5	58°00′.5	-12°13′.8	-1.4	0.3		49μ Tau	28
54°19′.0	-14°30′.5	54°20′.7	-14°29′.9	-1.7	-0.6		38ν Tau	29
64°09′.0	-9°32′.0	64°10′.6	-9°33′.0	-1.5	1.0		90c1 Tau	30
63°11′.0	-11°48′.0	63°13′.2	-11°47′.0	-2.1	-1.0		88d Tau	31
60°12′.0	-5°46′.5	60°13′.5	-5°46′.6	-1.4	0.1		54γ Tau	32
61°16′.5	-4°02′.0	61°17′.4	-4°00′.8	-0.9	-1.2		61δ1 Tau	33
62°22′.0	-5°53′.0	62°22′.9	-5°53′.0	-0.9	0.0		78θ2 Tau	34
64°12′.5	-5°31′.0	64°13′.0	-5°29′.7	-0.5	-1.3		87α Tau	35
62°53′.0	-2°36′.5	62°53′.1	-2°36′.7	-0.1	0.2		74ε Tau	36
68°12′.0	-3°40′.0	68°10′.7	-3°41′.0	1.3	1.0		97i Tau	37
72°13′.5	-2°30′.5	72°12′.7	-2°31′.0	0.8	0.5		106 l Tau	38
71°04′.0	-1°49′.5	71°12′.8	-1°14′.7	-8.8	-34.8		102ι Tau	39
79°12′.0	-2°14′.0	79°13′.0	-2°14′.7	-1.0	0.7		123ζ Tau	40
66°35′.0	0°40′.0	66°35′.2	0°39′.9	-0.2	0.1		94τ Tau	41
76°59′.5	5°20′.0	77°00′.4	5°21′.1	-0.9	-1.1		112β Tau	42
62°54′.0	1°04′.0	62°55′.4	1°03′.8	-1.4	0.2		69υ Tau	43
62°38′.0	0°35′.0	62°37′.6	0°35′.0	0.4	-0.0		65κ1 Tau	44
57°51′.0	1°12′.0	57°52′.8	1°13′.2	-1.8	-1.2		37A1 Tau	45
60°28′.5	-0°46′.5	60°29′.8	-0°47′.7	-1.3	1.2		50ω2 Tau	46
60°04′.0	5°16′.0	60°05′.7	5°16′.4	-1.7	-0.4		44p Tau	47
59°45′.5	7°55′.0	59°44′.3	7°54′.1	1.2	0.9		42ψ Tau	48
62°34′.0	3°57′.0	62°32′.9	3°58′.5	1.1	-1.5		59χ Tau	49
62°25′.5	5°45′.5	62°20′.9	5°45′.6	4.5	-0.1		52φ Tau	50

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
0545	4.04	4.21	4	22°56′.5	17°18′.6	22°57′.0	17°18′.2	-0.4	0.3
0553	2.64	2.81	4	23°09′.7	18°50′.2	23°11′.6	18°49′.3	-1.8	0.9
0617	2.00	2.16	3	26°13′.4	21°32′.9	26°13′.1	21°32′.1	0.2	0.8
0646	5.27	5.44	6	27°40′.1	19°19′.2	27°39′.6	19°17′.6	0.4	1.5
0669	5.62	5.79	6	29°02′.7	18°01′.3	29°01′.5	18°00′.7	1.1	0.6
0563	5.10	5.27	5	23°56′.0	15°48′.7	23°55′.6	15°50′.0	0.3	-1.3
0773	5.30	5.47	6	34°06′.5	20°11′.7	34°05′.1	20°11′.2	1.3	0.6
0887	3.88	4.05	5	39°08′.9	19°43′.1	39°08′.6	19°41′.3	0.3	1.8
0951	4.35	4.52	4	42°13′.3	18°09′.5	42°14′.7	18°09′.5	-1.3	-0.0
0972	4.89	5.06	5	43°03′.2	19°30′.4	43°02′.1	19°30′.3	1.1	0.1
1005	5.28	5.45	6	44°35′.3	19°41′.9	44°35′.4	19°38′.8	-0.1	3.1
0869	5.63	5.80	6	38°31′.8	16°25′.8	38°31′.0	16°22′.6	0.8	3.2
0836	5.22	5.40	6	36°47′.8	15°47′.3	36°47′.8	15°45′.1	0.1	2.1
0847	5.49	5.68	6	37°24′.4	13°24′.1	37°24′.1	13°23′.2	0.3	0.9
0809	5.77	5.95	6	35°42′.3	13°33′.8	35°40′.6	13°34′.3	1.6	-0.6
0793	5.69	5.86	6	35°00′.5	18°16′.1	35°00′.6	18°15′.6	-0.1	0.5
0613	5.03	5.20	6	26°05′.9	20°42′.9	26°06′.4	20°42′.4	-0.5	0.6
0782	5.30	5.46	5	34°24′.3	25°18′.2	34°23′.8	25°17′.7	0.5	0.5
0801	4.66	4.82	4	35°04′.1	25°58′.0	35°03′.9	25°57′.4	0.2	0.7
0838	3.63	3.79	3	36°42′.4	25°33′.8	36°40′.7	25°33′.6	1.5	0.2
0824	4.51	4.66	4	36°09′.3	27°32′.1	36°05′.8	27°32′.1	3.1	0.1
1066	4.11	4.29	5	47°13′.0	11°31′.8	47°14′.5	11°30′.5	-1.5	1.3
1061	5.14	5.34	6	47°09′.4	9°55′.2	47°10′.8	9°54′.4	-1.4	0.8
1038	3.74	3.94	4	46°22′.5	8°18′.1	46°24′.9	8°16′.9	-2.3	1.2
1030	3.60	3.80	4	45°51′.2	7°34′.7	45°51′.8	7°33′.9	-0.6	0.7
1174	5.07	5.27	5	51°36′.8	9°52′.2	51°37′.5	9°51′.0	-0.7	1.1
1239	3.47	3.66	4	54°37′.9	11°15′.7	54°40′.3	11°17′.7	-2.4	-2.0
1320	4.29	4.49	4	58°27′.8	7°50′.7	58°29′.4	7°49′.4	-1.6	1.3
1251	3.91	4.13	4	55°28′.7	4°49′.3	55°30′.3	4°49′.0	-1.6	0.3
1473	4.27	4.46	5	63°57′.3	11°40′.2	63°59′.2	11°38′.1	-1.8	2.1
1458	4.25	4.45	5	63°25′.2	9°16′.1	63°27′.3	9°16′.1	-2.0	0.0
1346	3.65	3.83	3	59°16′.3	14°36′.6	59°18′.0	14°35′.5	-1.6	1.1
1373	3.76	3.93	3	59°59′.6	16°31′.9	60°00′.6	16°31′.9	-0.9	-0.0
1412	3.40	3.58	4	61°28′.7	14°55′.8	61°29′.8	14°54′.7	-1.1	1.2
1457	0.85	1.02	1	63°16′.5	15°37′.9	63°16′.9	15°37′.9	-0.4	0.0
1409	3.53	3.70	3	61°21′.1	18°14′.6	61°21′.5	18°13′.1	-0.4	1.5
1547	5.10	5.27	6	67°02′.9	18°07′.5	67°01′.9	18°04′.9	0.9	2.6
1658	5.29	5.46	6	71°04′.8	19°50′.7	71°04′.2	19°48′.6	0.6	2.1
1620	4.64	4.81	4	69°45′.7	20°22′.0	69°50′.1	20°56′.2	-4.1	-34.2
1910	3.00	3.17	3	78°26′.5	20°51′.0	78°27′.8	20°48′.8	-1.2	2.1
1497	4.28	4.44	5	64°35′.7	22°08′.1	64°36′.2	22°06′.7	-0.5	1.4
1791	1.65	1.80	2	75°16′.2	28°11′.1	75°17′.2	28°10′.9	-0.9	0.3
1392	4.28	4.44	5	60°36′.7	21°51′.1	60°38′.5	21°49′.8	-1.7	1.3
1387	4.22	4.38	4	60°26′.0	21°19′.6	60°25′.8	21°18′.2	0.1	1.4
1256	4.36	4.52	5	55°16′.9	20°54′.8	55°18′.8	20°55′.1	-1.8	-0.3
1329	4.94	5.11	6	58°28′.3	19°33′.5	58°30′.2	19°31′.3	-1.8	2.2
1287	5.41	5.57	6	56°38′.3	25°22′.3	56°40′.4	25°21′.8	-2.0	0.5
1269	5.23	5.38	5	55°38′.4	27°53′.2	55°37′.8	27°50′.8	0.5	2.4
1369	5.37	5.53	5	59°37′.9	24°36′.7	59°36′.8	24°36′.6	1.0	0.1
1348	4.95	5.10	5	59°04′.2	26°21′.2	58°59′.6	26°19′.1	4.1	2.1

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
53°50′.0	4°11′.0	53°50′.7	4°08′.9	-0.7	2.1		17 Tau	51
54°03′.0	4°02′.0	54°07′.9	3°54′.8	-4.9	7.2		23 Tau	52
54°24′.0	4°00′.0	54°25′.5	4°00′.6	-1.5	-0.6		25η Tau	53
54°47′.0	3°55′.0	54°47′.3	3°52′.5	-0.3	2.5		27 Tau	54
49°57′.0	-13°30′.0	49°58′.9	-13°30′.5	-1.8	0.5		29 Tau	55
60°10′.0	-12°02′.0	60°11′.0	-12°01′.6	-1.0	-0.4		66r Tau	56
61°58′.5	-8°41′.0	61°58′.8	-8°40′.8	-0.3	-0.2		79b Tau	57
61°42′.0	-6°56′.5	61°43′.1	-6°57′.0	-1.1	0.5		73π Tau	58
63°28′.0	-7°04′.5	63°28′.2	-7°05′.3	-0.2	0.8		86ρ Tau	59
64°55′.0	-6°17′.5	64°55′.8	-6°12′.8	-0.8	-4.7		92σ2 Tau	60
75°02′.5	-1°04′.0	75°00′.3	-1°03′.2	2.2	-0.8		109n Tau	61
76°55′.5	-1°20′.0	76°55′.7	-1°20′.6	-0.2	0.6		114o Tau	62
47°33′.0	-9°34′.5	47°33′.8	-9°30′.8	-0.8	-3.7		6t Tau	63
59°22′.5	6°33′.0	59°22′.3	6°33′.1	0.2	-0.1		41 Tau	64
104°41′.0	10°02′.0	104°41′.2	10°03′.7	-0.2	-1.7		66α Gem	65
107°43′.0	6°38′.0	107°42′.8	6°39′.3	0.2	-1.3		78β Gem	66
95°32′.0	10°58′.0	95°33′.2	10°59′.1	-1.2	-1.1		34θ Gem	67
99°54′.0	7°43′.0	99°52′.6	7°42′.6	1.4	0.4		46τ Gem	68
103°24′.0	5°42′.5	103°24′.0	5°43′.3	0.0	-0.8		60ι Gem	69
105°47′.0	5°10′.0	105°46′.6	5°10′.9	0.4	-0.9		69υ Gem	70
108°06′.0	3°03′.0	108°06′.0	3°02′.3	0.0	0.7		77κ Gem	71
103°18′.0	2°56′.0	103°17′.5	2°55′.4	0.5	0.6		57A Gem	72
104°10′.0	6°00′.5	104°12′.2	6°03′.6	-2.2	-3.1	h	64-5b Gem	73
94°22′.0	2°11′.0	94°22′.3	2°01′.3	-0.3	9.7		27ϵ Gem	74
99°26′.0	-2°06′.5	99°25′.4	-2°05′.3	0.6	-1.2		43ζ Gem	75
102°56′.0	-0°13′.5	102°57′.3	-0°13′.5	-1.3	-0.0		55δ Gem	76
103°13′.0	-5°41′.0	103°13′.1	-5°40′.7	-0.1	-0.3		54λ Gem	77
87°53′.0	-0°58′.0	87°52′.6	-0°56′.3	0.4	-1.7		7η Gem	78
89°44′.0	-0°53′.0	89°43′.7	-0°51′.6	0.3	-1.4		13μ Gem	79
91°14′.0	-3°08′.0	91°14′.2	-3°06′.3	-0.2	-1.7		18ν Gem	80
93°31′.0	-6°48′.5	93°32′.0	-6°47′.3	-1.0	-1.2		24γ Gem	81
95°39′.5	-10°09′.0	95°39′.3	-10°07′.9	0.2	-1.1	r	31ξ Gem	82
97°56′.0	-9°41′.0	97°54′.8	-9°39′.9	1.2	-1.1		38e Gem	83
96°23′.5	-1°12′.0	96°23′.5	-1°11′.5	0.0	-0.5		36d Gem	84
98°37′.5	1°31′.0	98°38′.3	1°29′.6	-0.8	1.4		42ω Gem	85
109°42′.0	5°44′.0	109°40′.6	5°44′.3	1.4	-0.3		83ϕ Gem	86
107°04′.5	7°24′.0	107°02′.7	7°25′.7	1.8	-1.7		75σ Gem	87
103°29′.0	9°42′.0	103°30′.2	9°44′.4	-1.2	-2.4		62ρ Gem	88
85°22′.0	-0°13′.0	85°22′.8	-0°12′.8	-0.8	-0.2		1 Gem	89
107°02′.5	-5°52′.0	107°01′.4	-5°50′.5	1.1	-1.5		68 Gem	90
108°06′.0	-3°48′.5	108°06′.5	-3°47′.4	-0.5	-1.1		74f Gem	91
109°30′.5	-2°42′.0	109°31′.8	-2°41′.1	-1.3	-0.9		81g Gem	92
111°28′.0	-0°57′.5	111°29′.0	-0°55′.3	-1.0	-2.2		85 Gem	93
113°54′.0	1°18′.5	113°54′.4	1°18′.9	-0.4	-0.4		10μ2 Cnc	94
121°46′.5	1°14′.0	121°46′.1	1°15′.3	0.4	-1.3		Praesepe	95
119°49′.0	1°31′.5	119°50′.6	1°32′.2	-1.6	-0.7		33η Cnc	96
120°09′.5	-0°47′.5	120°10′.0	-0°48′.0	-0.5	0.5		31θ Cnc	97
121°57′.0	3°09′.0	121°58′.7	3°09′.5	-1.7	-0.5	r	43γ Cnc	98
123°08′.0	0°04′.0	123°09′.0	0°03′.8	-1.0	0.2		47δ Cnc	99
128°03′.5	-5°08′.0	128°04′.4	-5°06′.8	-0.9	-1.2		65α Cnc	100

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
1142	3.70	3.86	5	50°18′.6	22°50′.4	50°20′.3	22°47′.4	-1.6	3.0
1156	4.18	4.34	6	50°34′.7	22°45′.0	50°42′.2	22°38′.1	-7.0	6.9
1165	2.87	3.03	3	50°57′.2	22°48′.4	50°59′.1	22°48′.1	-1.7	0.3
1178	3.63	3.79	5	51°22′.7	22°49′.3	51°24′.1	22°45′.8	-1.3	3.5
1153	5.35	5.57	6	51°06′.5	4°45′.5	51°08′.5	4°44′.3	-2.0	1.2
1381	5.12	5.32	6	60°32′.0	8°28′.5	60°33′.0	8°27′.7	-1.0	0.8
1414	5.03	5.22	5	61°38′.3	12°06′.5	61°38′.7	12°05′.4	-0.4	1.1
1396	4.69	4.87	5	61°01′.1	13°45′.9	61°02′.5	13°44′.3	-1.3	1.6
1444	4.65	4.83	5	62°49′.1	13°57′.9	62°49′.6	13°55′.8	-0.5	2.1
1479	4.69	4.87	5	64°08′.2	14°59′.7	64°08′.3	15°03′.0	-0.1	-3.4
1739	4.94	5.10	6	73°53′.0	21°36′.9	73°50′.7	21°35′.9	2.1	0.9
1810	4.88	5.05	6	75°55′.6	21°32′.7	75°56′.1	21°30′.6	-0.4	2.0
1079	5.77	5.97	6	47°46′.9	7°55′.2	47°46′.8	7°57′.8	0.1	-2.6
1268	5.20	5.36	5	55°34′.4	26°28′.1	55°34′.6	26°26′.9	-0.2	1.3
2890	1.58	1.73	2	107°14′.9	32°40′.3	107°15′.1	32°40′.6	-0.1	-0.2
2990	1.14	1.29	2	110°12′.1	28°54′.7	110°11′.7	28°54′.6	0.3	0.1
2540	3.60	3.75	5	96°35′.1	34°21′.4	96°36′.4	34°20′.9	-1.1	0.5
2697	4.41	4.56	4	101°26′.7	30°50′.4	101°24′.9	30°48′.6	1.5	1.7
2821	3.79	3.94	4	105°12′.9	28°31′.1	105°12′.8	28°30′.4	0.1	0.7
2905	4.06	4.21	5	107°49′.1	27°42′.6	107°48′.5	27°42′.0	0.5	0.5
2985	3.57	3.72	4	110°04′.2	25°18′.6	110°03′.8	25°16′.5	0.4	2.1
2808	5.03	5.18	6	104°46′.8	25°46′.1	104°46′.1	25°44′.0	0.7	2.1
2857	4.28	4.43	6	106°06′.9	28°44′.0	106°09′.6	28°45′.3	-2.3	-1.3
2473	2.98	3.13	3	94°50′.4	25°37′.6	94°50′.3	25°26′.3	0.1	11.3
2650	3.79	3.95	3	100°06′.6	21°04′.6	100°06′.0	21°04′.4	0.6	0.2
2777	3.53	3.69	3	104°02′.2	22°39′.7	104°03′.4	22°38′.1	-1.1	1.6
2763	3.58	3.75	3	103°46′.7	17°12′.1	103°46′.7	17°10′.9	-0.0	1.2
2216	3.28	3.44	4	87°42′.5	22°32′.0	87°42′.0	22°32′.1	0.4	-0.2
2286	2.88	3.03	3	89°42′.7	22°38′.0	89°42′.3	22°37′.9	0.3	0.1
2343	4.15	4.32	4	91°18′.8	20°22′.7	91°19′.0	20°22′.8	-0.2	-0.1
2421	1.93	2.11	2	93°38′.7	16°39′.8	93°39′.8	16°39′.4	-1.0	0.4
2484	3.36	3.54	4	95°43′.3	13°15′.2	95°43′.2	13°14′.8	0.1	0.5
2564	4.65	4.83	6	98°02′.8	13°36′.7	98°01′.6	13°36′.3	1.1	0.4
2529	5.27	5.43	6	96°54′.1	22°09′.8	96°54′.1	22°08′.8	0.1	1.0
2630	5.18	5.34	6	99°30′.1	24°44′.9	99°30′.8	24°41′.9	-0.6	3.0
3067	4.97	5.12	6	112°16′.1	27°44′.1	112°14′.3	27°43′.2	1.6	0.9
2973	4.28	4.43	5	109°35′.8	29°45′.5	109°33′.7	29°46′.0	1.8	-0.5
2852	4.18	4.33	5	105°48′.6	32°28′.6	105°50′.0	32°29′.4	-1.2	-0.8
2134	4.16	4.32	4	84°57′.4	23°13′.1	84°58′.3	23°11′.8	-0.8	1.3
2886	5.25	5.43	6	107°42′.7	16°36′.3	107°41′.6	16°36′.5	1.0	-0.2
2938	5.05	5.21	6	109°04′.9	18°30′.8	109°05′.4	18°30′.4	-0.5	0.5
3003	4.88	5.04	6	110°42′.8	19°25′.2	110°44′.1	19°24′.5	-1.2	0.8
3086	5.35	5.52	6	113°03′.1	20°51′.1	113°04′.3	20°51′.8	-1.1	-0.7
3176	5.30	5.46	6	116°02′.4	22°41′.0	116°02′.6	22°40′.0	-0.2	1.0
3428	5.69	5.85	n	124°20′.1	21°01′.8	124°19′.7	21°02′.0	0.4	-0.1
3366	5.33	5.49	5	122°21′.2	21°44′.7	122°22′.7	21°43′.8	-1.4	0.9
3357	5.35	5.51	5	122°10′.9	19°24′.5	122°11′.0	19°22′.6	-0.1	1.9
3449	4.66	4.82	4	124°59′.3	22°51′.5	125°00′.9	22°50′.3	-1.5	1.1
3461	3.94	4.10	4	125°27′.7	19°35′.1	125°28′.3	19°33′.5	-0.6	1.6
3572	4.25	4.43	3	129°07′.6	13°20′.9	129°08′.6	13°20′.7	-0.9	0.2

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
120°44′.0	10°23′.0	120°46′.4	10°23′.5	-2.4	-0.5		48ι Cnc	101
113°56′.0	1°15′.5	113°54′.4	1°18′.9	1.6	-3.4		10μ2 Cnc	102
115°04′.0	-7°05′.0	115°03′.6	-7°05′.6	0.4	0.6		8 Cnc	103
115°45′.5	-2°18′.5	115°45′.9	-2°17′.8	-0.4	-0.7		16ζ Cnc	104
118°12′.5	-1°04′.0	118°12′.7	-1°02′.4	-0.2	-1.6		20d Cnc	105
126°47′.5	-1°54′.0	126°48′.7	-1°52′.6	-1.2	-1.4		62ο1 Cnc	106
130°36′.0	-5°36′.0	130°36′.4	-5°36′.1	-0.4	0.1		76κ Cnc	107
125°27′.0	7°14′.0	125°28′.3	7°15′.0	-1.2	-1.0		69ν Cnc	108
127°36′.5	5°20′.0	127°38′.4	5°23′.3	-1.9	-3.3		77ξ Cnc	109
129°41′.5	10°23′.0	129°43′.4	10°23′.9	-1.9	-0.9		1κ Leo	110
132°16′.5	7°52′.0	132°18′.1	7°51′.7	-1.6	0.3		4λ Leo	111
135°51′.0	12°21′.0	135°52′.4	12°20′.0	-1.4	1.0		24μ Leo	112
135°05′.0	9°40′.0	135°08′.1	9°41′.3	-3.0	-1.3		17ε Leo	113
141°57′.5	11°50′.0	141°59′.1	11°50′.4	-1.6	-0.4		36ζ Leo	114
143°59′.0	8°47′.0	144°00′.1	8°47′.7	-1.1	-0.7		41γ Leo	115
142°20′.0	4°52′.0	142°20′.0	4°50′.5	-0.0	1.5		30η Leo	116
144°17′.0	0°26′.5	144°17′.2	0°27′.1	-0.2	-0.6		32α Leo	117
144°50′.5	-1°25′.5	144°51′.2	-1°25′.9	-0.7	0.4		31A Leo	118
141°43′.5	0°00′.5	141°46′.3	0°01′.8	-2.8	-1.3		27ν Leo	119
137°54′.5	0°16′.0	137°55′.1	0°19′.4	-0.6	-3.4		16ψ Leo	120
136°07′.0	-3°10′.0	136°05′.3	-3°10′.4	1.7	0.4		5ξ Leo	121
138°40′.0	-3°47′.0	138°41′.8	-3°46′.5	-1.8	-0.5		14ο Leo	122
143°46′.0	-3°55′.0	143°45′.1	-3°55′.9	0.9	0.9		29π Leo	123
150°48′.0	0°08′.0	150°49′.3	0°08′.0	-1.3	0.0		47ρ Leo	124
142°24′.0	2°10′.0	148°53′.7	4°33′.8	-388.5	-143.8		46 Leo	125
152°06′.0	5°56′.0	152°05′.3	5°55′.5	0.7	0.5		52 Leo	126
154°05′.0	2°49′.5	154°06′.7	2°48′.2	-1.7	1.3		53 Leo	127
153°14′.0	12°53′.0	153°16′.6	12°53′.9	-2.5	-0.9		60b Leo	128
155°41′.0	14°20′.0	155°42′.9	14°19′.7	-1.8	0.3		68δ Leo	129
157°50′.0	9°41′.5	157°51′.0	9°40′.4	-1.0	1.1		70θ Leo	130
159°08′.0	7°50′.5	159°03′.7	7°52′.3	4.2	-1.8		73n Leo	131
161°58′.5	6°07′.0	161°58′.4	6°05′.9	0.1	1.1		78ι Leo	132
163°08′.5	1°40′.0	163°08′.8	1°41′.8	-0.3	-1.8		77σ Leo	133
165°57′.0	-0°33′.0	165°56′.5	-0°33′.5	0.5	0.5		84τ Leo	134
169°27′.0	-3°02′.5	169°28′.4	-3°03′.0	-1.4	0.5		91υ Leo	135
166°03′.0	12°18′.0	166°05′.1	12°17′.8	-2.0	0.2		94β Leo	136
136°32′.0	-4°48′.0	136°35′.5	-4°41′.0	-3.5	-7.0		6h Leo	137
136°01′.5	-5°43′.0	135°58′.4	-5°35′.1	3.0	-7.9		2ω Leo	138
150°14′.0	10°17′.0	150°15′.0	10°15′.1	-1.0	1.9		51m Leo	139
136°13′.0	10°47′.5	136°13′.4	10°45′.4	-0.4	2.1		22g Leo	140
165°53′.5	-7°39′.0	165°56′.0	-7°38′.5	-2.4	-0.5		74φ Leo	141
168°50′.0	-5°41′.0	168°48′.7	-5°42′.2	1.3	1.2		87e Leo	142
146°22′.5	17°40′.0	147°55′.1	13°57′.0	-89.9	223.0		41 LMi	143
149°57′.0	16°30′.0	149°55′.8	16°29′.0	1.1	1.0		54 Leo	144
154°54′.5	16°47′.0	154°53′.8	16°46′.6	0.7	0.4		72 Leo	145
163°22′.0	17°19′.0	163°24′.4	17°18′.6	-2.3	0.4		93 Leo	146
158°58′.0	1°20′.5	158°58′.4	1°21′.0	-0.4	-0.5		63χ Leo	147
158°30′.0	-0°09′.5	158°26′.6	-0°12′.7	3.4	3.2		59c Leo	148
159°20′.0	-2°29′.0	159°21′.1	-2°31′.5	-1.1	2.5		58d Leo	149
167°44′.0	6°06′.5	167°45′.3	6°06′.7	-1.3	-0.2		2ξ Vir	150

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	*m*	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
3474	3.92	4.07	5	125°33′.2	30°10′.4	125°35′.5	30°09′.1	-2.0	1.3
3176	5.30	5.46	5	116°03′.9	22°37′.7	116°02′.6	22°40′.0	1.2	-2.3
3163	5.12	5.30	5	115°42′.2	14°13′.1	115°41′.6	14°11′.1	0.7	1.9
3208	4.64	4.81	4	117°18′.1	18°47′.6	117°18′.5	18°46′.8	-0.3	0.7
3284	5.80	5.97	6	120°05′.9	19°32′.5	120°06′.1	19°32′.7	-0.2	-0.2
3561	5.20	5.37	6	128°42′.0	16°47′.8	128°43′.3	16°47′.6	-1.2	0.1
3623	5.24	5.43	5	131°30′.5	12°14′.5	131°30′.7	12°13′.2	-0.1	1.3
3595	5.45	5.61	6	129°47′.5	25°58′.2	129°48′.7	25°57′.7	-1.0	0.5
3627	5.14	5.30	6	131°31′.5	23°34′.5	131°34′.0	23°36′.1	-2.3	-1.5
3731	4.46	4.61	4	135°16′.7	27°51′.5	135°18′.5	27°50′.7	-1.5	0.7
3773	4.31	4.46	4	137°10′.8	24°42′.4	137°11′.9	24°40′.6	-0.9	1.8
3905	3.88	4.03	4	142°27′.7	27°52′.8	142°28′.2	27°50′.5	-0.4	2.3
3873	2.98	3.13	3	140°42′.4	25°34′.6	140°45′.4	25°33′.9	-2.8	0.7
4031	3.44	3.60	3	148°33′.7	25°23′.1	148°34′.9	25°22′.1	-1.1	0.9
4057	2.30	2.46	2	149°26′.6	21°49′.9	149°27′.4	21°49′.4	-0.8	0.5
3975	3.52	3.69	3	146°22′.7	18°42′.5	146°21′.8	18°40′.2	0.9	2.3
3982	1.35	1.53	1	146°45′.3	13°53′.2	146°45′.4	13°52′.8	-0.1	0.4
3980	4.37	4.55	5	146°39′.4	11°56′.4	146°39′.6	11°54′.9	-0.3	1.5
3937	5.26	5.44	4	144°07′.0	14°19′.1	144°09′.9	14°18′.5	-2.8	0.6
3866	5.35	5.52	5	140°27′.1	15°46′.0	140°28′.4	15°48′.1	-1.3	-2.1
3782	4.97	5.15	4	137°37′.2	13°02′.0	137°35′.1	13°01′.1	2.0	0.9
3852	3.52	3.71	4	139°54′.9	11°40′.8	139°56′.5	11°39′.7	-1.6	1.1
3950	4.70	4.89	4	144°47′.2	9°56′.6	144°45′.7	9°55′.2	1.4	1.4
4133	3.85	4.04	4	152°54′.9	11°21′.0	152°55′.9	11°19′.8	-1.0	1.2
4127	5.46	5.63	6	145°30′.4	16°08′.3	152°41′.9	16°09′.3	-414.4	-1.0
4209	5.48	5.65	6	156°19′.1	16°17′.4	156°17′.8	16°16′.6	1.3	0.8
4227	5.25	5.44	6	157°02′.3	12°40′.3	157°03′.1	12°37′.9	-0.8	2.4
4300	4.42	4.58	5	160°11′.2	22°18′.6	160°13′.5	22°18′.0	-2.1	0.6
4357	2.56	2.72	2	163°10′.3	22°43′.1	163°11′.4	22°41′.6	-1.0	1.5
4359	3.34	3.51	3	163°18′.1	17°37′.4	163°18′.1	17°35′.6	-0.0	1.8
4365	5.32	5.49	6	163°47′.4	15°25′.2	163°43′.6	15°28′.1	3.6	-2.8
4399	3.94	4.13	3	165°46′.8	12°44′.2	165°45′.9	12°42′.9	0.9	1.3
4386	4.05	4.25	4	165°07′.1	8°11′.0	165°07′.8	8°12′.1	-0.7	-1.1
4418	4.95	5.16	4	166°51′.7	5°03′.1	166°50′.9	5°02′.5	0.7	0.6
4471	4.30	4.53	4	169°06′.8	1°23′.5	169°07′.8	1°22′.2	-1.1	1.3
4534	2.14	2.32	1	172°08′.1	16°49′.0	172°09′.6	16°47′.9	-1.4	1.2
3779	5.07	5.25	6	137°31′.9	11°21′.0	137°37′.2	11°25′.6	-5.2	-4.6
3754	5.41	5.60	5	136°45′.9	10°37′.4	136°45′.1	10°44′.7	0.8	-7.4
4208	5.49	5.65	6	156°12′.1	21°00′.9	156°11′.7	20°58′.1	0.3	2.7
3900	5.32	5.48	6	142°16′.8	26°17′.3	142°15′.8	26°14′.3	0.8	3.0
4368	4.47	4.72	4	164°03′.2	-1°28′.2	164°05′.7	-1°29′.1	-2.5	0.9
4432	4.77	5.01	5	167°30′.7	-0°47′.8	167°29′.1	-0°48′.8	1.6	1.0
4192	5.08	5.24	5	155°25′.9	29°15′.7	155°23′.4	25°15′.0	2.2	240.8
4259	4.31	4.47	5	158°30′.0	26°52′.4	158°27′.6	26°51′.3	2.1	1.1
4362	4.63	4.78	5	163°29′.2	25°15′.8	163°27′.6	25°15′.2	1.4	0.6
4527	4.53	4.69	4	171°48′.0	22°27′.3	171°49′.5	22°25′.9	-1.3	1.5
4310	4.63	4.83	4	161°05′.4	9°28′.6	161°05′.7	9°28′.4	-0.3	0.1
4294	4.99	5.19	5	160°04′.8	8°15′.7	160°00′.2	8°13′.5	4.6	2.3
4291	4.84	5.05	5	159°58′.8	5°47′.7	159°58′.7	5°44′.4	0.0	3.3
4515	4.85	5.04	5	171°09′.1	10°28′.7	171°10′.1	10°28′.2	-1.0	0.5

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
168°33′.0	4°37′.0	168°34′.9	4°36′.3	-1.9	0.7		3ν Vir	151
172°07′.0	8°33′.5	172°08′.6	8°31′.9	-1.6	1.6		9o Vir	152
171°58′.0	6°10′.0	171°59′.1	6°09′.5	-1.1	0.5		8π Vir	153
171°32′.0	0°43′.0	171°30′.5	0°41′.4	1.5	1.6		5β Vir	154
179°16′.0	1°25′.0	179°16′.1	1°22′.7	-0.1	2.3		15η Vir	155
184°35′.5	2°50′.0	184°37′.8	2°49′.6	-2.3	0.4		29γ Vir	156
189°28′.5	2°23′.5	189°38′.4	2°22′.6	-9.9	0.9		44k Vir	157
192°37′.0	1°45′.0	192°40′.2	1°46′.1	-3.2	-1.1		51θ Vir	158
185°55′.0	8°41′.0	185°55′.9	8°39′.2	-0.9	1.8		43δ Vir	159
179°53′.0	13°36′.5	179°55′.2	13°33′.4	-2.2	3.1		30ρ Vir	160
181°52′.0	11°37′.0	181°51′.8	11°34′.7	0.2	2.3		32d2 Vir	161
184°23′.5	16°15′.5	184°23′.3	16°13′.7	0.2	1.8		47ϵ Vir	162
198°16′.0	-1°59′.0	198°16′.7	-2°01′.5	-0.7	2.5		67α Vir	163
195°22′.5	8°10′.0	196°35′.5	8°40′.1	-72.1	-30.1		79ζ Vir	164
197°58′.5	3°11′.0	198°01′.6	3°09′.3	-3.1	1.7		74 l2 Vir	165
201°09′.5	1°45′.5	201°09′.0	1°44′.3	0.5	1.2		82m Vir	166
199°44′.0	-0°19′.5	199°41′.1	-0°23′.6	2.9	4.1		76h Vir	167
204°44′.0	2°24′.5	207°10′.7	3°20′.5	-146.5	-56.0	h	95 Vir	168
207°49′.0	11°02′.5	207°48′.9	11°03′.5	0.1	-1.0		102υ Vir	169
208°09′.0	7°18′.5	208°12′.5	7°16′.6	-3.5	1.9		99ι Vir	170
208°51′.0	2°57′.5	208°55′.7	2°55′.9	-4.7	1.6		98κ Vir	171
209°51′.5	11°48′.0	209°53′.5	11°48′.0	-1.9	0.0		105ϕ Vir	172
211°22′.0	0°31′.5	211°23′.2	0°31′.4	-1.2	0.1		100λ Vir	173
214°30′.0	9°49′.0	214°32′.1	9°44′.3	-2.1	4.7		107μ Vir	174
181°21′.0	10°26′.0	181°21′.6	10°25′.3	-0.6	0.7		31d1 Vir	175
201°37′.5	9°40′.5	201°37′.3	9°37′.9	0.2	2.6		90p Vir	176
177°45′.5	4°59′.5	177°48′.4	5°05′.3	-2.9	-5.8		16c Vir	177
188°25′.0	16°14′.0	188°28′.2	16°13′.6	-3.1	0.4		59e Vir	178
190°11′.0	12°40′.5	190°12′.6	12°40′.0	-1.6	0.5		60σ Vir	179
194°46′.0	12°34′.5	194°48′.7	12°33′.5	-2.7	1.0		78 Vir	180
202°11′.0	13°07′.5	202°10′.1	13°05′.5	0.9	2.0		93τ Vir	181
172°56′.5	3°22′.5	172°57′.8	3°21′.2	-1.3	1.3		7b Vir	182
186°38′.0	-3°25′.5	186°35′.8	-3°26′.8	2.2	1.3		26χ Vir	183
190°39′.0	-3°23′.0	190°38′.3	-3°24′.7	0.7	1.7		40ψ Vir	184
194°08′.5	-3°13′.5	194°10′.7	-3°14′.4	-2.2	0.9		49 Vir	185
197°13′.0	-7°51′.0	197°11′.6	-7°52′.3	1.4	1.3		53 Vir	186
199°35′.0	-9°16′.0	199°30′.7	-9°07′.0	4.2	-9.0		61 Vir	187
200°35′.5	-6°16′.5	200°35′.6	-6°17′.4	-0.1	0.9		69 Vir	188
219°31′.0	0°26′.0	219°31′.4	0°23′.0	-0.4	3.0		9α Lib	189
218°42′.0	1°55′.0	218°36′.3	2°04′.5	5.7	-9.5		7μ Lib	190
223°48′.0	8°35′.0	223°48′.6	8°32′.6	-0.5	2.4		27β Lib	191
219°40′.5	8°18′.5	219°43′.0	8°17′.4	-2.5	1.1		19δ Lib	192
222°26′.5	1°14′.0	223°12′.4	1°14′.5	-45.9	-0.5		21ν Lib	193
226°19′.0	2°58′.5	226°21′.2	2°50′.0	-2.2	8.5		29o Lib	194
229°33′.0	4°28′.0	229°33′.7	4°25′.7	-0.7	2.3		38γ Lib	195
231°48′.5	4°04′.0	231°47′.2	4°03′.1	1.3	0.9		44η Lib	196
229°27′.0	2°21′.0	229°27′.0	2°16′.8	0.0	4.2		35ζ4 Lib	197
225°46′.0	8°07′.0	225°46′.6	8°06′.4	-0.6	0.6		31ϵ Lib	198
232°11′.0	0°02′.5	232°11′.5	0°02′.4	-0.5	0.1		43κ Lib	199
234°53′.5	0°07′.0	234°54′.5	0°08′.1	-1.0	-1.1	r	45λ Lib	200

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
4517	4.03	4.22	5	171°18′.6	8°47′.2	171°19′.8	8°45′.6	-1.2	1.6
4608	4.12	4.31	5	176°12′.3	10°59′.2	176°12′.8	10°57′.0	-0.5	2.2
4589	4.66	4.86	5	175°05′.5	8°51′.3	175°06′.1	8°50′.3	-0.5	1.0
4540	3.61	3.83	3	172°30′.7	4°01′.6	172°28′.6	4°00′.5	2.1	1.0
4689	3.89	4.12	4	179°53′.6	1°35′.5	179°52′.7	1°33′.3	0.8	2.2
4825	2.91	3.15	3	185°20′.3	0°46′.1	185°22′.2	0°45′.0	-1.9	1.1
4921	5.79	6.04	6	189°38′.6	-1°34′.1	189°47′.5	-1°38′.5	-8.8	4.4
4963	4.38	4.65	4	192°17′.0	-3°23′.3	192°20′.5	-3°23′.3	-3.5	-0.1
4910	3.38	3.58	3	188°53′.0	5°36′.7	188°52′.9	5°34′.9	0.0	1.8
4828	4.88	5.07	5	185°24′.7	12°30′.3	185°25′.1	12°26′.8	-0.4	3.5
4847	5.22	5.41	6	186°23′.3	9°53′.9	186°21′.9	9°52′.1	1.4	1.8
4932	2.83	3.01	3	190°35′.9	13°08′.6	190°34′.6	13°07′.3	1.3	1.3
5056	0.98	1.30	1	196°04′.3	-9°01′.0	196°04′.3	-9°03′.2	0.1	2.2
5107	3.37	3.60	3	197°18′.2	1°27′.8	198°36′.4	1°28′.3	-78.1	-0.5
5095	4.69	4.95	6	197°47′.2	-4°07′.8	197°49′.6	-4°10′.1	-2.4	2.3
5150	5.01	5.29	6	200°12′.3	-6°39′.1	200°11′.6	-6°39′.5	0.7	0.5
5100	5.21	5.51	6	198°04′.9	-8°02′.6	198°00′.9	-8°04′.9	4.0	2.2
5290	5.46	5.76	6	203°47′.5	-7°22′.2	206°25′.9	-7°22′.3	-157.1	0.1
5366	5.14	5.38	5	209°45′.7	-0°24′.5	209°46′.0	-0°22′.8	-0.2	-1.7
5338	4.08	4.35	4	208°45′.1	-4°01′.1	208°47′.9	-4°03′.4	-2.7	2.3
5315	4.19	4.49	4	207°51′.9	-8°20′.1	207°55′.9	-8°22′.6	-4.0	2.5
5409	4.81	5.05	4	211°54′.1	-0°23′.9	211°55′.9	-0°23′.8	-1.8	-0.1
5359	4.52	4.87	4	209°23′.4	-11°29′.7	209°24′.8	-11°29′.5	-1.4	-0.2
5487	3.88	4.15	4	215°31′.6	-3°48′.3	215°32′.0	-3°52′.5	-0.5	4.2
4829	5.59	5.79	6	185°26′.0	9°01′.3	185°26′.0	9°00′.5	-0.0	0.8
5232	5.15	5.38	6	203°35′.4	0°31′.4	203°34′.2	0°29′.7	1.2	1.7
4695	4.96	5.17	6	179°56′.5	5°28′.2	180°01′.4	5°32′.4	-4.8	-4.2
5011	5.22	5.41	6	194°12′.3	11°33′.1	194°14′.7	11°31′.9	-2.4	1.2
5015	4.80	5.00	5	194°21′.2	7°36′.4	194°22′.2	7°35′.7	-1.0	0.7
5105	4.94	5.15	6	198°27′.4	5°45′.6	198°29′.3	5°44′.2	-1.9	1.5
5264	4.26	4.48	5	205°22′.7	3°31′.5	205°21′.0	3°30′.7	1.7	0.9
4585	5.37	5.58	6	174°52′.0	5°54′.5	174°52′.5	5°52′.6	-0.5	1.9
4813	4.66	4.94	5	184°43′.3	-5°47′.1	184°40′.9	-5°47′.3	2.4	0.2
4902	4.79	5.08	5	188°26′.6	-7°20′.3	188°25′.4	-7°21′.3	1.2	1.0
4955	5.19	5.49	5	191°44′.5	-8°33′.9	191°46′.4	-8°35′.2	-1.9	1.4
4981	5.04	5.43	5	192°45′.9	-14°01′.1	192°44′.4	-14°01′.4	1.4	0.3
5019	4.74	5.17	5	194°25′.1	-16°14′.4	194°25′.2	-16°04′.1	-0.1	-10.3
5068	4.76	5.14	5	196°34′.5	-13°52′.2	196°34′.6	-13°52′.7	-0.1	0.5
5530	2.64	3.04	2	217°14′.6	-14°17′.8	217°14′.4	-14°19′.9	0.2	2.0
5523	5.31	5.67	5	216°56′.0	-12°37′.9	216°53′.8	-12°26′.1	2.1	-11.8
5685	2.61	2.92	2	223°54′.8	-7°49′.8	223°54′.8	-7°51′.2	0.0	1.4
5586	4.92	5.22	4	219°54′.3	-6°52′.0	219°56′.5	-6°52′.9	-2.2	0.9
5622	5.20	5.59	5	220°22′.2	-14°26′.8	221°07′.8	-14°39′.2	-44.2	12.4
5703	5.80	6.19	6	224°42′.9	-13°55′.2	224°42′.9	-14°02′.9	0.0	7.7
5787	3.91	4.28	3	228°19′.8	-13°22′.4	228°20′.1	-13°23′.7	-0.3	1.2
5848	5.41	5.81	4	230°27′.7	-14°20′.8	230°26′.4	-14°20′.1	1.3	-0.7
5764	5.50	5.92	4	227°38′.7	-15°23′.2	227°37′.8	-15°26′.1	0.9	2.9
5723	4.94	5.25	4	225°39′.7	-8°50′.0	225°40′.3	-8°49′.7	-0.6	-0.3
5838	4.74	5.21	4	229°45′.9	-18°20′.0	229°46′.7	-18°19′.1	-0.7	-0.9
5902	5.03	5.54	4	232°33′.1	-18°56′.3	232°34′.8	-18°54′.2	-1.6	-2.1

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
234°16′.0	3°33′.0	234°17′.8	3°30′.1	-1.8	2.9		46θ Lib	201
234°48′.0	6°10′.0	234°49′.8	6°08′.1	-1.8	1.9		48 Lib	202
235°41′.5	9°19′.0	235°44′.5	9°17′.1	-2.9	1.9		ξ Sco	203
237°19′.0	10°57′.0	237°21′.2	10°55′.4	-2.1	1.6		15ψ Sco	204
225°08′.0	-7°37′.0	225°07′.8	-7°35′.7	0.2	-1.3		20σ Lib	205
225°27′.0	-1°48′.0	225°26′.4	-1°48′.1	0.6	0.1		24ι1 Lib	206
237°36′.0	1°05′.0	237°37′.3	1°03′.5	-1.3	1.5		8β Sco	207
236°59′.0	-1°54′.5	237°00′.3	-1°56′.1	-1.3	1.6		7δ Sco	208
237°25′.0	-5°22′.5	237°22′.5	-5°25′.4	2.5	2.9		6π Sco	209
237°43′.5	-8°27′.5	237°35′.0	-8°32′.9	8.5	5.4		5ρ Sco	210
239°03′.5	1°42′.0	239°04′.6	1°41′.1	-1.1	0.9		14ν Sco	211
238°07′.0	0°14′.0	238°06′.1	0°16′.3	0.9	-2.3		9ω1 Sco	212
242°11′.0	-3°55′.0	242°14′.0	-3°59′.1	-3.0	4.1		20σ Sco	213
244°13′.0	-4°27′.0	244°11′.8	-4°31′.0	1.2	4.0		21α Sco	214
245°53′.0	-5°50′.0	245°53′.5	-6°04′.0	-0.5	14.0		23τ Sco	215
240°46′.5	-6°37′.5	240°40′.9	-6°37′.7	5.6	0.2		13c2 Sco	216
270°47′.5	-2°00′.0	270°45′.3	-2°03′.8	2.2	3.8		22λ Sgr	217
267°41′.5	2°27′.5	267°38′.7	2°23′.6	2.8	3.9		13μ Sgr	218
276°51′.0	-3°31′.0	276°49′.0	-3°23′.6	2.0	-7.4		34σ Sgr	219
274°40′.0	-3°50′.0	274°36′.4	-3°54′.2	3.6	4.2		27ϕ Sgr	220
277°56′.5	1°44′.5	277°52′.8	1°42′.8	3.7	1.7		37ξ2 Sgr	221
279°28′.0	0°58′.0	279°25′.1	0°55′.0	2.9	3.0	r	39o Sgr	222
280°43′.0	1°31′.0	280°41′.1	1°29′.4	1.9	1.6		41π Sgr	223
282°44′.0	3°06′.5	282°47′.0	3°18′.5	-3.0	-12.0	h	43d Sgr	224
283°54′.5	4°17′.0	283°53′.2	4°16′.1	1.3	0.9		44ρ1 Sgr	225
284°11′.0	6°09′.5	284°09′.8	6°08′.7	1.2	0.8		46υ Sgr	226
289°08′.5	5°08′.0	289°05′.2	5°11′.8	3.3	-3.8		55e2 Sgr	227
292°52′.5	5°12′.0	292°52′.5	5°08′.4	0.0	3.6		61g Sgr	228
289°24′.0	1°25′.0	289°22′.2	1°27′.6	1.8	-2.6		56f Sgr	229
286°26′.0	-3°08′.0	286°16′.3	-3°12′.6	9.7	4.6		52h2 Sgr	230
298°18′.0	7°02′.5	298°17′.3	6°58′.4	0.7	4.1		6α2 Cap	231
298°51′.0	6°53′.0	298°52′.1	6°37′.1	-1.1	15.9		8ν Cap	232
298°31′.0	4°41′.0	298°28′.7	4°37′.8	2.3	3.2		9β Cap	233
297°08′.0	7°16′.0	296°54′.9	7°14′.0	13.0	2.0		2ξ2 Cap	234
298°57′.0	0°48′.5	299°08′.8	0°56′.5	-11.8	-8.0		10π Cap	235
299°41′.0	0°28′.0	299°39′.0	0°26′.5	2.0	1.5		12o Cap	236
299°37′.0	1°20′.0	299°36′.0	1°14′.4	1.0	5.6		11ρ Cap	237
297°13′.0	0°24′.0	297°06′.6	0°29′.9	6.4	-5.9		7σ Cap	238
302°49′.0	3°25′.0	302°43′.8	3°23′.4	5.2	1.6		14τ Cap	239
302°06′.0	0°15′.0	302°05′.9	0°15′.8	0.1	-0.8		15υ Cap	240
301°47′.0	-6°58′.0	301°35′.8	-6°58′.4	11.1	0.4		16ψ Cap	241
302°28′.0	-9°02′.0	302°23′.2	-8°55′.5	4.7	-6.5		18ω Cap	242
306°13′.0	-8°08′.0	306°16′.5	-8°03′.9	-3.5	-4.1		24A Cap	243
311°24′.5	-6°56′.0	311°21′.8	-6°57′.6	2.7	1.6		34ζ Cap	244
312°00′.0	-6°29′.0	311°59′.8	-6°31′.8	0.2	2.8		36b Cap	245
309°23′.0	-4°25′.0	309°27′.2	-4°29′.6	-4.2	4.6		28ϕ Cap	246
307°31′.0	-4°27′.0	307°42′.8	-4°30′.8	-11.7	3.8		25χ Cap	247
307°18′.0	-3°01′.0	307°10′.5	-2°57′.2	7.5	-3.8		22η Cap	248
308°21′.0	-0°29′.0	308°16′.1	-0°32′.5	4.9	3.5		23θ Cap	249
312°07′.0	-1°16′.5	312°06′.6	-1°20′.0	0.4	3.5		32ι Cap	250

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
5908	4.15	4.56	4	232°47′.3	-15°27′.4	232°48′.6	-15°29′.3	-1.3	2.0
5941	4.88	5.26	4	233°57′.9	-13°02′.5	233°59′.5	-13°03′.6	-1.5	1.0
5977	4.16	4.49	4	235°35′.4	-10°11′.0	235°38′.0	-10°12′.2	-2.6	1.2
6031	4.94	5.26	5	237°32′.5	-8°56′.9	237°34′.3	-8°57′.6	-1.9	0.7
5603	3.29	3.97	3	220°13′.0	-23°41′.6	220°13′.8	-23°39′.3	-0.7	-2.3
5652	4.54	5.03	3	222°24′.9	-18°14′.5	222°24′.7	-18°13′.3	0.2	-1.1
5984	2.50	3.00	2	235°34′.3	-18°38′.0	235°35′.6	-18°38′.5	-1.2	0.5
5953	2.32	2.92	3	234°12′.2	-21°24′.2	234°13′.5	-21°24′.8	-1.2	0.6
5944	2.89	3.69	3	233°46′.4	-24°52′.5	233°43′.4	-24°53′.5	2.8	1.0
5928	3.88	5.01	4	233°16′.9	-27°56′.5	233°06′.7	-27°58′.5	9.1	2.0
6026	3.89	4.38	4	237°12′.9	-18°21′.2	237°14′.1	-18°21′.0	-1.1	-0.2
5993	3.96	4.49	5	235°54′.2	-19°34′.6	235°54′.1	-19°30′.9	0.0	-3.7
6084	2.89	3.66	4	239°13′.7	-24°30′.1	239°16′.4	-24°33′.4	-2.4	3.3
6134	0.96	1.76	1	241°18′.2	-25°25′.6	241°16′.4	-25°28′.0	1.7	2.4
6165	2.82	3.86	4	242°49′.9	-27°05′.8	242°47′.9	-27°18′.3	1.8	12.5
6028	4.59	5.57	5	237°04′.3	-26°51′.1	236°58′.5	-26°48′.8	5.1	-2.3
6913	2.81	3.64	4	270°52′.6	-25°30′.9	270°50′.2	-25°33′.2	2.2	2.3
6812	3.86	4.44	4	267°31′.7	-21°02′.3	267°28′.7	-21°04′.6	2.8	2.3
7121	2.02	2.99	4	277°40′.1	-26°51′.0	277°37′.3	-26°42′.2	2.5	-8.8
7039	3.17	4.21	5	275°14′.4	-27°15′.9	275°10′.5	-27°18′.7	3.5	2.8
7150	3.51	4.10	4	278°32′.3	-21°32′.4	278°28′.4	-21°32′.8	3.7	0.4
7217	3.77	4.39	4	280°13′.9	-22°12′.8	280°10′.9	-22°14′.5	2.8	1.7
7264	2.89	3.49	4	281°31′.8	-21°34′.2	281°29′.8	-21°34′.5	1.9	0.2
7304	4.96	5.47	6	283°31′.7	-19°48′.6	283°33′.6	-19°34′.9	-1.7	-13.7
7340	3.93	4.42	4	284°38′.6	-18°31′.6	284°37′.2	-18°31′.1	1.3	-0.5
7342	4.61	5.05	5	284°43′.8	-16°38′.0	284°42′.4	-16°37′.5	1.3	-0.5
7489	5.06	5.51	6	289°58′.6	-17°03′.7	289°54′.5	-16°59′.0	3.9	-4.7
7614	5.02	5.46	6	293°48′.3	-16°26′.4	293°48′.7	-16°28′.6	-0.4	2.2
7515	4.86	5.41	6	290°47′.6	-20°42′.4	290°45′.1	-20°38′.6	2.3	-3.7
7440	4.60	5.47	6	288°15′.3	-25°36′.7	288°05′.0	-25°41′.0	9.3	4.3
7754	3.57	3.95	3	298°57′.7	-13°40′.0	298°57′.6	-13°42′.8	0.1	2.9
7773	4.76	5.15	6	299°32′.7	-13°42′.9	299°36′.8	-13°56′.9	-4.0	14.0
7776	3.08	3.50	3	299°39′.5	-15°56′.2	299°37′.6	-15°58′.4	1.8	2.2
7715	5.85	6.23	6	297°44′.9	-13°40′.0	297°31′.9	-13°43′.1	12.6	3.1
7814	5.25	5.78	n	300°55′.5	-19°38′.7	301°05′.7	-19°27′.1	-9.6	-11.6
7829	5.52	6.06	n	301°45′.7	-19°49′.6	301°43′.7	-19°50′.2	1.9	0.6
7822	4.78	5.29	6	301°30′.0	-18°59′.6	301°30′.0	-19°03′.9	0.0	4.3
7761	5.28	5.81	n	299°12′.2	-20°23′.5	299°04′.0	-20°17′.6	7.7	-5.8
7889	5.22	5.66	6	304°18′.1	-16°15′.9	304°13′.0	-16°17′.4	4.9	1.5
7900	5.10	5.60	6	304°19′.0	-19°30′.7	304°18′.4	-19°28′.7	0.6	-2.0
7936	4.14	5.09	6	305°47′.1	-26°36′.5	305°34′.7	-26°38′.3	11.1	1.8
7980	4.11	5.23	6	307°05′.1	-28°27′.2	306°57′.5	-28°20′.8	6.6	-6.4
8080	4.50	5.40	6	310°52′.3	-26°38′.5	310°54′.3	-26°32′.4	-1.8	-6.1
8204	3.74	4.46	5	315°58′.7	-24°03′.9	315°55′.9	-24°05′.2	2.5	1.3
8213	4.51	5.20	6	316°27′.0	-23°27′.8	316°27′.3	-23°29′.5	-0.2	1.7
8127	5.24	5.86	6	313°06′.4	-22°13′.0	313°11′.7	-22°15′.1	-4.9	2.1
8087	5.28	5.94	6	311°10′.5	-22°44′.9	311°23′.5	-22°44′.3	-11.9	-0.6
8060	4.84	5.43	5	310°32′.7	-21°25′.3	310°23′.5	-21°22′.4	8.6	-2.9
8075	4.07	4.57	5	310°55′.3	-18°42′.1	310°51′.0	-18°45′.6	4.1	3.5
8167	4.28	4.76	5	314°58′.3	-18°26′.4	314°58′.6	-18°28′.8	-0.3	2.4

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
314°25′.0	-4°48′.0	314°37′.6	-4°56′.7	-12.5	8.7		39ϵ Cap	251
316°06′.0	-4°49′.0	316°03′.5	-4°48′.3	2.5	-0.7		43κ Cap	252
316°14′.0	-2°26′.0	316°12′.2	-2°31′.1	1.9	5.1		40γ Cap	253
318°00′.0	-2°29′.0	317°57′.4	-2°32′.0	2.6	3.0		49δ Cap	254
318°14′.0	2°22′.0	319°26′.5	1°57′.5	-72.5	24.5	h	48λ Cap	255
320°27′.0	-0°14′.5	320°13′.9	-0°38′.8	13.1	24.3		51μ Cap	256
320°16′.0	-0°10′.0	320°13′.9	-0°38′.8	2.1	28.8		51μ Cap	257
319°54′.0	4°17′.0	319°50′.9	4°14′.2	3.1	2.8		46c1 Cap	258
322°26′.5	15°23′.0	322°24′.2	15°22′.3	2.2	0.7		25d Aqr	259
327°49′.5	10°42′.0	327°47′.6	10°41′.0	1.9	1.0		34α Aqr	260
326°36′.0	9°11′.5	326°32′.8	9°11′.2	3.2	0.3		31o Aqr	261
317°51′.0	8°42′.0	317°49′.9	8°38′.7	1.0	3.3		22β Aqr	262
318°38′.0	6°00′.5	318°32′.7	5°59′.5	5.3	1.0		23ξ Aqr	263
310°51′.0	4°50′.0	310°49′.4	4°48′.1	1.6	1.9		13ν Aqr	264
307°28′.5	8°19′.0	307°29′.5	8°16′.8	-1.0	2.2		6μ Aqr	265
306°12′.0	8°10′.0	306°09′.5	8°07′.3	2.5	2.7		2ϵ Aqr	266
331°10′.0	8°17′.5	331°08′.4	8°15′.4	1.6	2.1		48γ Aqr	267
333°04′.5	10°31′.0	333°02′.3	10°29′.3	2.2	1.7		52π Aqr	268
333°23′.0	8°52′.5	333°19′.6	8°51′.9	3.4	0.6		55ζ Aqr	269
334°53′.0	8°10′.0	334°50′.1	8°10′.2	2.8	-0.2		62η Aqr	270
327°45′.0	2°46′.0	327°41′.2	2°44′.0	3.8	2.0		43θ Aqr	271
328°31′.0	2°29′.5	328°27′.7	2°23′.5	3.3	6.0		46ρ Aqr	272
329°53′.0	-1°10′.0	329°49′.2	-1°12′.4	3.8	2.4		57σ Aqr	273
323°13′.0	-2°00′.0	323°08′.9	-2°03′.0	4.1	3.0		33ι Aqr	274
333°22′.0	-8°10′.0	333°18′.2	-8°10′.5	3.7	0.5		76δ Aqr	275
333°05′.0	-5°37′.0	333°01′.6	-5°38′.8	3.4	1.8		71τ2 Aqr	276
329°40′.0	-9°40′.0	330°15′.1	-11°00′.3	-34.4	80.3	h	68 Aqr	277
326°55′.5	-10°48′.5	326°56′.9	-10°51′.4	-1.4	2.9		59υ Aqr	278
329°50′.0	-9°57′.5	329°39′.8	-9°56′.3	10.1	-1.2		66g1 Aqr	279
333°52′.0	4°08′.5	333°51′.8	4°08′.1	0.2	0.4		63κ Aqr	280
336°04′.0	-0°19′.5	336°00′.3	-0°22′.6	3.7	3.1		73λ Aqr	281
339°00′.0	-1°24′.0	338°49′.3	-1°40′.3	10.7	16.3		83h Aqr	282
341°38′.0	-1°00′.0	341°34′.5	-1°01′.4	3.5	1.4		90ϕ Aqr	283
341°33′.0	-2°49′.0	341°29′.6	-2°50′.0	3.4	1.0		92χ Aqr	284
340°43′.0	-3°58′.5	340°42′.0	-3°58′.5	1.0	0.0		91ψ1 Aqr	285
341°11′.0	-4°10′.5	341°09′.4	-4°16′.4	1.6	5.9		93ψ2 Aqr	286
341°14′.5	-4°44′.0	341°13′.5	-4°46′.2	1.0	2.2		95ψ3 Aqr	287
344°07′.0	-10°59′.0	344°05′.1	-11°01′.5	1.9	2.5		102ω1 Aqr	288
344°38′.0	-11°33′.0	344°36′.7	-11°36′.2	1.3	3.2		105ω2 Aqr	289
343°03′.0	-14°29′.0	343°01′.8	-14°30′.5	1.2	1.5		104A2 Aqr	290
343°46′.0	-15°16′.5	343°22′.8	-15°09′.9	22.4	-6.6	h	106i1 Aqr	291
344°44′.0	-16°23′.0	344°42′.7	-16°26′.5	1.2	3.5		108 Aqr	292
337°54′.5	-14°45′.0	337°53′.6	-14°46′.3	0.9	1.3		98b1 Aqr	293
338°21′.0	-15°30′.0	338°20′.2	-15°33′.6	0.8	3.6		99b2 Aqr	294
339°50′.0	-16°31′.0	339°48′.9	-16°30′.5	1.1	-0.5		101b4 Aqr	295
334°25′.0	-14°25′.5	334°25′.8	-14°28′.6	-0.8	3.1		88c2 Aqr	296
334°02′.0	-15°40′.0	334°00′.1	-15°41′.6	1.8	1.6		89c3 Aqr	297
333°17′.0	-15°53′.0	332°44′.9	-16°34′.1	30.8	41.1		86c1 Aqr	298
328°11′.5	-21°00′.0	328°14′.7	-21°05′.1	-3.0	5.1		24α PsA	299
343°02′.0	9°04′.0	343°01′.5	9°03′.6	0.5	0.4		4β Psc	300

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
8260	4.68	5.27	4	318°23′.8	-21°08′.7	318°39′.0	-21°12′.3	-14.2	3.6
8288	4.73	5.28	5	320°06′.8	-20°39′.1	320°03′.6	-20°38′.2	3.0	-0.9
8278	3.68	4.17	3	319°28′.5	-18°20′.5	319°27′.9	-18°25′.0	0.6	4.5
8322	2.87	3.35	3	321°15′.5	-17°50′.8	321°13′.5	-17°53′.5	1.9	2.7
8319	5.58	5.96	5	319°56′.2	-13°09′.7	321°14′.4	-13°09′.7	-76.2	0.0
8351	5.08	5.50	5	322°56′.8	-14°56′.9	322°51′.6	-15°23′.2	5.0	26.3
8351	5.08	5.50	6	322°44′.5	-14°56′.1	322°51′.6	-15°23′.2	-6.8	27.1
8311	5.09	5.42	6	320°57′.0	-10°49′.5	320°54′.7	-10°52′.2	2.3	2.7
8277	5.10	5.33	6	319°51′.0	0°30′.0	319°49′.1	0°29′.6	1.9	0.4
8414	2.96	3.21	3	326°20′.3	-2°12′.5	326°18′.8	-2°13′.3	1.5	0.8
8402	4.69	4.96	5	325°42′.5	-4°02′.1	325°39′.5	-4°02′.6	3.0	0.5
8232	2.91	3.20	3	317°37′.5	-7°14′.3	317°37′.3	-7°16′.7	0.1	2.5
8264	4.69	5.01	5	319°11′.5	-9°34′.3	319°06′.5	-9°35′.8	4.9	1.6
8093	4.51	4.87	5	311°57′.9	-12°54′.9	311°56′.6	-12°55′.9	1.3	1.1
7990	4.73	5.06	5	307°44′.5	-10°24′.7	307°45′.9	-10°25′.3	-1.4	0.7
7950	3.77	4.11	4	306°32′.0	-10°51′.8	306°30′.0	-10°53′.8	1.9	2.0
8518	3.84	4.11	3	330°16′.0	-3°20′.1	330°15′.2	-3°21′.9	0.8	1.8
8539	4.66	4.91	5	331°14′.6	-0°35′.4	331°13′.1	-0°37′.0	1.5	1.6
8558	3.75	4.00	4	332°06′.7	-2°00′.9	332°03′.8	-2°02′.0	3.0	1.1
8597	4.02	4.28	4	333°45′.1	-2°08′.6	333°42′.4	-2°08′.8	2.8	0.2
8499	4.16	4.48	4	328°58′.8	-9°41′.7	328°55′.6	-9°44′.1	3.1	2.4
8512	5.37	5.70	6	329°48′.3	-9°41′.4	329°47′.0	-9°47′.4	1.3	6.0
8573	4.82	5.19	5	332°24′.8	-12°38′.5	332°21′.7	-12°41′.3	3.0	2.9
8418	4.27	4.70	4	326°15′.1	-15°42′.6	326°11′.7	-15°46′.0	3.2	3.3
8709	3.27	3.75	3	338°24′.4	-17°53′.8	338°20′.6	-17°55′.2	3.7	1.3
8679	4.01	4.42	5	337°08′.6	-15°38′.1	337°05′.6	-15°40′.4	2.9	2.3
8670	5.26	5.85	6	335°24′.1	-20°38′.9	336°29′.9	-21°40′.1	-61.1	61.2
8592	5.20	5.85	5	333°08′.9	-22°41′.8	333°10′.9	-22°43′.3	-1.8	1.5
8649	4.69	5.25	6	335°40′.8	-20°51′.5	335°29′.8	-20°53′.4	10.3	1.9
8610	5.03	5.31	4	334°15′.8	-6°15′.7	334°15′.7	-6°15′.5	0.1	-0.2
8698	3.74	4.05	4	337°58′.6	-9°37′.0	337°56′.1	-9°40′.7	2.5	3.7
8782	5.43	5.76	6	341°08′.6	-9°31′.1	341°04′.5	-9°49′.7	4.0	18.6
8834	4.22	4.52	5	343°27′.2	-8°08′.8	343°24′.2	-8°11′.0	2.9	2.2
8850	5.06	5.37	5	344°04′.8	-9°51′.4	344°01′.8	-9°53′.2	3.0	1.8
8841	4.21	4.55	5	343°45′.1	-11°14′.7	343°43′.9	-11°14′.7	1.2	-0.0
8858	4.39	4.74	5	344°16′.1	-11°15′.1	344°16′.6	-11°20′.7	-0.5	5.6
8865	4.98	5.34	5	344°32′.6	-11°44′.6	344°32′.2	-11°46′.6	0.4	2.0
8968	5.00	5.44	5	349°46′.4	-16°22′.4	349°45′.2	-16°25′.2	1.2	2.8
8988	4.49	4.94	5	350°29′.7	-16°41′.4	350°29′.4	-16°44′.6	0.3	3.2
8982	4.82	5.35	5	350°15′.4	-19°59′.8	350°14′.3	-20°01′.3	1.0	1.5
8998	5.24	5.80	6	351°16′.5	-20°26′.2	350°51′.2	-20°29′.1	23.7	2.9
9031	5.18	5.77	6	352°40′.1	-21°03′.9	352°39′.9	-21°07′.4	0.2	3.5
8892	3.97	4.59	5	345°29′.4	-22°14′.7	345°28′.5	-22°15′.9	0.9	1.2
8906	4.39	5.03	5	346°14′.3	-22°45′.7	346°14′.5	-22°49′.0	-0.2	3.3
8939	4.71	5.39	5	348°06′.1	-23°06′.9	348°04′.2	-23°06′.5	1.7	-0.3
8812	3.66	4.33	5	341°59′.1	-23°17′.1	342°00′.6	-23°19′.2	-1.4	2.1
8817	4.69	5.46	5	342°08′.8	-24°34′.3	342°07′.0	-24°36′.1	1.6	1.8
8789	4.47	5.33	5	341°30′.6	-25°03′.3	341°16′.4	-25°52′.7	12.8	49.4
8728	1.16	3.24	1	338°46′.2	-31°39′.9	338°51′.0	-31°42′.8	-4.0	2.9
8773	4.53	4.76	5	340°53′.9	1°41′.5	340°53′.6	1°41′.5	0.3	0.0

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_{D}	β_{D}	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
345°50′.5	7°17′.5	345°48′.8	7°17′.5	1.7	-0.0		6γ Psc	301
347°30′.5	8°54′.5	347°27′.6	8°53′.0	2.8	1.5		7b Psc	302
349°42′.0	9°03′.0	349°38′.7	9°02′.0	3.3	1.0		10θ Psc	303
351°56′.5	7°13′.5	352°03′.9	7°12′.8	-7.3	0.7		17ι Psc	304
347°21′.0	4°27′.0	347°20′.1	4°26′.9	0.9	0.1		8κ Psc	305
351°05′.0	3°25′.0	351°02′.6	3°25′.6	2.4	-0.6		18λ Psc	306
357°02′.0	6°23′.5	357°00′.7	6°22′.5	1.3	1.0		28ω Psc	307
358°27′.0	7°27′.0	358°25′.0	7°31′.6	1.9	-4.6		32c2 Psc	308
2°29′.0	5°28′.0	2°25′.0	5°27′.6	4.0	0.4		41d Psc	309
8°36′.0	2°11′.0	8°34′.5	2°10′.1	1.5	0.9		63δ Psc	310
11°58′.0	1°05′.5	11°57′.9	1°04′.1	0.1	1.4		71ϵ Psc	311
14°19′.0	0°57′.5	14°18′.0	-0°13′.4	1.0	70.9		86ζ Psc	312
12°25′.0	-1°31′.0	12°22′.9	-1°30′.2	2.1	-0.8		80e Psc	313
13°46′.0	-4°19′.5	13°45′.5	-4°17′.1	0.5	-2.4		89f Psc	314
17°33′.0	-3°03′.0	17°32′.2	-3°04′.3	0.8	1.3		98μ Psc	315
19°56′.0	-4°40′.5	19°56′.2	-4°43′.3	-0.2	2.8		106ν Psc	316
21°57′.5	-7°56′.0	21°56′.6	-7°57′.1	0.8	1.1		111ξ Psc	317
23°47′.5	-9°04′.5	23°48′.1	-9°05′.3	-0.6	0.8		113α Psc	318
22°12′.0	-1°38′.5	22°09′.9	-1°39′.0	2.1	0.5		110ο Psc	319
21°16′.0	1°51′.5	21°21′.2	1°51′.7	-5.2	-0.2		102π Psc	320
21°16′.0	5°21′.0	21°15′.0	5°21′.1	1.0	-0.1		99η Psc	321
21°36′.5	9°24′.0	21°31′.3	9°21′.9	5.1	2.1		93ρ Psc	322
23°15′.0	22°00′.0	23°14′.2	21°58′.7	0.7	1.3		82g Psc	323
22°49′.5	20°43′.0	22°45′.6	20°43′.1	3.6	-0.1		83τ Psc	324
19°22′.5	20°55′.0	19°21′.0	20°56′.5	1.4	-1.5		68h Psc	325
18°06′.5	19°24′.0	18°10′.3	19°29′.0	-3.6	-5.0		67k Psc	326
17°03′.5	20°24′.0	17°04′.3	20°30′.2	-0.8	-6.2		65i Psc	327
17°56′.5	13°21′.0	17°52′.6	13°20′.6	3.8	0.4		74ψ1 Psc	328
18°02′.5	12°21′.5	18°04′.9	12°28′.5	-2.3	-7.0		79ψ2 Psc	329
18°09′.0	11°21′.0	18°04′.1	11°17′.6	4.8	3.4		81ψ3 Psc	330
23°18′.0	17°26′.0	23°13′.9	17°26′.3	3.9	-0.3		90υ Psc	331
20°58′.5	15°30′.0	20°54′.2	15°28′.8	4.1	1.2		85ϕ Psc	332
19°00′.0	12°27′.5	18°58′.3	12°25′.1	1.7	2.4		84χ Psc	333
24°11′.0	18°31′.0	24°11′.9	18°39′.4	-0.8	-8.4		91 l Psc	334
21°41′.0	23°03′.0	21°39′.8	23°03′.4	1.1	-0.4		69σ Psc	335
83°02′.5	66°02′.0	82°59′.4	66°03′.2	1.2	-1.2		1α UMi	336
85°36′.0	69°50′.5	85°37′.5	69°53′.9	-0.5	-3.4		23δ UMi	337
93°24′.0	73°50′.0	93°32′.0	73°52′.3	-2.2	-2.3		22ϵ UMi	338
111°29′.0	75°00′.0	111°44′.2	75°04′.6	-3.9	-4.6		16ζ UMi	339
114°52′.0	77°38′.5	114°41′.4	77°48′.6	2.2	-10.1		21η UMi	340
127°16′.5	72°51′.5	127°37′.8	72°57′.4	-6.2	-5.9		7β UMi	341
135°41′.0	75°23′.5	135°52′.5	75°12′.9	-2.9	10.6	r	13γ UMi	342
122°54′.0	71°23′.0	122°44′.8	71°13′.6	3.0	9.4		5 UMi	343
117°20′.5	70°18′.0	117°10′.0	70°17′.2	3.5	0.8		4 UMi	344
77°17′.0	35°50′.0	75°54′.7	35°52′.8	66.7	-2.8	Uz	11-2 Cam	345
77°28′.0	37°20′.0	75°42′.3	37°22′.8	84.0	-2.8	uz	10β Cam	346
77°45′.0	40°13′.0	75°25′.0	43°22′.0	101.8	-189.0	uz	9α Cam	347
78°03′.0	42°56′.0	62°19′.9	45°12′.5	664.5	-136.5	uz	A Cam	348
111°38′.0	57°55′.0	110°35′.7	58°33′.6	32.5	-38.6	z	Dra	349
81°55′.0	70°42′.0	113°54′.4	64°12′.1	-835.3	389.9	z	Cam	350

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	*m*	μ	m	α_{D}	δ_{D}	α	δ	$\Gamma\alpha$	$\Delta\delta$
8852	3.69	3.92	4	344°08′.8	1°07′.3	344°07′.3	1°07′.1	1.5	0.2
8878	5.05	5.27	6	345°02′.4	3°15′.1	345°00′.5	3°13′.1	1.9	2.0
8916	4.28	4.49	5	346°58′.8	4°13′.9	346°56′.3	4°11′.9	2.5	1.9
8969	4.13	4.35	6	349°44′.7	3°25′.8	349°51′.8	3°28′.3	-7.1	-2.5
8911	4.94	5.19	5	346°38′.0	-0°54′.9	346°37′.2	-0°55′.0	0.8	0.1
8984	4.50	4.74	5	350°27′.9	-0°24′.4	350°25′.5	-0°24′.5	2.4	0.2
9072	4.01	4.22	5	354°43′.7	4°40′.7	354°43′.0	4°39′.4	0.7	1.3
9093	5.63	5.84	6	355°35′.8	6°12′.7	355°32′.3	6°16′.2	3.4	-3.5
0080	5.37	5.57	6	0°05′.3	6°00′.1	0°01′.9	5°58′.2	3.4	2.0
0224	4.43	4.63	4	7°01′.7	5°25′.5	7°00′.8	5°24′.0	0.9	1.6
0294	4.28	4.49	4	10°34′.1	5°45′.0	10°34′.8	5°43′.4	-0.7	1.6
0361	4.89	5.10	4	12°47′.8	6°32′.7	13°14′.7	5°26′.7	-26.8	66.1
0330	5.52	5.74	6	12°00′.5	3°31′.5	11°58′.3	3°31′.1	2.2	0.4
0378	5.16	5.39	6	14°20′.7	1°27′.8	14°19′.3	1°29′.4	1.4	-1.6
0434	4.84	5.05	5	17°20′.6	4°05′.5	17°20′.4	4°03′.6	0.1	1.9
0489	4.44	4.65	5	20°09′.9	3°29′.3	20°11′.3	3°26′.3	-1.4	3.0
0549	4.62	4.85	5	23°15′.0	1°13′.0	23°14′.7	1°11′.0	0.4	1.9
0595	3.94	4.18	3	25°21′.4	0°49′.3	25°22′.3	0°48′.0	-0.8	1.2
0510	4.26	4.46	5	21°08′.0	7°08′.9	21°06′.5	7°07′.1	1.6	1.8
0463	5.57	5.76	5	18°55′.9	10°02′.6	19°01′.0	10°04′.3	-5.0	-1.7
0437	3.62	3.80	4	17°34′.7	13°16′.4	17°34′.0	13°15′.7	0.6	0.7
0413	5.38	5.55	5	16°17′.1	17°08′.5	16°13′.5	17°04′.1	3.4	4.4
0349	5.16	5.31	6	12°19′.5	29°18′.6	12°20′.2	29°16′.8	-0.6	1.8
0352	4.51	4.66	5	12°31′.6	27°58′.7	12°28′.7	27°56′.9	2.6	1.8
0274	5.42	5.57	6	9°08′.1	26°48′.5	9°06′.8	26°49′.1	1.2	-0.6
0262	6.00	6.16	6	8°38′.6	24°56′.0	8°40′.6	25°01′.8	-1.8	-5.8
0230	5.54	5.70	6	7°11′.4	25°25′.5	7°10′.0	25°31′.3	1.2	-5.8
0310	4.69	4.86	5	11°09′.9	19°20′.9	11°06′.9	19°18′.8	2.9	2.2
0328	5.55	5.72	6	11°40′.8	18°28′.8	11°40′.6	18°35′.8	0.2	-7.0
0339	5.55	5.72	6	12°12′.3	17°35′.8	12°09′.6	17°30′.5	2.6	5.3
0383	4.76	4.92	5	14°29′.5	25°10′.1	14°26′.1	25°08′.5	3.1	1.6
0360	4.65	4.81	5	13°07′.0	22°30′.0	13°04′.1	22°26′.9	2.7	3.1
0351	4.66	4.83	5	12°32′.6	18°56′.7	12°32′.5	18°53′.5	0.1	3.2
0389	5.23	5.38	6	14°51′.4	26°30′.0	14°49′.2	26°37′.6	2.0	-7.6
0291	5.50	5.65	6	10°18′.5	29°38′.9	10°18′.0	29°38′.5	0.4	0.4
0424	2.02	2.18	2	5°45′.7	87°09′.9	5°56′.6	87°08′.7	-0.5	1.2
6789	4.36	4.52	4	293°54′.1	86°15′.5	293°34′.8	86°14′.6	1.3	0.9
6322	4.23	4.38	4	262°40′.7	82°33′.3	262°25′.2	82°32′.6	2.0	0.7
5903	4.32	4.47	4	240°05′.0	79°02′.6	240°05′.0	78°58′.5	-0.0	4.2
6116	4.95	5.09	5	246°59′.0	76°41′.5	247°34′.3	76°38′.1	-8.2	3.5
5563	2.08	2.22	2	222°59′.2	75°52′.6	223°13′.6	75°47′.0	-3.5	5.6
5735	3.05	3.19	3	231°13′.9	73°15′.1	230°31′.7	73°15′.1	12.2	-0.0
5430	4.25	4.39	4	217°23′.1	77°23′.7	216°34′.4	77°28′.9	10.6	-5.2
5321	4.82	4.96	5	213°10′.8	79°20′.4	213°00′.3	79°25′.1	1.9	-4.7
1622	4.76	4.90	6	70°02′.5	58°28′.6	67°57′.5	58°17′.7	65.7	10.9
1603	4.03	4.16	6	69°49′.5	59°58′.8	67°05′.2	59°44′.2	82.8	14.6
1542	4.29	4.43	6	69°11′.9	62°51′.4	63°46′.3	65°31′.9	134.9	-160.5
0985	4.84	4.98	6	68°30′.1	65°33′.9	41°29′.6	64°06′.1	707.8	87.8
4126	4.84	4.98	6	149°40′.9	76°53′.3	149°35′.0	77°42′.9	1.3	-49.6
4646	5.14	5.29	6	301°13′.1	84°51′.3	178°02′.8	79°50′.2	1304.1	301.2

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
84°31′.0	69°08′.0	75°52′.8	65°10′.0	217.6	238.0	z	Cep	351
75°07′.0	68°04′.0	75°06′.0	68°00′.2	0.4	3.8	z	Cep	352
67°22′.0	67°43′.0	67°01′.2	67°43′.5	7.9	-0.5	z	Cep	353
69°57′.0	67°22′.0	70°07′.8	67°29′.4	-4.1	-7.4	z	Cep	354
86°30′.0	63°55′.0	87°17′.8	63°47′.2	-21.1	7.8	z	Cep	355
107°36′.5	40°02′.5	107°25′.3	40°12′.8	8.6	-10.3		1o UMa	356
107°10′.0	43°55′.5	107°13′.9	43°58′.9	-2.8	-3.4		4π2 UMa	357
106°08′.0	44°22′.0	106°44′.6	44°34′.9	-26.1	-12.9	h	3π1 UMa	358
108°25′.0	47°50′.5	108°22′.8	47°54′.3	1.5	-3.8		8ρ UMa	359
109°44′.5	47°44′.5	109°42′.3	47°47′.6	1.5	-3.1		13σ2 UMa	360
114°42′.5	51°36′.5	110°44′.6	51°12′.0	149.1	24.5		24d UMa	361
113°50′.0	42°30′.0	113°41′.4	42°47′.5	6.3	-17.5		16c UMa	362
115°02′.0	45°03′.0	115°12′.7	45°07′.1	-7.6	-4.1		23h UMa	363
118°00′.0	46°21′.5	111°59′.3	44°32′.0	257.1	109.5	h	14τ UMa	364
120°38′.0	42°36′.0	120°41′.9	42°38′.5	-2.9	-2.5		29υ UMa	365
123°38′.5	38°15′.5	123°45′.3	38°13′.3	-5.3	2.2		30ϕ UMa	366
120°32′.5	34°34′.5	121°45′.8	34°57′.1	-60.1	-22.6		25θ UMa	367
115°56′.0	29°15′.5	117°15′.5	29°34′.4	-69.2	-18.9		9ι UMa	368
117°10′.0	28°38′.0	118°21′.2	28°56′.7	-62.3	-18.7		12κ UMa	369
117°07′.0	33°30′.0	117°32′.7	33°25′.3	-21.4	4.7	m	15f UMa	370
117°26′.0	36°06′.0	117°43′.0	36°03′.5	-13.7	2.5	m	18e UMa	371
129°34′.0	49°40′.0	129°35′.6	49°39′.6	-1.0	0.4		50α UMa	372
133°43′.5	45°03′.5	133°49′.0	45°05′.7	-3.9	-2.2		48β UMa	373
145°25′.5	51°37′.0	145°25′.4	51°37′.6	0.0	-0.6		69δ UMa	374
144°45′.0	47°06′.5	144°50′.8	47°06′.7	-4.0	-0.2		64γ UMa	375
133°56′.5	29°51′.5	133°58′.5	29°52′.0	-1.7	-0.5		33λ UMa	376
135°04′.5	28°45′.0	135°39′.3	28°58′.1	-30.4	-13.1		34μ UMa	377
142°33′.0	35°14′.0	143°13′.1	35°31′.2	-32.6	-17.2		52ψ UMa	378
150°55′.0	26°14′.0	151°04′.0	26°08′.7	-8.1	5.3	m	54ν UMa	379
151°36′.0	24°54′.0	151°46′.1	24°47′.3	-9.2	6.7	m	53ξ UMa	380
153°10′.0	54°18′.0	153°16′.8	54°17′.8	-4.0	0.2		77ϵ UMa	381
159°56′.5	56°22′.0	160°02′.1	56°21′.8	-3.1	0.2		79ζ UMa	382
171°12′.0	54°25′.0	171°18′.6	54°23′.9	-3.8	1.1		85η UMa	383
167°43′.5	40°06′.0	168°59′.3	40°07′.7	-58.0	-1.7		12α CVn	384
148°10′.0	41°30′.0	148°04′.2	41°31′.8	4.4	-1.8		63χ UMa	385
141°02′.0	33°01′.0	140°55′.1	33°02′.2	5.8	-1.2		45ω UMa	386
126°17′.0	17°55′.0	126°17′.3	17°56′.0	-0.3	-1.0		40α Lyn	387
128°10′.0	20°42′.0	128°14′.2	20°42′.8	-3.9	-0.8		10 LMi	388
125°00′.0	20°05′.0	124°59′.3	20°04′.7	0.7	0.3		38 Lyn	389
121°57′.0	20°51′.0	121°58′.0	20°51′.5	-0.9	-0.5		Lyn	390
119°42′.0	23°41′.0	119°44′.1	23°42′.9	-1.9	-1.9		Lyn	391
134°12′.0	21°53′.0	135°25′.1	22°04′.1	-67.8	-11.1		21 LMi	392
138°55′.0	25°04′.0	138°57′.6	25°03′.2	-2.3	0.8		31β LMi	393
139°57′.0	24°59′.0	139°49′.5	22°13′.1	7.0	165.9		30 LMi	394
143°22′.5	21°38′.0	143°15′.5	21°36′.7	6.5	1.3		37 LMi	395
146°09′.0	20°44′.0	145°19′.1	21°02′.9	46.6	-18.9		42 LMi	396
145°19′.0	24°58′.0	145°15′.8	24°56′.0	2.9	2.0		46 LMi	397
162°16′.0	40°30′.0	162°12′.2	40°33′.0	2.9	-3.0		8β CVn	398
111°29′.0	53°08′.0	163°39′.1	57°49′.6	-1666.7	-281.6	wz	83 UMa	399
113°55′.0	47°14′.0	164°38′.6	51°47′.0	-1882.9	-273.0	wz	21 CVn	400

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
0285	4.25	4.40	6	305°24′.7	86°38′.0	6°33′.8	84°04′.8	-378.4	153.1
8546	5.27	5.42	6	337°44′.5	84°03′.0	338°39′.3	84°03′.9	-5.7	-0.9
8702	4.74	4.89	6	341°38′.1	81°09′.3	341°44′.7	81°02′.1	-1.0	7.2
8748	4.71	4.86	6	344°21′.4	82°07′.5	343°42′.9	82°12′.5	5.2	-5.0
2609	5.07	5.22	6	58°32′.9	87°03′.1	66°06′.6	87°03′.0	-23.3	0.0
3323	3.36	3.49	4	119°19′.5	61°46′.8	119°05′.6	61°57′.1	6.5	-10.3
3403	4.60	4.73	4	120°58′.8	65°36′.5	121°05′.4	65°37′.1	-2.7	-0.7
3391	5.64	5.78	5	119°32′.4	66°14′.4	120°41′.3	66°17′.7	-27.7	-3.3
3576	4.76	4.89	4	126°21′.8	69°02′.7	126°18′.5	69°05′.1	1.2	-2.4
3616	4.80	4.94	4	128°33′.8	68°37′.8	128°29′.8	68°39′.6	1.4	-1.8
3771	4.56	4.70	5	141°46′.7	70°42′.3	134°22′.8	71°30′.0	140.8	-47.7
3648	5.13	5.27	5	130°30′.6	62°42′.1	130°28′.5	62°59′.1	1.0	-17.1
3757	3.67	3.81	4	134°28′.8	64°44′.6	134°45′.8	64°43′.9	-7.3	0.7
3624	4.67	4.81	5	140°12′.5	65°03′.6	129°15′.0	65°03′.0	277.3	0.6
3888	3.80	3.94	4	140°22′.5	60°51′.6	140°27′.3	60°51′.4	-2.3	0.2
3894	4.59	4.73	4	141°00′.2	55°57′.8	141°05′.0	55°52′.4	-2.7	5.4
3775	3.17	3.30	3	134°38′.4	53°27′.2	136°24′.5	53°26′.2	-63.2	1.1
3569	3.14	3.28	3	126°02′.7	49°34′.7	127°51′.9	49°32′.2	-70.9	2.5
3594	3.60	3.74	3	127°22′.2	48°40′.9	128°59′.5	48°39′.8	-64.2	1.2
3619	4.48	4.62	5	129°33′.1	53°21′.1	130°03′.0	53°08′.6	-17.9	12.6
3662	4.83	4.97	5	131°23′.6	55°44′.3	131°43′.1	55°35′.8	-11.0	8.4
4301	1.79	1.92	2	159°36′.9	63°54′.5	159°34′.3	63°52′.8	1.1	1.6
4295	2.37	2.51	2	159°11′.7	58°30′.8	159°17′.1	58°29′.8	-2.8	0.9
4660	3.31	3.45	2	178°51′.5	59°14′.7	178°48′.8	59°15′.2	1.4	-0.5
4554	2.44	2.58	2	173°03′.1	55°56′.9	173°06′.1	55°54′.6	-1.7	2.4
4033	3.45	3.59	4	148°09′.1	44°53′.3	148°09′.9	44°52′.0	-0.6	1.3
4069	3.05	3.18	4	148°49′.0	43°29′.0	149°33′.1	43°28′.1	-32.0	0.9
4335	3.01	3.14	4	160°51′.3	46°39′.2	161°43′.1	46°38′.6	-35.6	0.5
4377	3.48	3.62	4	164°05′.8	35°24′.2	164°10′.6	35°15′.3	-3.9	8.8
4374	3.86	4.01	4	164°05′.1	33°56′.0	164°10′.4	33°45′.5	-4.4	10.5
4905	1.77	1.91	2	189°01′.0	58°10′.9	189°03′.0	58°08′.4	-1.1	2.5
5054	2.06	2.20	2	196°54′.5	57°03′.5	196°55′.3	57°01′.8	-0.4	1.7
5191	1.86	2.00	2	202°54′.5	51°22′.3	202°55′.8	51°19′.8	-0.8	2.5
4914	2.81	2.95	2	188°13′.3	40°57′.5	189°18′.3	40°29′.3	-49.4	28.1
4518	3.71	3.84	4	171°16′.1	49°55′.6	171°09′.4	49°59′.1	4.3	-3.5
4248	4.71	4.85	5	157°48′.3	45°14′.4	157°39′.8	45°17′.3	6.0	-2.9
3705	3.13	3.27	3	134°07′.7	36°01′.8	134°07′.4	36°01′.3	0.3	0.5
3800	4.55	4.69	4	137°18′.6	38°08′.7	137°22′.4	38°06′.8	-3.0	1.9
3690	3.82	3.96	4	133°28′.0	38°27′.4	133°26′.0	38°25′.8	1.6	1.6
3612	4.56	4.70	4	130°12′.6	40°00′.3	130°12′.9	39°58′.9	-0.2	1.4
3579	3.97	4.11	4	128°34′.1	43°18′.0	128°36′.1	43°17′.7	-1.5	0.3
3974	4.48	4.62	4	144°30′.9	37°23′.6	145°54′.3	37°08′.8	-66.4	14.8
4100	4.21	4.35	4	151°06′.9	38°45′.6	151°07′.8	38°43′.0	-0.7	2.6
4090	4.74	4.88	5	152°10′.6	38°19′.2	150°41′.8	35°47′.6	72.1	151.6
4166	4.71	4.85	5	154°09′.5	34°00′.8	154°00′.4	34°01′.1	7.5	-0.4
4203	5.24	5.39	5	156°35′.1	32°10′.6	155°51′.9	32°45′.4	36.4	-34.8
4247	3.83	3.97	4	157°46′.8	36°21′.9	157°41′.2	36°20′.4	4.6	1.4
4785	4.26	4.40	5	183°42′.1	43°27′.9	183°39′.0	43°32′.1	2.3	-4.2
5154	4.66	4.79	6	138°46′.3	73°00′.8	201°22′.3	56°43′.4	-2060.8	977.4
5023	5.15	5.29	6	134°54′.9	67°03′.2	195°16′.5	51°48′.0	-2239.6	915.1

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
109°49′.0	47°30′.0	168°45′.3	52°51′.6	-2135.1	-321.6	wz	24 CVn	401
143°17′.0	46°50′.0	172°46′.0	38°54′.1	-1376.6	475.9	wz	14 CVn	402
153°58′.0	47°55′.0	171°58′.7	41°40′.2	-807.3	374.8	wz	15-7 CVn	403
156°00′.0	48°40′.0	171°38′.5	43°27′.2	-681.3	312.8	wz	CVn	404
156°30′.0	49°42′.0	172°12′.6	44°11′.8	-675.8	330.2	wz	20 CVn	405
156°19′.0	49°42′.0	173°08′.1	44°06′.7	-724.5	335.3	wz	23 CVn	406
169°05′.0	49°00′.0	178°33′.6	42°59′.6	-415.9	360.4	cz	CVn	407
168°01′.0	49°27′.0	179°49′.0	42°29′.6	-522.0	417.4	cz	25 CVn	408
175°42′.0	48°11′.0	180°32′.2	45°23′.6	-203.8	167.4	cz	CVn	409
166°02′.0	52°25′.0	184°08′.6	42°27′.0	-801.8	598.0	cz	CVn	410
121°41′.0	35°40′.0	121°50′.5	35°19′.6	-7.7	20.4	z	26 UMa	411
228°56′.5	76°17′.0	229°07′.8	76°16′.4	-2.7	0.6		21μ Dra	412
244°14′.5	78°14′.5	244°39′.7	78°11′.1	-5.2	3.4		24-5ν Dra	413
246°19′.5	75°21′.0	246°21′.6	75°19′.7	-0.5	1.3		23β Dra	414
259°03′.0	80°21′.5	259°07′.6	80°19′.5	-0.8	2.0		32ξ Dra	415
262°24′.0	75°03′.5	262°24′.8	74°58′.6	-0.2	4.9		33γ Dra	416
287°04′.0	81°53′.0	286°46′.4	81°49′.0	2.5	4.0		39b Dra	417
294°31′.0	77°57′.0	294°26′.2	77°54′.6	1.0	2.4		46c Dra	418
290°33′.5	79°51′.5	290°15′.6	79°48′.1	3.2	3.4		45d Dra	419
309°29′.0	80°53′.5	309°31′.0	80°50′.3	-0.3	3.2		47o Dra	420
358°23′.0	81°51′.0	358°08′.1	81°49′.6	2.1	1.4		58π Dra	421
12°26′.5	82°49′.0	11°53′.9	82°52′.6	4.0	-3.6		7δ Dra	422
15°21′.0	78°09′.5	14°59′.3	78°08′.5	4.5	1.0		67ρ Dra	423
27°47′.0	79°25′.0	27°20′.0	79°28′.1	4.9	-3.1		63ϵ Dra	424
45°18′.0	83°05′.0	44°58′.8	83°11′.1	2.3	-6.1		52υ Dra	425
49°40′.5	80°38′.0	49°29′.2	80°38′.7	1.8	-0.7		60τ Dra	426
26°44′.0	80°54′.0	26°16′.0	80°55′.3	4.4	-1.3		61σ Dra	427
96°34′.5	83°04′.5	98°00′.7	84°06′.9	-8.8	-62.4		31ψ1 Dra	428
71°28′.0	83°28′.5	71°02′.7	83°30′.0	2.9	-1.5	r	44χ Dra	429
65°31′.0	84°48′.5	65°38′.4	84°49′.8	-0.7	-1.3		43ϕ Dra	430
149°44′.5	81°04′.5	149°29′.8	81°01′.6	2.3	2.9		15A Dra	431
126°26′.0	86°53′.0	126°28′.9	86°53′.3	-0.2	-0.3		28ω Dra	432
178°21′.0	83°18′.0	178°52′.5	83°18′.3	-3.7	-0.3		19h1 Dra	433
178°22′.0	81°41′.0	178°28′.9	81°38′.3	-1.0	2.7		18g Dra	434
176°51′.5	84°46′.0	177°16′.7	84°46′.2	-2.3	-0.2		22ζ Dra	435
187°55′.0	78°32′.0	188°42′.7	78°27′.4	-9.5	4.6		14η Dra	436
192°28′.5	74°11′.5	191°06′.9	74°27′.4	21.9	-15.9		13θ Dra	437
179°22′.0	71°04′.0	179°14′.3	71°06′.1	2.5	-2.1		12ι Dra	438
149°17′.0	65°18′.0	149°15′.1	65°21′.0	0.8	-3.0		10i Dra	439
152°10′.5	66°36′.0	151°47′.2	66°21′.0	9.3	15.0		11α Dra	440
130°26′.0	61°33′.0	130°37′.4	61°44′.0	-5.4	-11.0		5κ Dra	441
124°37′.5	57°07′.0	124°42′.7	57°12′.5	-2.8	-5.5		1λ Dra	442
1°04′.0	77°31′.5	0°49′.4	77°29′.9	3.2	1.6		64e Dra	443
30°13′.0	71°07′.0	30°05′.5	71°07′.2	2.4	-0.2		8β Cep	444
7°13′.0	68°54′.0	7°18′.1	68°54′.6	-1.8	-0.6		5α Cep	445
27°53′.5	62°35′.0	27°47′.2	62°35′.2	2.9	-0.2		32ι Cep	446
8°29′.0	61°03′.0	8°28′.9	61°07′.9	0.0	-4.9		21ζ Cep	447
7°53′.5	59°59′.0	7°29′.4	59°57′.5	12.1	1.5		23ϵ Cep	448
13°39′.0	58°46′.0	12°07′.3	59°31′.4	46.5	-45.4		27δ Cep	449
359°21′.0	71°49′.0	359°00′.4	71°43′.8	6.5	5.2		3η Cep	450

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	*m*	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
5112	4.70	4.84	6	128°26′.9	68°23′.2	199°30′.3	51°04′.8	-2678.5	1038.4
4943	5.25	5.39	6	171°18′.2	56°18′.3	191°44′.4	37°57′.1	-966.9	1101.2
4967	5.33	5.47	6	182°31′.4	52°55′.8	192°54′.0	40°38′.3	-472.5	737.5
4997	4.92	5.06	6	185°03′.6	52°43′.2	193°52′.4	42°17′.2	-391.2	626.1
5017	4.73	4.87	6	186°32′.1	53°20′.6	194°52′.9	42°41′.6	-368.0	638.9
5032	5.60	5.74	6	186°22′.7	53°24′.9	195°34′.7	42°16′.0	-408.5	669.0
5110	4.98	5.12	6	196°12′.8	47°51′.9	199°13′.3	39°15′.1	-139.8	516.8
5127	4.82	4.96	6	195°45′.9	48°38′.4	199°54′.7	38°21′.0	-195.2	617.3
5186	5.50	5.64	6	200°43′.8	44°41′.5	202°25′.7	40°33′.9	-77.3	247.6
5214	5.44	5.58	6	197°02′.0	51°45′.2	203°21′.9	36°42′.5	-304.5	902.7
3799	4.50	4.64	6	136°46′.1	54°09′.0	136°43′.9	53°45′.8	1.3	23.2
6369	5.06	5.20	4	254°14′.1	55°01′.3	254°17′.0	55°01′.5	-1.6	-0.2
6554	4.12	4.26	4	260°59′.9	55°31′.6	261°06′.3	55°28′.7	-3.6	2.8
6536	2.79	2.92	3	260°22′.2	52°37′.2	260°22′.0	52°37′.7	0.1	-0.6
6688	3.75	3.88	4	266°39′.3	56°57′.7	266°40′.0	56°57′.6	-0.4	0.0
6705	2.23	2.36	3	266°51′.1	51°37′.0	266°50′.6	51°34′.1	0.3	2.9
6923	4.98	5.12	5	274°33′.9	58°37′.8	274°31′.2	58°35′.4	1.4	2.4
7049	5.04	5.18	5	278°43′.5	55°10′.3	278°43′.4	55°09′.8	0.0	0.6
6978	4.77	4.90	5	276°29′.0	56°47′.9	276°25′.4	56°45′.9	2.0	2.1
7125	4.66	4.79	4	281°14′.9	58°55′.9	281°19′.1	58°55′.3	-2.2	0.7
7371	4.59	4.73	4	289°33′.8	64°57′.7	289°36′.6	64°57′.2	-1.2	0.5
7310	3.07	3.20	3	288°12′.2	66°59′.5	288°03′.6	66°57′.6	3.4	1.8
7685	4.51	4.64	4	300°08′.3	66°47′.3	300°10′.7	66°44′.5	-0.9	2.8
7582	3.83	3.97	3	297°22′.3	69°18′.2	297°16′.6	69°14′.9	2.0	3.3
7180	4.82	4.96	4	284°55′.6	70°48′.0	284°44′.8	70°44′.9	3.6	3.2
7352	4.45	4.59	4	290°36′.6	72°35′.4	290°40′.0	72°35′.4	-1.0	0.0
7462	4.68	4.81	4	293°14′.5	69°01′.6	293°14′.0	68°58′.9	0.2	2.7
6636	4.27	4.41	4	267°14′.4	73°20′.2	267°18′.2	72°19′.1	-1.1	61.1
6927	3.57	3.71	4	276°55′.0	72°32′.7	277°02′.3	72°32′.2	-2.2	0.5
6920	4.22	4.36	4	276°38′.6	71°05′.0	276°35′.5	71°06′.3	1.0	-1.3
6161	5.00	5.14	3	247°26′.7	69°33′.1	247°17′.5	69°37′.7	3.2	-4.6
6596	4.80	4.94	4	264°51′.2	68°54′.3	264°50′.9	68°56′.0	0.1	-1.7
6315	4.89	5.03	5	253°29′.1	65°46′.7	253°30′.6	65°45′.1	-0.6	1.6
6223	4.83	4.96	5	249°42′.9	65°21′.1	249°35′.8	65°21′.3	3.0	-0.1
6396	3.17	3.31	3	256°57′.0	66°12′.8	256°57′.3	66°12′.6	-0.1	0.3
6132	2.74	2.87	3	244°41′.2	62°34′.8	244°41′.6	62°26′.1	-0.2	8.7
5986	4.01	4.15	3	238°43′.9	59°10′.4	238°38′.3	59°39′.2	2.8	-28.8
5744	3.29	3.42	3	229°04′.7	60°18′.6	229°02′.8	60°23′.4	0.9	-4.8
5226	4.65	4.78	5	204°55′.4	66°39′.8	204°56′.6	66°42′.9	-0.5	-3.1
5291	3.65	3.79	2	209°12′.4	66°16′.4	208°24′.6	66°18′.2	19.2	-1.9
4787	3.87	4.01	3	183°25′.3	71°58′.2	183°58′.5	71°59′.8	-10.3	-1.6
4434	3.84	3.98	3	166°26′.0	71°29′.8	166°38′.8	71°31′.2	-4.1	-1.3
7676	5.27	5.40	5	299°13′.5	63°44′.8	299°15′.8	63°43′.0	-1.0	1.8
8238	3.23	3.37	3	320°46′.3	68°50′.2	320°47′.8	68°49′.2	-0.5	1.0
8162	2.44	2.58	3	317°10′.9	60°51′.8	317°14′.9	60°55′.0	-1.9	-3.2
8694	3.52	3.65	4	338°55′.6	64°08′.5	338°55′.3	64°07′.0	0.1	1.5
8465	3.35	3.48	4	329°20′.4	56°11′.0	329°16′.8	56°15′.4	2.0	-4.5
8494	4.19	4.33	4	330°18′.0	55°13′.1	330°07′.1	55°04′.6	6.2	8.4
8571	3.75	3.88	4	335°33′.0	56°23′.5	333°37′.7	56°23′.6	63.8	-0.1
7957	3.43	3.57	4	309°12′.6	60°25′.3	309°15′.6	60°18′.6	-1.5	6.7

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
359°54′.0	74°00′.5	359°27′.7	73°55′.8	7.3	4.7		2θ Cep	451
18°46′.0	65°42′.0	18°42′.2	65°44′.3	1.5	-2.3		17ξ Cep	452
57°33′.0	75°27′.0	57°34′.8	75°26′.4	-0.4	0.6		1κ Cep	453
54°23′.0	64°28′.0	54°32′.6	64°36′.6	-4.1	-8.6		35γ Cep	454
174°09′.5	58°53′.0	174°17′.5	58°53′.9	-4.1	-0.9		17κ Boo	455
175°33′.0	58°51′.0	175°29′.0	58°50′.9	2.1	0.1		21ι Boo	456
176°59′.5	60°05′.0	176°56′.1	60°10′.0	1.7	-5.0		23θ Boo	457
181°18′.0	54°40′.0	181°22′.2	54°39′.4	-2.4	0.6		19λ Boo	458
192°05′.5	49°33′.5	192°04′.1	49°33′.8	0.9	-0.3		27γ Boo	459
198°43′.5	54°15′.5	198°37′.4	54°10′.9	3.5	4.6		42β Boo	460
207°29′.5	49°01′.0	207°31′.3	49°00′.3	-1.2	0.7		49δ Boo	461
202°29′.5	40°40′.0	202°30′.5	40°39′.2	-0.8	0.8		36ε Boo	462
198°16′.0	42°11′.0	198°16′.4	42°08′.8	-0.3	2.2		28σ Boo	463
197°17′.5	42°35′.5	197°11′.8	42°28′.1	4.2	7.4		25ρ Boo	464
207°26′.5	27°57′.0	207°26′.4	27°54′.6	0.1	2.4		30ζ Boo	465
193°42′.0	28°09′.0	193°43′.9	28°08′.2	-1.7	0.8		8η Boo	466
192°25′.0	26°33′.0	192°23′.8	26°33′.1	1.1	-0.1		4τ Boo	467
193°37′.0	25°14′.0	193°37′.3	25°13′.1	-0.3	0.9		5υ Boo	468
198°39′.5	31°02′.5	198°40′.1	31°00′.7	-0.5	1.8		16α Boo	469
206°13′.5	30°27′.5	206°15′.8	30°23′.6	-2.0	3.9		29π Boo	470
207°11′.0	31°22′.0	207°13′.5	31°17′.7	-2.1	4.3		35o Boo	471
207°52′.0	33°52′.0	207°55′.9	33°48′.4	-3.2	3.6		37ξ Boo	472
208°11′.0	40°14′.5	208°12′.3	40°12′.6	-1.0	1.9		41ω Boo	473
209°40′.0	40°31′.5	209°40′.7	40°30′.7	-0.5	0.8		45c Boo	474
207°53′.0	42°16′.0	207°55′.6	42°12′.6	-1.9	3.4		43ψ Boo	475
209°16′.0	41°55′.0	209°19′.7	41°55′.7	-2.7	-0.7		46b Boo	476
209°34′.5	45°06′.0	209°36′.7	45°05′.1	-1.6	0.9		48χ Boo	477
211°26′.5	46°52′.0	211°29′.9	46°50′.6	-2.3	1.4		2η CrB	478
207°32′.0	53°27′.5	207°35′.1	53°27′.1	-1.9	0.4		51μ Boo	479
212°35′.0	54°00′.0	212°39′.4	53°58′.9	-2.6	1.1		7ζ CrB	480
191°49′.0	60°40′.0	192°12′.3	60°34′.8	-11.4	5.2	z	44i Boo	481
192°33′.0	60°57′.0	192°01′.7	61°07′.4	15.1	-10.4	z	47k Boo	482
168°17′.0	28°25′.0	168°17′.9	28°24′.6	-0.8	0.4		15γ Com	483
178°15′.0	28°32′.0	180°49′.3	21°47′.2	-143.3	404.8	h	36 Com	484
168°42′.0	27°24′.0	168°40′.9	27°27′.1	0.9	-3.1		14 Com	485
168°46′.0	27°20′.0	169°02′.1	27°06′.8	-14.3	13.2		16 Com	486
169°19′.0	27°07′.0	169°55′.3	26°29′.3	-32.5	37.7		17 Com	487
168°25′.0	25°51′.0	168°30′.8	25°47′.4	-5.2	3.6		12 Com	488
168°49′.0	26°07′.0	168°47′.7	26°11′.8	1.2	-4.8		13 Com	489
168°00′.0	23°30′.0	168°02′.8	23°28′.3	-2.6	1.7		7h Com	490
171°10′.0	25°16′.0	171°03′.2	25°29′.2	6.1	-13.2	h	21 Com	491
170°51′.0	24°56′.0	170°55′.4	24°55′.1	-4.0	0.9		18 Com	492
172°52′.0	24°00′.5	172°51′.7	24°07′.4	0.2	-6.9		23k Com	493
178°58′.5	32°46′.0	178°54′.7	32°28′.4	3.2	17.6		43β Com	494
177°49′.0	31°42′.0	177°47′.7	31°50′.0	1.1	-8.0		41 Com	495
174°17′.0	30°16′.0	174°16′.4	30°12′.7	0.5	3.3		31 Com	496
216°38′.5	44°23′.0	216°40′.3	44°22′.0	-1.3	1.0		5α CrB	497
213°37′.0	46°08′.0	213°32′.5	46°05′.3	3.1	2.7		3β CrB	498
213°10′.5	48°25′.0	213°50′.5	48°35′.4	-26.5	-10.4		4θ CrB	499
218°02′.0	50°21′.0	216°35′.4	50°30′.4	55.0	-9.4		9π CrB	500

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	*m*	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
7850	4.22	4.36	4	305°38′.8	61°47′.3	305°41′.2	61°40′.3	-1.1	7.0
8417	4.29	4.43	5	328°06′.8	62°41′.1	328°04′.1	62°42′.2	1.2	-1.1
7750	4.39	4.54	4	305°04′.6	76°26′.0	305°11′.1	76°28′.3	-1.5	-2.3
8974	3.21	3.35	3	351°11′.6	75°17′.1	350°54′.7	75°24′.6	4.3	-7.5
5328	4.40	4.54	4	209°43′.3	53°42′.2	209°47′.1	53°41′.0	-2.2	1.1
5350	4.75	4.89	4	210°35′.0	53°11′.9	210°29′.9	53°14′.2	3.1	-2.3
5404	4.05	4.19	4	212°52′.8	53°37′.5	212°54′.0	53°43′.4	-0.7	-5.9
5351	4.18	4.32	4	210°17′.1	47°58′.0	210°17′.5	47°57′.1	-0.3	1.0
5435	3.03	3.17	3	214°02′.0	40°03′.5	213°59′.8	40°05′.3	1.7	-1.8
5602	3.50	3.64	3	221°52′.4	42°01′.0	221°43′.8	42°00′.2	6.4	0.8
5681	3.47	3.61	3	224°51′.5	34°50′.5	224°51′.4	34°50′.8	0.1	-0.3
5505	2.59	2.74	3	216°53′.9	28°47′.7	216°53′.4	28°47′.8	0.4	-0.2
5447	4.46	4.61	4	214°21′.3	31°32′.0	214°19′.4	31°31′.0	1.6	0.9
5429	3.58	3.72	4	213°48′.7	32°13′.2	213°39′.3	32°09′.6	8.0	3.6
5477	3.86	4.04	3	215°33′.3	15°30′.1	215°31′.9	15°29′.0	1.4	1.0
5235	2.68	2.84	3	203°54′.6	20°26′.4	203°55′.2	20°25′.8	-0.6	0.6
5185	4.50	4.67	4	202°06′.1	19°27′.3	202°04′.4	19°28′.5	1.6	-1.3
5200	4.07	4.24	4	202°34′.2	17°48′.6	202°33′.5	17°48′.5	0.7	0.1
5340	-0.04	0.12	1	209°23′.2	21°18′.5	209°22′.3	21°17′.7	0.9	0.8
5475	4.54	4.71	4	215°30′.1	18°13′.5	215°29′.9	18°10′.3	0.1	3.1
5502	4.60	4.77	4	216°39′.9	18°45′.4	216°39′.7	18°41′.8	0.2	3.6
5544	4.55	4.71	4	218°13′.9	20°51′.4	218°15′.0	20°48′.1	-1.1	3.3
5600	4.81	4.96	5	221°10′.2	26°38′.5	221°09′.6	26°37′.8	0.5	0.8
5634	4.93	5.09	5	222°27′.4	26°27′.7	222°26′.9	26°28′.2	0.5	-0.4
5616	4.54	4.69	5	221°50′.8	28°35′.4	221°50′.4	28°32′.9	0.3	2.6
5638	5.67	5.82	6	222°45′.4	27°51′.6	222°47′.8	27°52′.5	-2.1	-0.9
5676	5.26	5.41	5	224°26′.8	30°41′.5	224°27′.2	30°41′.4	-0.3	0.1
5727	5.05	5.20	5	226°40′.0	31°47′.2	226°41′.0	31°46′.5	-0.9	0.7
5733	4.17	4.31	4	227°20′.7	38°48′.8	227°21′.5	38°49′.1	-0.6	-0.3
5833	4.69	4.83	4	231°04′.2	37°59′.0	231°05′.6	37°58′.5	-1.1	0.5
5618	4.76	4.90	6	222°32′.2	49°24′.1	222°39′.7	49°14′.4	-4.9	9.6
5627	5.57	5.71	6	223°14′.3	49°24′.8	223°03′.5	49°43′.6	6.9	-18.8
4737	4.36	4.51	3	181°44′.5	30°30′.3	181°43′.9	30°29′.6	0.5	0.7
4920	4.78	4.94	5	190°42′.5	26°39′.5	189°47′.3	19°34′.7	52.1	424.9
4733	4.95	5.10	4	181°35′.5	29°25′.9	181°34′.9	29°29′.2	0.5	-3.2
4738	5.00	5.15	4	181°37′.0	29°20′.7	181°43′.8	29°02′.6	-5.9	18.2
4752	5.29	5.44	4	182°00′.4	28°56′.0	182°13′.1	28°07′.8	-11.2	48.2
4707	4.81	4.96	4	180°32′.6	28°09′.5	180°35′.0	28°04′.0	-2.2	5.5
4717	5.18	5.33	4	181°02′.6	28°14′.2	181°02′.7	28°19′.1	-0.1	-4.8
4667	4.95	5.10	4	179°00′.0	26°12′.8	179°00′.7	26°10′.1	-0.7	2.7
4766	5.46	5.62	4	182°45′.5	26°32′.3	182°44′.8	26°46′.9	0.6	-14.6
4753	5.48	5.64	4	182°18′.4	26°21′.9	182°21′.0	26°19′.4	-2.3	2.5
4789	4.81	4.97	4	183°41′.2	24°43′.8	183°43′.3	24°50′.2	-1.9	-6.4
4983	4.26	4.41	4	193°31′.5	30°08′.9	193°17′.7	29°55′.2	12.0	13.7
4954	4.80	4.95	4	191°57′.3	29°39′.1	191°59′.3	29°47′.1	-1.7	-8.0
4883	4.94	5.09	4	188°06′.0	29°46′.0	188°02′.5	29°43′.6	3.0	2.4
5793	2.23	2.38	2	229°27′.1	28°06′.2	229°27′.3	28°06′.4	-0.2	-0.1
5747	3.68	3.83	4	227°56′.3	30°31′.4	227°50′.9	30°31′.6	4.6	-0.2
5778	4.14	4.29	5	228°39′.9	32°44′.5	229°12′.9	32°45′.1	-27.8	-0.6
5855	5.56	5.70	6	233°02′.0	33°18′.1	232°04′.3	33°49′.3	48.0	-31.3

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
219°14′.5	44°33′.0	219°17′.4	44°32′.7	-2.1	0.3		8γ CrB	501
221°25′.0	44°52′.0	221°26′.1	44°48′.9	-0.8	3.1		10δ CrB	502
223°32′.0	46°09′.5	223°31′.6	46°07′.2	0.3	2.3		13ϵ CrB	503
223°02′.0	48°24′.0	223°24′.8	49°12′.2	-14.9	-48.2		14ι CrB	504
250°31′.0	37°23′.0	250°34′.8	37°20′.0	-3.0	3.0		64α Her	505
235°27′.5	42°48′.0	235°31′.0	42°45′.2	-2.6	2.8		27β Her	506
233°36′.0	40°05′.5	233°38′.1	40°03′.1	-1.6	2.4		20γ Her	507
230°06′.5	37°19′.0	230°08′.1	37°15′.7	-1.2	3.3		7κ Her	508
249°10′.0	47°47′.0	249°11′.1	47°45′.3	-0.8	1.7		65δ Her	509
254°22′.0	49°23′.0	254°19′.6	49°20′.6	1.6	2.4		76λ Her	510
259°36′.0	51°16′.5	259°42′.3	51°14′.4	-3.9	2.1		86μ Her	511
267°19′.0	52°19′.0	267°08′.2	52°14′.1	6.6	4.9		103o Her	512
263°57′.0	53°46′.0	263°53′.5	53°40′.8	2.1	5.2		94ν Her	513
263°38′.0	52°47′.0	263°37′.0	52°44′.4	0.6	2.6		92ξ Her	514
236°02′.0	53°10′.5	235°57′.9	53°07′.6	2.5	2.9		40ζ Her	515
242°45′.5	53°21′.0	242°44′.9	53°17′.8	0.4	3.2		58ϵ Her	516
246°21′.5	59°38′.0	246°29′.1	59°36′.1	-3.8	1.9		67π Her	517
247°19′.0	60°11′.5	247°22′.6	60°09′.1	-1.8	2.4		69e Her	518
249°47′.5	60°13′.5	249°47′.9	60°10′.6	-0.2	2.9		75ρ Her	519
262°56′.0	60°47′.0	262°54′.8	60°44′.2	0.6	2.8		91θ Her	520
254°17′.0	69°22′.0	254°18′.6	69°19′.0	-0.6	3.0		85ι Her	521
247°05′.5	71°20′.0	247°00′.9	71°15′.0	1.5	5.0		77x Her	522
251°07′.0	71°13′.5	251°58′.2	71°49′.0	-16.0	-35.5		82y Her	523
258°00′.0	71°05′.0	257°45′.9	71°01′.7	4.6	3.3		Her	524
233°08′.5	60°22′.5	233°10′.0	60°20′.6	-0.7	1.9		44η Her	525
227°39′.5	63°14′.0	227°37′.5	63°12′.1	0.9	1.9		35σ Her	526
218°43′.5	65°55′.0	218°44′.9	65°52′.0	-0.6	3.0		22τ Her	527
215°57′.0	63°51′.0	216°00′.1	63°48′.8	-1.4	2.2		11ϕ Her	528
212°43′.0	64°23′.0	212°43′.0	64°21′.3	-0.0	1.7		6υ Her	529
226°32′.0	62°29′.0	225°55′.3	62°20′.9	17.0	8.1		30g Her	530
212°28′.5	60°15′.5	212°34′.6	60°15′.1	-3.0	0.4		1χ Her	531
207°06′.0	57°15′.5	207°01′.0	57°10′.6	2.7	4.9		52-3ν Boo	532
279°43′.0	61°47′.5	279°43′.6	61°45′.2	-0.3	2.3		30α Lyr	533
283°14′.0	62°27′.0	283°05′.4	62°24′.5	4.0	2.5		4-5ϵ Lyr	534
282°26′.0	60°26′.0	282°34′.1	60°23′.3	-4.0	2.7		6-7ζ Lyr	535
286°10′.5	59°26′.0	286°08′.3	59°21′.8	1.1	4.2		12δ2 Lyr	536
294°32′.5	60°46′.0	294°32′.5	60°43′.1	-0.0	2.9		20η Lyr	537
295°02′.0	59°41′.0	295°00′.5	59°36′.5	0.8	4.5		21θ Lyr	538
283°16′.5	56°05′.0	283°20′.8	56°01′.9	-2.4	3.1		10β Lyr	539
283°03′.5	55°16′.0	283°03′.4	55°14′.3	0.1	1.7		9ν2 Lyr	540
286°11′.0	55°06′.0	286°23′.3	55°03′.6	-7.0	2.4		14γ Lyr	541
286°20′.0	54°31′.5	286°36′.2	54°29′.0	-9.4	2.5		15λ Lyr	542
290°52′.0	58°06′.0	290°40′.8	58°03′.8	5.9	2.2		18ι Lyr	543
295°44′.0	49°02′.0	295°43′.1	49°00′.6	0.6	1.4		6β Cyg	544
299°20′.0	50°42′.0	299°24′.3	50°39′.5	-2.7	2.5		12ϕ Cyg	545
307°33′.0	54°19′.0	307°25′.3	54°18′.7	4.5	0.3		21η Cyg	546
319°25′.0	57°09′.5	319°20′.6	57°09′.1	2.4	0.4		37γ Cyg	547
329°53′.5	59°56′.5	329°50′.7	59°55′.4	1.4	1.1		50α Cyg	548
310°53′.0	64°28′.0	310°45′.0	64°26′.7	3.5	1.3		18δ Cyg	549
313°21′.0	69°42′.0	313°09′.1	69°37′.6	4.2	4.4	z	13θ Cyg	550

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
5849	3.84	4.00	4	231°28′.8	27°36′.0	231°30′.2	27°36′.6	-1.2	-0.6
5889	4.63	4.78	4	233°14′.3	27°22′.0	233°13′.3	27°20′.4	0.9	1.6
5947	4.15	4.30	4	235°18′.2	28°05′.5	235°16′.5	28°05′.0	1.6	0.4
5971	4.99	5.14	6	235°47′.6	30°19′.1	236°22′.3	31°01′.1	-29.7	-42.0
6406	3.31	3.48	3	254°04′.8	14°56′.0	254°07′.3	14°54′.6	-2.4	1.4
6148	2.77	2.93	3	243°14′.9	22°26′.5	243°16′.6	22°25′.0	-1.5	1.5
6095	3.75	3.92	3	241°04′.7	20°09′.8	241°05′.3	20°08′.8	-0.6	1.0
6008	4.70	4.87	4	237°31′.6	18°11′.8	237°31′.6	18°10′.0	0.0	1.8
6410	3.14	3.30	3	254°39′.9	25°21′.9	254°40′.1	25°22′.0	-0.2	-0.1
6526	4.41	4.56	4	258°41′.9	26°28′.3	258°39′.6	26°28′.1	2.0	0.2
6623	3.42	3.57	4	262°39′.0	28°01′.0	262°43′.2	28°00′.6	-3.6	0.4
6779	3.83	3.98	4	268°07′.7	28°48′.5	268°00′.0	28°45′.8	6.7	2.7
6707	4.41	4.56	4	265°51′.7	30°19′.7	265°48′.9	30°16′.6	2.4	3.1
6703	3.70	3.85	4	265°35′.2	29°21′.4	265°34′.3	29°20′.8	0.8	0.6
6212	2.81	2.96	3	246°38′.3	32°22′.8	246°34′.1	32°22′.5	3.6	0.3
6324	3.92	4.07	3	251°17′.5	31°35′.2	251°15′.8	31°34′.0	1.4	1.2
6418	3.16	3.30	4	255°13′.9	37°19′.1	255°17′.8	37°18′.5	-3.1	0.7
6436	4.65	4.79	3	255°57′.9	37°46′.3	255°59′.1	37°45′.5	-1.0	0.8
6484	4.14	4.28	4	257°30′.0	37°34′.6	257°29′.2	37°33′.7	0.6	0.9
6695	3.86	4.00	3	265°40′.0	37°21′.9	265°38′.9	37°21′.1	0.9	0.8
6588	3.80	3.94	3	262°03′.7	46°16′.6	262°03′.6	46°15′.5	0.1	1.0
6509	5.80	5.94	6	259°07′.5	48°40′.5	259°03′.1	48°38′.0	2.9	2.6
6574	5.37	5.50	6	260°59′.6	48°17′.5	261°33′.5	48°51′.3	-22.3	-33.8
6641	5.93	6.07	n	264°14′.5	47°47′.9	264°06′.9	47°47′.3	5.1	0.6
6220	3.53	3.67	3	247°19′.3	39°43′.8	247°18′.8	39°43′.6	0.4	0.1
6168	4.20	4.34	4	245°22′.1	43°17′.8	245°19′.2	43°18′.2	2.1	-0.4
6092	3.89	4.03	4	241°59′.4	47°19′.3	241°57′.0	47°18′.2	1.6	1.2
6023	4.26	4.40	4	239°04′.5	46°02′.1	239°03′.6	46°01′.3	0.6	0.8
5982	4.76	4.90	4	237°38′.7	47°10′.8	237°36′.3	47°11′.0	1.6	-0.2
6146	5.04	5.17	5	244°20′.1	42°47′.5	243°53′.7	42°48′.2	19.4	-0.7
5914	4.62	4.76	4	234°41′.2	43°36′.8	234°43′.5	43°36′.7	-1.7	0.1
5763	4.27	4.41	4	229°23′.7	42°17′.3	229°16′.1	42°15′.9	5.6	1.4
7001	0.03	0.17	1	275°50′.9	38°27′.9	275°51′.6	38°27′.6	-0.6	0.2
7051	3.83	3.97	5	277°51′.8	39°17′.2	277°47′.3	39°16′.2	3.5	1.0
7056	4.09	4.23	5	277°40′.1	37°14′.4	277°45′.7	37°14′.2	-4.4	0.2
7139	4.30	4.44	4	280°08′.9	36°28′.7	280°08′.5	36°26′.4	0.3	2.3
7298	4.39	4.53	5	285°01′.6	38°31′.2	285°02′.8	38°30′.3	-1.0	0.9
7314	4.36	4.50	5	285°37′.3	37°30′.8	285°38′.0	37°28′.2	-0.6	2.6
7106	3.45	3.60	3	278°47′.1	32°57′.8	278°50′.5	32°57′.1	-2.9	0.8
7102	5.25	5.40	6	278°44′.7	32°08′.3	278°45′.0	32°08′.6	-0.3	-0.3
7178	3.24	3.39	3	280°51′.6	32°11′.1	281°00′.5	32°11′.7	-7.5	-0.5
7192	4.93	5.07	6	281°03′.0	31°37′.6	281°14′.6	31°38′.4	-9.9	-0.8
7262	5.28	5.43	5	283°22′.5	35°32′.6	283°16′.1	35°31′.4	5.2	1.2
7417	2.92	3.07	3	288°39′.6	27°10′.1	288°39′.6	27°10′.5	-0.0	-0.5
7478	4.69	4.84	5	290°50′.4	29°17′.0	290°54′.5	29°17′.1	-3.6	-0.1
7615	3.89	4.03	4	295°24′.8	34°04′.0	295°20′.3	34°04′.2	3.7	-0.2
7796	2.20	2.34	3	302°00′.7	39°00′.9	301°58′.9	39°01′.3	1.4	-0.4
7924	1.25	1.39	2	306°57′.6	43°53′.5	306°57′.8	43°53′.5	-0.1	-0.0
7528	2.87	3.01	3	293°10′.6	44°12′.5	293°07′.6	44°11′.8	2.2	0.6
7469	4.48	4.62	4	291°27′.9	49°23′.8	291°25′.9	49°19′.9	1.3	3.9

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
312°39′.5	71°31′.0	312°29′.8	71°28′.3	3.1	2.7		10ι2 Cyg	551
309°36′.5	73°50′.5	309°26′.7	73°49′.6	2.7	0.9		1κ Cyg	552
322°09′.5	49°26′.0	322°09′.2	49°25′.8	0.2	0.2		53ε Cyg	553
324°18′.0	51°41′.5	324°14′.2	51°38′.2	2.3	3.3		54λ Cyg	554
327°33′.0	43°44′.0	327°31′.4	43°43′.2	1.2	0.8	r	64ζ Cyg	555
330°32′.0	54°59′.0	330°38′.5	54°55′.9	-3.7	3.1		58ν Cyg	556
335°21′.5	56°36′.0	335°18′.4	56°35′.7	1.7	0.3		62ξ Cyg	557
322°50′.0	63°37′.0	322°35′.5	63°37′.5	6.5	-0.5		30-1ο1 Cyg	558
324°34′.5	64°17′.5	324°19′.3	64°18′.5	6.6	-1.0		32ο2 Cyg	559
333°03′.5	50°33′.0	333°02′.5	50°31′.9	0.6	1.1		65τ Cyg	560
334°53′.5	51°31′.0	334°50′.6	51°30′.4	1.8	0.6		67σ Cyg	561
334°33′.0	38°39′.0	334°54′.4	39°32′.9	-16.5	-53.9		78μ Cyg	562
289°57′.0	66°15′.0	289°42′.5	66°12′.9	5.8	2.1		13 Lyr	563
294°49′.5	68°52′.0	294°29′.6	68°50′.0	7.2	2.0		16 Lyr	564
313°31′.0	69°35′.0	313°09′.1	69°37′.6	7.6	-2.6	z	13θ Cyg	565
328°44′.0	25°11′.0	324°14′.2	51°38′.2	167.4	-1587.2	Hz	54λ Cyg	566
328°22′.0	25°35′.0	324°14′.2	51°38′.2	153.8	-1563.2	Rz	54λ Cyg	567
318°15′.0	53°12′.0	324°14′.2	51°38′.2	-223.0	93.8	z	54λ Cyg	568
313°18′.0	69°42′.0	313°09′.1	69°37′.6	3.1	4.4	z	13θ Cyg	569
29°35′.0	44°40′.5	29°32′.2	44°41′.3	2.0	-0.8		17ζ Cas	570
32°17′.5	46°35′.5	32°15′.2	46°35′.6	1.6	-0.1		18α Cas	571
34°38′.0	47°05′.0	34°37′.3	47°05′.4	0.5	-0.4		24η Cas	572
38°27′.5	48°46′.0	38°24′.0	48°46′.7	2.3	-0.7		27γ Cas	573
42°21′.0	46°22′.0	42°21′.6	46°23′.1	-0.4	-1.1		37δ Cas	574
49°13′.5	47°29′.0	49°13′.4	47°30′.4	0.1	-1.4		45ε Cas	575
56°39′.0	48°54′.0	56°41′.2	48°55′.8	-1.4	-1.8		ι Cas	576
36°14′.5	43°06′.5	36°14′.2	43°05′.9	0.2	0.6		33θ Cas	577
35°16′.0	43°28′.0	35°18′.6	43°26′.7	-1.9	1.3		30μ Cas	578
24°39′.0	49°24′.5	24°36′.7	49°22′.9	1.5	1.6		8σ Cas	579
37°06′.0	52°14′.0	37°04′.7	52°14′.5	0.8	-0.5		15κ Cas	580
29°35′.5	51°14′.5	29°32′.9	51°14′.1	1.7	0.4		11β Cas	581
25°34′.0	51°08′.0	25°32′.2	51°08′.5	1.1	-0.5		7ρ Cas	582
25°32′.0	52°39′.0	25°31′.7	52°38′.8	0.2	0.2		5τ Cas	583
49°28′.0	52°48′.0	49°24′.9	52°49′.2	1.9	-1.2		36ψ Cas	584
52°21′.0	56°13′.0	58°01′.3	54°20′.3	-198.4	112.7	w	50 Cas	585
52°33′.0	54°27′.0	56°22′.9	53°10′.4	-137.8	76.7	w	48A Cas	586
51°58′.0	52°08′.5	53°36′.7	51°38′.5	-61.2	30.0	u	46ω Cas	587
42°57′.5	44°57′.5	42°53′.4	44°58′.2	2.9	-0.7		39χ Cas	588
40°00′.0	45°04′.5	39°58′.6	45°03′.5	1.0	1.0		34φ Cas	589
36°52′.0	47°31′.5	37°04′.8	47°31′.5	-8.6	-0.0		28υ2 Cas	590
29°10′.0	45°38′.0	29°08′.1	45°38′.0	1.3	-0.0		14λ Cas	591
29°32′.0	41°15′.0	29°28′.6	41°14′.9	2.6	0.1		25ν Cas	592
27°57′.0	41°25′.5	27°56′.7	41°24′.9	0.2	0.6		19ξ Cas	593
26°56′.0	39°15′.5	26°55′.8	39°16′.9	0.2	-1.4		22ο Cas	594
25°54′.5	38°19′.0	25°53′.4	38°17′.9	0.9	1.1	r	20π Cas	595
61°46′.0	53°16′.0	62°02′.3	53°14′.8	-9.8	1.2	z	Cas	596
66°12′.0	53°32′.0	66°49′.2	53°29′.2	-22.1	2.8	z	Cas	597
60°11′.0	52°04′.0	69°05′.3	49°34′.2	-346.5	149.8	z	γ Cam	598
68°45′.0	49°08′.0	68°43′.4	49°10′.0	1.0	-2.0	rz	Cam	599
77°17′.0	35°50′.0	75°54′.7	35°52′.8	66.7	-2.8	Uz	11-2 Cam	600

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	*m*	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
7420	3.79	3.93	4	289°56′.1	50°56′.6	289°54′.4	50°54′.8	1.1	1.9
7328	3.77	3.90	4	287°00′.6	52°39′.8	286°57′.9	52°39′.8	1.6	-0.0
7949	2.46	2.60	3	307°30′.7	32°29′.9	307°31′.4	32°31′.2	-0.6	-1.3
7963	4.53	4.68	4	307°58′.6	35°06′.3	307°58′.5	35°03′.9	0.1	2.4
8115	3.20	3.35	3	314°00′.0	28°37′.6	313°59′.9	28°37′.9	0.1	-0.3
8028	3.94	4.08	4	310°27′.8	39°39′.7	310°35′.0	39°40′.1	-5.6	-0.5
8079	3.72	3.85	4	312°37′.4	42°21′.9	312°36′.9	42°22′.3	0.4	-0.4
7730	3.44	3.57	4	300°23′.6	45°34′.8	300°16′.1	45°34′.1	5.3	0.7
7751	3.98	4.11	4	300°55′.2	46°32′.0	300°47′.1	46°31′.5	5.5	0.5
8130	3.72	3.86	4	314°42′.7	36°22′.6	314°43′.6	36°22′.8	-0.8	-0.2
8143	4.23	4.37	4	315°27′.4	37°45′.5	315°26′.9	37°45′.5	0.4	-0.1
8309	4.45	4.60	4	321°41′.8	26°01′.2	321°35′.3	26°58′.6	5.8	-57.3
7157	4.04	4.17	4	280°55′.0	43°28′.9	280°48′.0	43°27′.8	5.1	1.2
7215	5.01	5.15	4	282°41′.3	46°26′.2	282°32′.3	46°24′.5	6.2	1.7
7469	4.48	4.62	6	291°37′.3	49°18′.9	291°25′.9	49°19′.9	7.4	-1.0
7963	4.53	4.68	6	322°10′.6	11°41′.6	307°58′.5	35°03′.9	697.5	-1402.3
7963	4.53	4.68	6	321°43′.1	11°57′.2	307°58′.5	35°03′.9	674.9	-1386.7
7963	4.53	4.68	6	303°06′.5	35°05′.8	307°58′.5	35°03′.9	-239.0	1.9
7469	4.48	4.62	6	291°26′.5	49°23′.4	291°25′.9	49°19′.9	0.4	3.4
0153	3.66	3.80	4	3°49′.0	51°42′.0	3°48′.1	51°41′.4	0.5	0.6
0168	2.23	2.36	3	4°35′.4	54°21′.2	4°35′.9	54°20′.2	-0.3	1.0
0219	3.44	3.57	4	6°22′.0	55°41′.1	6°23′.8	55°40′.9	-1.0	0.2
0264	2.47	2.61	3	8°20′.6	58°33′.4	8°19′.6	58°32′.3	0.5	1.1
0403	2.68	2.82	3	15°04′.3	58°07′.2	15°06′.9	58°07′.8	-1.4	-0.6
0542	3.38	3.52	3	21°37′.9	61°39′.2	21°39′.6	61°39′.6	-0.8	-0.4
0707	4.52	4.66	4	29°17′.2	65°31′.3	29°21′.7	65°32′.6	-1.9	-1.3
0343	4.33	4.47	4	11°47′.7	53°01′.3	11°50′.6	53°00′.2	-1.7	1.1
0321	5.18	5.31	5	10°28′.9	52°56′.5	10°35′.4	52°56′.1	-3.9	0.4
9071	4.88	5.02	6	354°45′.3	53°34′.1	354°47′.7	53°32′.1	-1.4	2.0
0130	4.16	4.30	4	2°43′.1	60°43′.4	2°44′.8	60°43′.2	-0.8	0.2
0021	2.27	2.40	3	357°04′.6	56°58′.2	357°05′.9	56°56′.9	-0.7	1.3
9045	4.54	4.67	6	353°42′.1	55°17′.1	353°42′.9	55°16′.9	-0.5	0.1
9008	4.87	5.00	6	351°56′.3	56°26′.1	351°59′.3	56°26′.1	-1.7	-0.0
0399	4.74	4.87	6	14°44′.5	66°01′.7	14°43′.5	66°00′.9	0.4	0.8
0580	3.98	4.12	6	11°57′.3	69°41′.1	22°47′.0	70°26′.1	-217.6	-45.0
0575	4.54	4.68	6	15°33′.7	68°28′.2	22°41′.1	68°55′.1	-153.7	-26.9
0548	4.99	5.13	6	18°42′.7	66°28′.2	21°34′.7	66°40′.6	-68.1	-12.4
0442	4.71	4.84	6	17°10′.8	57°10′.6	17°08′.5	57°09′.0	1.2	1.6
0382	4.98	5.11	6	13°52′.3	56°08′.2	13°54′.6	56°06′.4	-1.3	1.8
0265	4.63	4.76	6	8°07′.1	56°55′.6	8°22′.9	57°00′.4	-8.6	-4.8
0123	4.73	4.87	6	2°32′.5	52°19′.5	2°33′.4	52°18′.6	-0.5	0.8
0223	4.89	5.03	6	6°40′.9	48°48′.3	6°39′.9	48°46′.6	0.6	1.7
0179	4.80	4.94	6	5°01′.0	48°19′.5	5°03′.5	48°18′.7	-1.6	0.8
0193	4.54	4.68	6	5°42′.4	46°04′.3	5°43′.2	46°05′.2	-0.6	-0.9
0184	4.94	5.08	6	5°24′.7	44°51′.3	5°26′.4	44°49′.7	-1.2	1.6
0743	5.16	5.30	6	29°59′.1	70°56′.1	30°30′.7	70°59′.7	-10.3	-3.7
0932	4.87	5.01	6	36°31′.3	72°38′.1	37°44′.4	72°46′.4	-21.7	-8.2
1148	4.63	4.77	6	29°40′.9	69°24′.0	47°27′.1	69°59′.0	-365.0	-34.9
1138	5.44	5.58	6	47°19′.9	69°31′.1	47°18′.5	69°31′.1	0.5	0.1
1622	4.76	4.90	6	70°02′.5	58°28′.6	67°57′.5	58°17′.7	65.7	10.9

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
87°19′.0	35°48′.0	87°32′.0	35°34′.2	-10.6	13.8	z	2 Lyn	601
92°33′.0	34°49′.0	93°34′.1	35°24′.1	-49.8	-35.1	z	15 Lyn	602
93°00′.0	30°22′.0	91°41′.3	36°14′.6	63.4	-352.6	z	12 Lyn	603
90°45′.0	44°10′.0	91°11′.3	44°22′.8	-18.8	-12.8	z	42 Cam	604
90°57′.0	45°32′.0	91°18′.5	45°43′.1	-15.0	-11.1	z	43 Cam	605
86°15′.0	45°43′.0	86°48′.9	45°52′.8	-23.6	-9.8	z	L Cam	606
90°10′.0	53°43′.0	90°05′.1	53°47′.0	2.9	-4.0	rz	M Cam	607
87°45′.0	56°15′.0	88°10′.5	56°17′.5	-14.1	-2.5	z	Cam	608
94°13′.0	56°55′.0	94°27′.0	57°05′.3	-7.6	-10.3	z	Cam	609
89°58′.0	59°18′.0	90°11′.0	59°23′.0	-6.6	-5.0	z	Cam	610
97°54′.0	60°47′.0	98°53′.1	60°38′.4	-29.0	8.6	uz	Dra	611
100°14′.0	62°04′.0	99°40′.7	62°51′.8	15.2	-47.8	uz	Cam	612
99°37′.0	62°46′.0	96°31′.3	63°48′.3	82.0	-62.3	uz	Cam	613
110°58′.0	63°17′.0	101°07′.5	67°02′.9	230.3	-225.9	wz	Cam	614
48°31′.0	39°00′.5	48°28′.7	38°57′.1	1.8	3.4		9i Per	615
53°09′.5	37°28′.5	53°09′.1	37°26′.2	0.4	2.3		15η Per	616
54°26′.5	34°30′.0	54°28′.2	34°29′.0	-1.4	1.0		23γ Per	617
49°04′.5	31°34′.5	49°04′.8	31°35′.6	-0.2	-1.1		13θ Per	618
51°50′.0	34°26′.5	52°21′.7	34°19′.5	-26.2	7.0		18τ Per	619
53°33′.0	30°36′.5	53°34′.0	30°38′.3	-0.8	-1.8		ι Per	620
56°17′.0	30°05′.0	56°31′.4	30°04′.8	-12.5	0.2		33α Per	621
57°04′.5	27°59′.0	57°03′.0	27°59′.8	1.3	-0.8		35σ Per	622
58°13′.5	27°55′.0	58°11′.2	27°55′.5	2.0	-0.5		37ψ Per	623
59°15′.0	27°14′.0	59°14′.5	27°15′.4	0.4	-1.4		39δ Per	624
52°06′.0	26°04′.0	52°07′.2	26°03′.5	-1.1	0.5		27κ Per	625
50°37′.0	22°22′.0	50°36′.6	22°23′.0	0.4	-1.0		26β Per	626
50°31′.0	20°54′.0	50°48′.4	20°55′.4	-16.2	-1.4		28ω Per	627
49°18′.0	20°33′.0	49°20′.5	20°32′.7	-2.4	0.3		25ρ Per	628
48°20′.0	21°35′.0	48°20′.7	21°41′.5	-0.7	-6.5		22π Per	629
66°13′.5	28°22′.5	66°14′.9	28°24′.4	-1.3	-1.9		72b Per	630
64°11′.5	28°50′.0	64°11′.7	28°50′.4	-0.1	-0.4		47λ Per	631
63°55′.0	26°11′.0	63°56′.1	26°11′.3	-1.0	-0.3		48c Per	632
65°14′.0	26°39′.0	65°14′.0	26°39′.5	-0.0	-0.5		51μ Per	633
66°00′.0	24°35′.0	66°03′.3	24°34′.3	-3.0	0.7		53d Per	634
68°01′.0	18°56′.0	68°01′.1	18°57′.4	-0.1	-1.4		58e Per	635
58°11′.0	22°06′.0	58°15′.9	22°06′.3	-4.6	-0.3		41ν Per	636
60°08′.0	19°04′.0	60°06′.9	19°04′.1	1.0	-0.1		45ϵ Per	637
59°23′.5	14°53′.5	59°24′.6	14°53′.7	-1.0	-0.2		46ξ Per	638
55°33′.0	12°08′.0	55°34′.8	12°08′.3	-1.8	-0.3		38o Per	639
57°36′.0	11°17′.5	57°33′.6	11°17′.2	2.4	0.3		44ζ Per	640
56°45′.0	42°26′.0	66°45′.2	31°41′.7	-510.6	644.3		Cam	641
62°32′.0	29°31′.0	62°30′.2	29°32′.7	1.5	-1.7		43A Per	642
46°16′.0	20°53′.0	46°15′.7	20°55′.1	0.3	-2.1		16 Per	643
62°18′.0	45°10′.0	62°19′.9	45°12′.5	-1.3	-2.5	z	A Cam	644
64°02′.0	48°07′.0	60°43′.9	38°26′.4	155.2	580.6	uz	Cam	645
64°41′.0	49°27′.0	59°27′.3	35°10′.2	256.5	856.8	uz	Cam	646
66°15′.0	53°37′.0	61°01′.7	39°29′.0	241.8	848.0	uz	Cam	647
83°38′.0	32°15′.0	83°34′.4	32°13′.0	3.0	2.0		30ξ Aur	648
84°14′.0	30°50′.0	84°20′.4	30°48′.4	-5.5	1.6		33δ Aur	649
76°16′.0	22°50′.5	76°17′.2	22°51′.6	-1.1	-1.1		13α Aur	650

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
2238	4.48	4.62	6	85°44′.2	59°17′.1	86°06′.0	59°01′.7	-11.2	15.4
2560	4.35	4.48	6	93°59′.2	58°18′.4	95°37′.4	58°49′.4	-50.9	-31.0
2470	4.87	5.01	6	94°23′.4	53°50′.7	92°42′.1	59°43′.1	51.1	-352.3
2490	5.14	5.28	6	91°25′.0	67°41′.3	92°15′.2	67°51′.7	-18.9	-10.4
2511	5.12	5.26	6	91°51′.7	69°03′.1	92°34′.3	69°11′.8	-15.1	-8.7
2209	4.80	4.94	6	82°37′.8	69°08′.7	83°43′.0	69°18′.1	-23.1	-9.3
2527	4.55	4.69	6	90°26′.8	77°14′.5	90°13′.6	77°16′.5	2.9	-2.0
2401	5.45	5.60	6	82°58′.8	79°43′.2	84°18′.0	79°44′.8	-14.1	-1.6
3082	5.38	5.53	6	103°41′.7	80°14′.4	104°34′.5	80°21′.2	-8.8	-6.8
2742	4.96	5.11	6	89°51′.8	82°49′.5	90°45′.1	82°52′.4	-6.6	-2.9
3751	4.29	4.44	6	125°15′.0	83°19′.5	128°01′.2	82°56′.3	-20.4	23.2
4084	5.26	5.41	6	139°55′.2	83°45′.3	143°04′.0	84°29′.7	-18.1	-44.4
4062	5.50	5.66	6	142°26′.6	84°28′.0	138°22′.5	86°09′.2	16.4	-101.3
4892	4.78	4.94	6	169°59′.6	80°35′.9	192°06′.1	85°35′.2	-102.1	-299.3
0685	5.17	5.31	6	28°45′.6	54°02′.7	28°48′.0	53°57′.9	-1.4	4.8
0834	3.76	3.89	4	35°30′.3	54°13′.7	35°33′.6	54°10′.3	-1.9	3.4
0915	2.93	3.06	3	39°02′.4	51°54′.0	39°07′.1	51°52′.3	-2.9	1.7
0799	4.12	4.25	4	34°20′.1	47°28′.7	34°21′.6	47°28′.8	-1.0	-0.0
0854	3.95	4.08	5	35°53′.3	51°01′.2	36°38′.0	51°03′.8	-28.1	-2.6
0937	4.05	4.18	4	40°09′.7	48°00′.2	40°11′.6	48°00′.9	-1.3	-0.7
1017	1.79	1.93	2	43°45′.2	48°19′.3	44°04′.6	48°21′.9	-12.9	-2.6
1052	4.36	4.49	5	45°43′.7	46°33′.5	45°43′.0	46°32′.4	0.4	1.2
1087	4.23	4.37	5	47°09′.9	46°48′.7	47°08′.4	46°47′.1	1.1	1.6
1122	3.01	3.15	3	48°43′.6	46°26′.1	48°43′.8	46°25′.8	-0.1	0.3
0941	3.80	3.94	4	40°41′.6	43°18′.0	40°44′.7	43°16′.6	-2.3	1.4
0936	2.12	2.26	3	40°37′.9	39°21′.7	40°38′.3	39°21′.2	-0.3	0.5
0947	4.63	4.77	5	41°07′.7	37°56′.6	41°27′.8	38°01′.8	-15.9	-5.2
0921	3.39	3.53	4	39°54′.8	37°14′.6	39°58′.9	37°13′.8	-3.3	0.8
0879	4.70	4.84	4	38°24′.4	37°55′.1	38°23′.7	38°00′.2	0.6	-5.1
1324	4.61	4.75	5	57°06′.8	49°12′.7	57°09′.2	49°13′.1	-1.6	-0.4
1261	4.29	4.43	4	54°17′.5	49°11′.9	54°19′.0	49°10′.6	-0.9	1.3
1273	4.04	4.18	5	54°58′.2	46°34′.5	55°00′.8	46°33′.4	-1.8	1.1
1303	4.14	4.27	4	56°28′.3	47°19′.4	56°29′.4	47°18′.2	-0.7	1.2
1350	4.85	4.99	6	58°09′.7	45°28′.9	58°15′.2	45°27′.2	-3.8	1.7
1454	4.25	4.39	5	62°18′.6	40°21′.7	62°19′.2	40°21′.2	-0.4	0.5
1135	3.77	3.91	4	49°29′.3	41°14′.4	49°36′.2	41°14′.4	-5.2	-0.0
1220	2.89	3.03	3	52°50′.7	38°48′.3	52°50′.4	38°46′.5	0.3	1.8
1228	4.04	4.19	5	53°17′.7	34°35′.1	53°19′.7	34°33′.9	-1.6	1.2
1131	3.83	3.98	4	49°50′.2	30°57′.9	49°52′.9	30°57′.1	-2.3	0.8
1203	2.85	3.00	3	52°20′.8	30°39′.9	52°19′.0	30°37′.4	1.6	2.5
1314	5.19	5.33	5	36°14′.4	59°53′.1	56°30′.5	52°30′.7	-740.1	442.4
1210	5.28	5.42	5	51°52′.1	49°27′.4	51°50′.5	49°27′.0	1.0	0.4
0840	4.23	4.37	4	36°25′.8	36°36′.3	36°25′.8	36°37′.0	-0.0	-0.6
0985	4.84	4.98	6	41°26′.1	64°04′.6	41°29′.6	64°06′.1	-1.5	-1.5
1040	4.54	4.67	6	40°53′.7	67°15′.0	44°41′.4	57°24′.5	-122.7	590.5
1046	5.09	5.23	6	40°16′.4	68°37′.9	45°02′.5	53°59′.3	-168.2	878.6
1035	4.21	4.35	6	36°27′.2	72°43′.3	44°22′.7	58°27′.7	-248.7	855.5
2029	4.99	5.13	6	80°27′.2	55°33′.8	80°22′.7	55°29′.6	2.6	4.2
2077	3.72	3.85	4	81°31′.3	54°11′.3	81°41′.2	54°08′.1	-5.8	3.2
1708	0.08	0.21	1	71°48′.7	45°30′.0	71°50′.7	45°29′.3	-1.4	0.7

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
84°28′.0	21°27′.5	84°20′.9	21°27′.4	6.6	0.1		34β Aur	651
83°59′.0	13°44′.0	84°22′.2	13°43′.8	-22.5	0.2		37θ Aur	652
73°09′.0	20°52′.0	73°16′.6	20°53′.6	-7.1	-1.6		7ε Aur	653
73°05′.5	18°08′.5	73°04′.0	18°09′.2	1.4	-0.7		8ζ Aur	654
73°49′.5	18°11′.5	73°52′.7	18°14′.4	-3.0	-2.9		10η Aur	655
71°04′.5	10°22′.0	71°04′.4	10°24′.3	0.1	-2.3		3ι Aur	656
84°25′.5	22°27′.0	84°25′.1	22°26′.8	0.3	0.2	r	35π Aur	657
76°52′.5	18°34′.5	76°56′.1	18°33′.9	-3.4	0.6		20ρ Aur	658
76°06′.0	16°59′.0	76°13′.6	16°58′.5	-7.3	0.5		15λ Aur	659
74°58′.0	15°21′.5	75°00′.3	15°22′.9	-2.2	-1.4		11μ Aur	660
77°09′.0	14°04′.0	77°12′.1	14°07′.0	-3.0	-3.0		21σ Aur	661
72°00′.0	15°03′.0	72°04′.0	15°03′.6	-3.9	-0.6		4ω Aur	662
82°12′.5	15°42′.5	82°15′.3	15°42′.8	-2.7	-0.3		29τ Aur	663
82°44′.0	15°43′.0	82°43′.1	15°40′.1	0.8	2.9		32ν Aur	664
82°35′.0	13°49′.0	82°35′.5	13°50′.0	-0.5	-1.0		31υ Aur	665
76°39′.5	11°15′.0	77°38′.6	11°10′.8	-57.9	4.2		24φ Aur	666
78°34′.0	8°51′.0	78°35′.8	8°50′.3	-1.8	0.7		25χ Aur	667
70°04′.5	14°51′.0	70°07′.5	14°51′.6	-2.9	-0.6		1 Aur	668
70°31′.0	14°02′.0	70°34′.9	14°01′.2	-3.8	0.8		2 Aur	669
87°47′.0	6°04′.0	87°48′.2	6°04′.9	-1.2	-0.9		44κ Aur	670
82°58′.0	4°06′.0	82°57′.0	4°07′.8	1.0	-1.8		136 Tau	671
83°58′.0	2°26′.0	83°58′.9	2°27′.8	-0.9	-1.8		139 Tau	672
79°52′.5	2°28′.0	79°52′.2	2°29′.3	0.3	-1.3		125 Tau	673
81°55′.0	1°06′.0	81°56′.1	1°06′.2	-1.1	-0.2		132 Tau	674
254°23′.0	2°12′.0	254°29′.2	-3°22′.0	-6.2	334.0	Fm	36A Oph	675
255°01′.0	2°16′.0	255°18′.6	2°05′.5	-17.6	10.5	Fm	40ξ Oph	676
255°42′.0	1°32′.0	255°49′.7	-1°47′.3	-7.6	199.3	Fm	42θ Oph	677
256°23′.0	0°20′.0	256°45′.9	-0°53′.7	-22.9	73.7	Fm	44b Oph	678
257°12′.0	0°29′.0	257°54′.2	-0°37′.8	-42.2	66.8	Fm	51c Oph	679
257°36′.0	-0°58′.0	254°52′.7	-1°08′.5	163.3	10.5	Fm	39o Oph	680
256°50′.0	-7°10′.0	257°18′.6	-6°33′.7	-28.4	-36.3	rm	45d Oph	681
261°45′.0	-4°20′.0	261°40′.5	-4°22′.1	4.5	2.1	rm	3 Sgr	682
240°07′.0	23°34′.0	240°01′.2	23°36′.8	5.3	-2.8	m	10λ Oph	683
255°00′.0	10°18′.0	254°43′.5	10°18′.9	16.3	-0.9	m	53ν Ser	684
259°02′.0	8°05′.0	258°59′.0	7°59′.6	3.0	5.4	m	55ξ Ser	685
260°04′.0	10°40′.0	259°50′.0	10°32′.9	13.7	7.1	m	56o Ser	686
259°05′.0	15°16′.0	258°45′.0	15°16′.0	19.3	0.0	m	57μ Oph	687
256°50′.0	35°57′.0	256°51′.7	35°54′.7	-1.3	2.3		55α Oph	688
259°45′.0	28°01′.0	259°46′.5	27°58′.5	-1.3	2.5		60β Oph	689
261°05′.0	26°11′.0	261°04′.1	26°10′.3	0.8	0.7		62γ Oph	690
244°59′.5	32°35′.5	245°04′.4	32°33′.5	-4.1	2.0		25ι Oph	691
246°16′.0	31°56′.0	246°17′.0	31°53′.5	-0.9	2.5		27κ Oph	692
240°03′.0	23°39′.5	240°01′.2	23°36′.8	1.6	2.7		10λ Oph	693
236°44′.5	17°19′.0	236°43′.8	17°18′.3	0.7	0.7		1δ Oph	694
237°57′.0	16°30′.5	237°55′.7	16°28′.9	1.3	1.6		2ε Oph	695
259°03′.0	15°19′.0	258°45′.0	15°16′.0	17.3	3.0		57μ Oph	696
264°13′.5	13°47′.0	264°11′.2	13°43′.8	2.2	3.2		64ν Oph	697
265°14′.5	15°20′.0	265°13′.3	15°18′.8	1.2	1.2		69τ Oph	698
252°24′.0	7°18′.0	252°23′.9	7°14′.3	0.1	3.7	d	35η Oph	699
243°39′.0	11°30′.0	243°39′.5	11°26′.3	-0.4	3.7		13ζ Oph	700

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	*m*	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
2088	1.90	2.04	2	82°43′.7	44°50′.6	82°34′.7	44°48′.1	6.4	2.5
2095	2.62	2.76	4	82°39′.9	37°06′.3	83°08′.3	37°05′.2	-22.6	1.1
1605	2.99	3.13	4	68°13′.1	43°07′.3	68°23′.0	43°08′.1	-7.3	-0.8
1612	3.75	3.89	4	68°42′.8	40°25′.3	68°41′.5	40°23′.8	1.0	1.4
1641	3.17	3.31	4	69°36′.5	40°34′.5	69°40′.5	40°35′.9	-3.0	-1.4
1577	2.69	2.83	4	67°47′.3	32°26′.3	67°47′.3	32°26′.7	0.0	-0.4
2091	4.26	4.39	5	82°35′.8	45°49′.9	82°35′.6	45°47′.6	0.1	2.3
1749	5.23	5.37	6	73°20′.4	41°20′.5	73°25′.5	41°18′.3	-3.8	2.1
1729	4.71	4.85	5	72°38′.0	39°40′.3	72°48′.0	39°38′.7	-7.7	1.6
1689	4.86	5.00	5	71°30′.9	37°55′.2	71°33′.9	37°55′.0	-2.4	0.2
1773	4.99	5.13	6	74°21′.0	36°53′.6	74°24′.7	36°55′.0	-2.9	-1.3
1592	4.94	5.08	5	67°59′.8	37°12′.3	68°05′.0	37°11′.6	-4.2	0.7
1995	4.52	4.66	5	80°20′.2	38°58′.3	80°23′.9	38°56′.7	-2.9	1.6
2012	3.97	4.11	5	80°59′.1	39°00′.8	80°58′.5	38°55′.9	0.5	4.9
2011	4.74	4.88	6	80°57′.4	37°06′.5	80°58′.2	37°05′.5	-0.7	1.0
1805	5.07	5.21	5	74°09′.0	34°02′.5	75°19′.4	34°02′.5	-58.4	-0.1
1843	4.76	4.91	5	76°40′.1	31°50′.7	76°42′.6	31°48′.2	-2.1	2.5
1533	4.88	5.02	5	65°44′.4	36°42′.4	65°48′.5	36°41′.6	-3.3	0.8
1551	4.78	4.92	5	66°26′.0	35°58′.3	66°31′.4	35°56′.3	-4.4	2.1
2219	4.35	4.50	4	87°27′.9	29°34′.3	87°29′.4	29°33′.2	-1.3	1.1
2034	4.58	4.74	4	82°05′.4	27°25′.9	82°04′.3	27°25′.7	1.0	0.2
2084	4.82	4.98	4	83°18′.0	25°49′.1	83°19′.0	25°48′.9	-0.9	0.2
1928	5.18	5.34	4	78°46′.2	25°35′.8	78°46′.0	25°35′.1	0.2	0.7
2002	4.86	5.02	4	81°07′.3	24°22′.5	81°08′.6	24°20′.7	-1.2	1.8
6401	4.56	5.43	4	253°19′.1	-20°25′.3	252°43′.8	-25°55′.8	31.8	330.5
6445	4.39	4.95	3	253°59′.9	-20°25′.6	254°17′.6	-20°36′.0	-16.6	10.4
6453	3.27	4.05	4	254°38′.4	-21°13′.8	254°23′.8	-24°30′.9	13.2	197.1
6486	4.17	4.89	4	255°14′.3	-22°29′.7	255°31′.2	-23°43′.3	-15.5	73.6
6519	4.81	5.52	5	256°08′.0	-22°25′.5	256°47′.1	-23°34′.0	-35.9	68.5
6424	4.98	5.68	5	256°25′.0	-23°54′.4	253°26′.5	-23°45′.9	163.4	-8.5
6492	4.29	5.66	5	254°52′.3	-30°00′.0	255°29′.5	-29°24′.9	-32.3	-35.2
6616	4.54	5.59	6	260°42′.6	-27°35′.5	260°37′.5	-27°35′.3	4.5	-0.2
6149	3.82	4.05	5	242°47′.5	2°49′.8	242°42′.8	2°55′.4	4.7	-5.6
6446	4.33	4.69	5	254°53′.1	-12°26′.3	254°36′.7	-12°21′.8	16.0	-4.6
6561	3.54	3.95	4	258°45′.3	-15°00′.8	258°41′.9	-15°03′.9	3.3	3.1
6581	4.26	4.63	5	260°00′.0	-12°30′.8	259°45′.5	-12°34′.9	14.1	4.1
6567	4.62	4.92	5	259°22′.3	-7°51′.3	259°03′.0	-7°47′.8	19.2	-3.5
6556	2.08	2.26	3	259°05′.7	12°55′.4	259°06′.7	12°55′.0	-1.0	0.4
6603	2.77	2.98	3	260°55′.8	4°48′.9	260°56′.9	4°48′.3	-1.1	0.6
6629	3.75	3.98	3	261°59′.7	2°54′.4	261°58′.8	2°55′.8	0.9	-1.4
6281	4.38	4.57	4	248°43′.9	10°54′.1	248°47′.6	10°53′.3	-3.6	0.8
6299	3.20	3.39	4	249°42′.1	10°04′.3	249°42′.4	10°03′.6	-0.3	0.7
6149	3.82	4.05	4	242°45′.0	2°55′.9	242°42′.8	2°55′.4	2.2	0.5
6056	2.74	2.99	3	238°23′.5	-2°37′.3	238°22′.8	-2°36′.0	0.7	-1.2
6075	3.24	3.50	3	239°20′.9	-3°39′.6	239°19′.4	-3°39′.1	1.5	-0.5
6567	4.62	4.92	4	259°20′.6	-7°48′.2	259°03′.0	-7°47′.8	17.5	-0.3
6698	3.34	3.66	4	264°18′.7	-9°37′.6	264°16′.4	-9°38′.7	2.3	1.0
6733	4.78	5.09	5	265°21′.9	-8°06′.9	265°20′.7	-8°06′.0	1.2	-0.8
6378	2.43	2.84	3	251°54′.0	-15°07′.3	251°53′.6	-15°09′.0	0.4	1.7
6175	2.56	2.89	3	243°49′.2	-9°39′.2	243°49′.1	-9°41′.1	0.1	1.9

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
252°24′.0	7°18′.0	252°23′.9	7°14′.3	0.1	3.7	D	35η Oph	701
266°31′.0	33°02′.5	266°36′.3	33°01′.9	-4.4	0.6		72 Oph	702
226°48′.0	26°36′.5	226°50′.8	26°35′.8	-2.5	0.7		27λ Ser	703
254°49′.0	10°21′.0	254°43′.5	10°18′.9	5.4	2.1		53ν Ser	704
258°57′.0	8°04′.0	258°59′.0	7°59′.6	-2.0	4.4		55ξ Ser	705
259°48′.0	10°35′.0	259°50′.0	10°32′.9	-2.0	2.1		56o Ser	706
258°45′.0	15°18′.0	258°45′.0	15°16′.0	-0.0	2.0		57μ Oph	707
240°57′.0	13°19′.0	240°59′.5	13°15′.7	-2.4	3.3		3υ Oph	708
264°30′.0	27°55′.0	264°30′.5	27°51′.7	-0.5	3.3		66 Oph	709
264°38′.0	26°23′.0	264°36′.8	26°25′.4	1.0	-2.4		67 Oph	710
264°53′.0	24°50′.0	264°54′.9	24°47′.8	-1.7	2.2		68 Oph	711
265°58′.0	26°10′.0	265°55′.1	26°06′.3	2.6	3.7		70 Oph	712
221°35′.0	38°12′.0	221°35′.4	38°09′.2	-0.3	2.8		21ι Ser	713
224°24′.5	39°06′.5	223°55′.8	40°02′.6	22.0	-56.1		38ρ Ser	714
227°06′.5	35°25′.0	227°06′.5	35°22′.1	-0.0	2.9		41γ Ser	715
224°21′.5	34°27′.5	224°21′.0	34°22′.3	0.4	5.2		28β Ser	716
225°10′.0	37°28′.5	224°11′.3	37°09′.8	46.8	18.7		35κ Ser	717
226°32′.0	42°37′.0	226°32′.3	42°29′.6	-0.2	7.4		44π Ser	718
222°46′.5	28°58′.0	222°45′.9	28°55′.4	0.5	2.6		13δ Ser	719
226°30′.0	25°35′.5	226°28′.7	25°32′.6	1.1	2.9		24α Ser	720
228°46′.5	24°05′.5	228°44′.3	24°02′.5	2.0	3.0		37ϵ Ser	721
230°26′.5	16°26′.5	230°22′.4	16°17′.3	3.9	9.2		32μ Ser	722
264°34′.5	19°57′.0	264°32′.7	19°48′.4	1.7	8.6		57ζ Ser	723
270°12′.5	20°37′.5	270°11′.0	20°33′.7	1.4	3.8		58η Ser	724
280°10′.0	26°59′.0	280°11′.4	26°55′.4	-1.3	3.6		63θ Ser	725
301°32′.0	39°13′.0	301°29′.6	39°13′.7	1.8	-0.7		12γ Sge	726
297°55′.0	38°58′.5	297°50′.7	38°57′.2	3.4	1.3		7δ Sge	727
298°31′.0	39°31′.0	298°29′.8	39°27′.3	0.9	3.7		8ζ Sge	728
295°30′.5	38°53′.0	295°31′.6	38°50′.3	-0.9	2.7		5α Sge	729
295°39′.0	38°18′.0	295°39′.7	38°15′.9	-0.6	2.1		6β Sge	730
300°13′.0	42°43′.0	300°15′.1	42°42′.2	-1.5	0.8		12 Vul	731
301°36′.0	44°02′.0	301°30′.0	43°58′.5	4.3	3.5		13 Vul	732
293°57′.0	46°03′.0	293°59′.6	45°54′.6	-1.8	8.4		6α Vul	733
299°28′.5	27°08′.5	299°28′.9	27°03′.6	-0.4	4.9		63τ Aql	734
296°53′.0	26°49′.5	296°52′.7	26°45′.3	0.3	4.2		60β Aql	735
296°09′.0	29°21′.5	296°08′.9	29°19′.0	0.0	2.5		53α Aql	736
296°33′.0	30°54′.5	296°39′.1	30°51′.9	-5.2	2.6	r	54o Aql	737
295°26′.0	31°18′.0	295°23′.3	31°17′.2	2.3	0.8		50γ Aql	738
296°08′.5	31°59′.0	298°23′.6	31°32′.6	-115.1	26.4		61ϕ Aql	739
291°16′.5	28°46′.5	291°14′.1	28°43′.3	2.1	3.2		38μ Aql	740
292°14′.0	26°35′.0	292°15′.2	26°31′.1	-1.0	3.9		44σ Aql	741
284°15′.5	36°16′.5	284°14′.8	36°14′.6	0.6	1.9		17ζ Aql	742
282°44′.0	37°40′.0	282°43′.1	37°37′.4	0.7	2.6		13ϵ Aql	743
279°12′.0	43°32′.5	279°14′.0	43°29′.3	-1.5	3.2		110 Her	744
279°17′.5	41°05′.0	279°17′.9	41°03′.2	-0.3	1.8		111 Her	745
299°21′.5	18°48′.0	299°21′.2	18°46′.1	0.3	1.9		65θ Aql	746
290°17′.5	20°14′.5	290°16′.8	20°03′.4	0.7	11.1		41ι Aql	747
289°17′.0	14°28′.0	289°17′.6	14°23′.5	-0.6	4.5		39κ Aql	748
288°01′.0	24°56′.0	288°03′.0	24°51′.5	-1.8	4.5		30δ Aql	749
294°50′.0	21°38′.0	294°52′.6	21°34′.0	-2.4	4.0		55η Aql	750

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
6378	2.43	2.84	3	251°54′.0	-15°07′.3	251°53′.6	-15°09′.0	0.4	1.7
6771	3.73	3.93	4	267°02′.4	9°33′.2	267°06′.8	9°34′.5	-4.4	-1.4
5868	4.43	4.63	4	231°45′.0	8°39′.4	231°47′.1	8°39′.6	-2.1	-0.2
6446	4.33	4.69	4	254°42′.4	-12°22′.2	254°36′.7	-12°21′.8	5.5	-0.4
6561	3.54	3.95	3	258°40′.1	-15°01′.4	258°41′.9	-15°03′.9	-1.7	2.5
6581	4.26	4.63	4	259°43′.6	-12°34′.6	259°45′.5	-12°34′.9	-1.9	0.2
6567	4.62	4.92	4	259°03′.1	-7°47′.8	259°03′.0	-7°47′.8	0.1	0.0
6129	4.63	4.93	5	241°32′.7	-7°22′.5	241°34′.6	-7°24′.5	-1.8	2.0
6712	4.64	4.86	4	265°07′.6	4°29′.1	265°07′.9	4°27′.8	-0.3	1.3
6714	3.97	4.20	4	265°11′.2	2°56′.9	265°10′.3	3°01′.4	1.0	-4.5
6723	4.45	4.68	4	265°21′.4	1°23′.5	265°23′.0	1°23′.3	-1.7	0.2
6752	4.03	4.25	4	266°22′.6	2°41′.6	266°19′.9	2°39′.9	2.7	1.6
5842	4.52	4.69	5	230°58′.1	21°01′.7	230°56′.9	21°00′.5	1.1	1.2
5899	4.76	4.92	3	233°31′.1	21°12′.0	233°26′.6	22°13′.8	4.2	-61.8
5933	3.85	4.02	3	234°32′.4	17°02′.4	234°31′.2	17°01′.2	1.2	1.1
5867	3.67	3.85	3	231°59′.6	16°46′.7	231°57′.2	16°43′.5	2.3	3.2
5879	4.09	4.25	4	233°35′.9	19°27′.8	232°42′.3	19°25′.7	50.6	2.1
5972	4.83	4.99	4	236°19′.8	24°03′.4	236°17′.1	23°57′.9	2.5	5.4
5788	3.05	3.24	3	228°58′.4	11°56′.4	228°56′.9	11°55′.6	1.5	0.8
5854	2.65	2.85	2	231°12′.2	7°45′.3	231°10′.1	7°44′.3	2.1	0.9
5892	3.71	3.92	3	232°47′.8	5°45′.1	232°44′.9	5°44′.3	2.9	0.8
5881	3.53	3.79	4	232°19′.4	-2°02′.5	232°13′.3	-2°08′.8	6.1	6.3
6710	4.62	4.89	3	264°53′.5	-3°28′.7	264°51′.5	-3°35′.3	2.0	6.6
6869	3.26	3.52	3	270°11′.7	-2°54′.0	270°10′.3	-2°55′.7	1.4	1.7
7141	4.03	4.25	3	279°04′.2	3°46′.7	279°05′.8	3°45′.3	-1.6	1.5
7635	3.47	3.63	4	295°17′.0	18°25′.7	295°15′.3	18°27′.9	1.7	-2.1
7536	3.82	3.99	5	292°27′.0	17°36′.5	292°24′.0	17°36′.4	2.8	0.1
7546	5.00	5.17	6	292°48′.9	18°13′.9	292°49′.0	18°11′.9	-0.1	2.0
7479	4.37	4.54	4	290°32′.4	17°10′.0	290°34′.0	17°09′.3	-1.5	0.6
7488	4.37	4.54	4	290°45′.8	16°36′.7	290°47′.0	16°36′.6	-1.1	0.1
7565	4.95	5.12	4	293°26′.3	21°37′.7	293°28′.5	21°39′.1	-2.0	-1.4
7592	4.58	4.74	4	294°11′.0	23°08′.1	294°07′.6	23°05′.6	3.1	2.5
7405	4.44	4.59	4	287°57′.9	24°00′.8	288°01′.7	23°54′.7	-3.5	6.0
7669	5.52	5.72	6	296°08′.1	6°15′.6	296°09′.5	6°12′.8	-1.4	2.9
7602	3.71	3.92	3	293°54′.9	5°30′.7	293°55′.5	5°28′.4	-0.6	2.4
7557	0.77	0.98	2	292°49′.0	7°53′.3	292°49′.5	7°52′.7	-0.5	0.6
7560	5.11	5.30	6	292°52′.8	9°28′.5	292°58′.6	9°28′.8	-5.7	-0.2
7525	2.72	2.91	3	291°51′.3	9°41′.5	291°49′.3	9°42′.2	2.0	-0.7
7610	5.28	5.47	5	292°20′.2	10°28′.2	294°20′.0	10°25′.5	-117.9	2.7
7429	4.45	4.65	4	288°40′.4	6°37′.4	288°38′.8	6°35′.8	1.6	1.6
7474	5.17	5.39	5	289°50′.7	4°34′.9	289°52′.3	4°33′.2	-1.7	1.7
7235	2.99	3.18	3	281°46′.5	13°20′.0	281°46′.2	13°20′.0	0.3	-0.1
7176	4.02	4.20	3	280°23′.2	14°36′.1	280°22′.8	14°35′.4	0.4	0.7
7061	4.19	4.35	4	277°05′.7	20°14′.6	277°07′.6	20°13′.5	-1.8	1.1
7069	4.36	4.53	4	277°20′.6	17°47′.7	277°21′.2	17°48′.0	-0.5	-0.3
7710	3.23	3.49	3	297°40′.2	-1°56′.4	297°40′.2	-1°56′.5	-0.0	0.1
7447	4.36	4.62	3	289°00′.0	-1°57′.0	289°00′.8	-2°06′.2	-0.8	9.1
7446	4.95	5.26	3	288°49′.8	-7°48′.1	288°50′.9	-7°50′.6	-1.1	2.4
7377	3.36	3.59	3	286°18′.2	2°25′.5	286°20′.5	2°23′.3	-2.4	2.3
7570	3.90	4.14	3	292°58′.8	0°04′.5	293°01′.8	0°02′.8	-3.1	1.6

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
281°46′.0	17°41′.0	281°46′.5	17°37′.4	-0.4	3.6		16λ Aql	751
280°29′.0	16°57′.0	280°29′.3	16°53′.9	-0.2	3.1		12 Aql	752
308°32′.0	29°08′.0	308°30′.9	29°06′.6	1.0	1.4		2ϵ Del	753
309°48′.0	28°52′.5	309°46′.3	28°51′.5	1.5	1.0		5ι Del	754
309°42′.0	27°34′.0	309°39′.9	27°32′.1	1.9	1.9		7κ Del	755
310°56′.0	31°57′.5	310°47′.2	31°57′.5	7.5	-0.0		6β Del	756
311°50′.5	33°05′.0	311°49′.9	33°03′.4	0.5	1.6		9α Del	757
312°36′.5	32°00′.0	312°34′.7	31°58′.8	1.5	1.2	r	11δ Del	758
313°52′.0	32°47′.0	313°50′.4	32°45′.2	1.3	1.8		12γ Del	759
310°17′.0	32°08′.5	310°12′.6	32°11′.3	3.7	-2.8		4ζ Del	760
309°18′.0	30°41′.5	309°16′.4	30°42′.5	1.4	-1.0		3η Del	761
310°42′.0	30°41′.0	310°40′.5	30°38′.6	1.3	2.4		8θ Del	762
317°32′.5	20°12′.5	317°33′.8	20°09′.7	-1.2	2.8		8α Equ	763
319°54′.5	21°06′.0	319°52′.7	21°03′.4	1.7	2.6		10β Equ	764
317°54′.0	25°16′.0	317°52′.8	25°13′.7	1.1	2.3		5γ Equ	765
318°54′.5	24°52′.0	318°54′.3	24°47′.6	0.2	4.4		7δ Equ	766
326°22′.0	22°07′.5	326°20′.0	22°07′.3	1.9	0.2		8ϵ Peg	767
331°15′.5	16°25′.0	331°15′.0	16°21′.9	0.5	3.1		26θ Peg	768
329°45′.5	15°43′.0	329°44′.5	15°42′.2	1.0	0.8		22ν Peg	769
343°00′.0	14°30′.5	343°00′.4	14°30′.0	-0.4	0.5		50ρ Peg	770
342°44′.0	15°43′.5	342°42′.8	15°43′.7	1.2	-0.2		49σ Peg	771
340°39′.5	17°41′.0	340°35′.5	17°41′.6	3.8	-0.6		42ζ Peg	772
342°25′.0	18°29′.0	342°23′.7	18°28′.3	1.2	0.7		46ξ Peg	773
333°23′.0	36°42′.5	333°23′.9	36°39′.2	-0.7	3.3		10κ Peg	774
338°50′.0	34°19′.0	338°50′.3	34°16′.6	-0.2	2.4		24ι Peg	775
344°03′.0	41°00′.5	344°01′.8	40°59′.4	0.9	1.1		29π2 Peg	776
347°29′.5	28°49′.0	347°30′.6	28°48′.1	-1.0	0.9		47λ Peg	777
348°53′.5	29°24′.5	348°50′.0	29°24′.0	3.1	0.5		48μ Peg	778
350°10′.5	35°07′.5	350°10′.9	35°06′.7	-0.4	0.8		44η Peg	779
349°25′.0	34°24′.5	349°23′.0	34°25′.3	1.7	-0.8		43o Peg	780
355°33′.0	25°35′.0	355°30′.5	25°34′.0	2.2	1.0		62τ Peg	781
356°26′.0	24°50′.5	356°24′.5	24°47′.7	1.3	2.8	r	68υ Peg	782
347°56′.5	19°26′.0	347°55′.9	19°24′.9	0.6	1.1		54α Peg	783
353°49′.5	31°07′.5	353°48′.5	31°08′.0	0.9	-0.5		53β Peg	784
3°38′.0	12°35′.0	3°36′.0	12°35′.3	1.9	-0.3		88γ Peg	785
336°28′.0	20°51′.0	336°24′.3	20°51′.8	3.5	-0.8		31 Peg	786
324°51′.0	33°21′.0	324°45′.5	33°18′.3	4.6	2.7		1 Peg	787
328°47′.0	36°11′.0	328°35′.9	36°09′.7	9.0	1.3		2 Peg	788
345°15′.5	23°16′.0	329°27′.8	29°02′.8	828.5	-346.8	W	9 Peg	789
8°47′.0	25°42′.0	8°45′.5	25°41′.2	1.3	0.8		21α And	790
17°06′.5	27°06′.5	17°08′.0	27°07′.6	-1.4	-1.1		29π And	791
15°25′.0	23°03′.5	15°24′.9	23°00′.9	0.1	2.6		30ϵ And	792
14°58′.0	31°33′.0	14°52′.3	31°34′.6	4.9	-1.6		25σ And	793
15°45′.5	33°20′.5	15°40′.3	33°21′.8	4.3	-1.3		24θ And	794
16°07′.0	32°14′.5	16°05′.3	32°22′.1	1.4	-7.6		27ρ And	795
10°28′.0	40°56′.5	10°33′.4	41°00′.8	-4.0	-4.3		17ι And	796
11°46′.0	41°44′.0	11°45′.9	41°42′.3	0.1	1.7		19κ And	797
14°23′.0	42°58′.0	14°25′.0	42°55′.7	-1.5	2.3	r	20ψ And	798
12°47′.0	43°49′.5	12°46′.8	43°48′.3	0.1	1.2		16λ And	799
15°09′.0	17°48′.0	15°02′.5	17°36′.1	6.2	11.9		34ζ And	800

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
7236	3.44	3.72	3	281°15′.2	-5°22′.9	281°15′.9	-5°24′.4	-0.7	1.5
7193	4.02	4.30	4	280°05′.0	-6°12′.5	280°05′.4	-6°13′.6	-0.4	1.1
7852	4.03	4.23	3	303°32′.5	10°00′.0	303°32′.1	10°00′.1	0.4	-0.1
7883	5.43	5.63	3	304°41′.8	10°02′.0	304°40′.8	10°02′.3	1.0	-0.3
7896	5.05	5.25	6	304°57′.2	8°44′.8	304°56′.0	8°44′.2	1.2	0.7
7882	3.63	3.81	3	304°49′.7	13°15′.9	304°42′.5	13°15′.6	7.0	0.3
7906	3.77	3.95	3	305°16′.3	14°33′.4	305°16′.6	14°33′.4	-0.2	0.0
7928	4.43	4.61	3	306°13′.3	13°41′.7	306°12′.5	13°41′.7	0.8	-0.0
7947	3.87	4.05	3	307°02′.7	14°44′.7	307°02′.3	14°44′.2	0.4	0.5
7871	4.68	4.86	5	304°13′.9	13°17′.7	304°09′.7	13°21′.1	4.1	-3.3
7858	5.38	5.57	6	303°47′.5	11°40′.6	303°46′.1	11°42′.8	1.4	-2.3
7892	5.72	5.90	6	304°58′.8	11°59′.0	304°58′.5	11°58′.1	0.4	1.0
8131	3.92	4.14	4	313°55′.8	3°39′.7	313°57′.8	3°38′.8	-2.1	0.9
8178	5.16	5.37	4	315°46′.7	5°10′.7	315°46′.0	5°09′.1	0.7	1.6
8097	4.69	4.89	4	312°44′.1	8°35′.4	312°43′.9	8°34′.4	0.2	1.0
8123	4.49	4.69	4	313°44′.2	8°29′.0	313°45′.6	8°26′.2	-1.3	2.8
8308	2.39	2.58	3	321°10′.3	8°04′.7	321°08′.8	8°05′.2	1.5	-0.5
8450	3.53	3.75	4	327°30′.2	4°18′.1	327°30′.9	4°16′.2	-0.7	2.0
8413	4.84	5.06	5	326°23′.6	3°08′.7	326°23′.1	3°08′.7	0.6	-0.0
8717	4.90	5.11	6	338°46′.6	6°42′.2	338°47′.4	6°42′.6	-0.8	-0.4
8697	5.16	5.36	6	338°04′.0	7°43′.6	338°03′.0	7°44′.1	0.9	-0.5
8634	3.40	3.60	3	335°27′.2	8°46′.5	335°23′.7	8°46′.4	3.4	0.1
8665	4.19	4.38	5	336°42′.4	10°09′.3	336°41′.9	10°09′.0	0.5	0.3
8315	4.13	4.29	4	321°36′.5	23°52′.3	321°39′.3	23°50′.9	-2.6	1.5
8430	3.76	3.92	4	327°05′.4	23°26′.7	327°07′.4	23°25′.7	-1.8	1.0
8454	4.29	4.44	4	328°04′.6	31°15′.4	328°05′.3	31°15′.0	-0.6	0.3
8667	3.95	4.11	4	336°48′.8	21°28′.9	336°50′.9	21°29′.3	-1.9	-0.4
8684	3.48	3.64	4	337°44′.4	22°32′.0	337°42′.4	22°31′.0	1.8	1.0
8650	2.94	3.09	3	336°04′.2	28°09′.2	336°06′.0	28°09′.4	-1.6	-0.2
8641	4.79	4.95	5	335°48′.0	27°14′.1	335°46′.8	27°14′.9	1.0	-0.8
8880	4.60	4.76	6	345°15′.8	21°35′.5	345°14′.9	21°34′.2	0.9	1.4
8905	4.40	4.56	6	346°22′.8	21°15′.8	346°23′.6	21°13′.2	-0.7	2.7
8781	2.49	2.68	2	341°13′.7	13°05′.2	341°14′.1	13°04′.6	-0.4	0.6
8775	2.42	2.57	2	341°08′.3	25°55′.5	341°08′.2	25°56′.2	0.1	-0.7
0039	2.38	2.57	2	358°13′.3	12°58′.2	358°11′.8	12°57′.8	1.5	0.4
8520	5.01	5.21	4	330°31′.7	10°13′.1	330°28′.4	10°13′.5	3.2	-0.4
8173	4.08	4.25	4	315°57′.9	18°11′.2	315°54′.8	18°08′.4	3.0	2.7
8225	4.57	4.73	4	318°06′.4	21°59′.0	317°58′.6	21°55′.8	7.3	3.2
8313	4.34	4.51	4	337°16′.8	15°35′.8	321°24′.6	15°33′.5	917.3	2.3
0015	2.06	2.22	2	356°59′.0	26°54′.4	356°59′.1	26°53′.2	-0.1	1.2
0154	4.36	4.51	5	3°54′.9	31°29′.3	3°57′.0	31°30′.7	-1.8	-1.4
0163	4.37	4.52	4	4°22′.8	27°10′.6	4°25′.0	27°08′.1	-2.0	2.6
0068	4.52	4.67	5	359°30′.5	34°35′.0	359°25′.8	34°34′.1	3.9	0.9
0063	4.61	4.75	4	359°11′.4	36°28′.7	359°07′.5	36°27′.7	3.2	0.9
0082	5.18	5.32	5	0°09′.9	35°39′.1	0°05′.3	35°45′.2	3.7	-6.0
8965	4.29	4.43	4	349°38′.6	40°57′.9	349°42′.0	41°04′.0	-2.6	-6.1
8976	4.14	4.28	4	350°12′.1	42°09′.0	350°15′.1	42°07′.9	-2.2	1.1
9003	4.95	5.09	5	351°32′.6	44°13′.5	351°38′.0	44°12′.6	-3.9	0.9
8961	3.82	3.96	4	349°31′.8	44°19′.0	349°34′.5	44°18′.3	-2.0	0.7
0215	4.06	4.22	4	6°35′.3	22°18′.6	6°35′.3	22°05′.0	-0.1	13.6

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
16°53′.5	15°58′.0	16°49′.6	15°54′.6	3.7	3.4		38η And	801
24°49′.0	25°59′.0	24°50′.7	25°56′.0	-1.5	3.0		43β And	802
24°06′.5	30°33′.5	23°36′.8	29°38′.0	25.8	55.5		37μ And	803
23°36′.0	32°30′.5	23°36′.5	32°32′.2	-0.4	-1.7		35ν And	804
38°39′.0	27°46′.5	38°40′.4	27°46′.5	-1.2	0.0		57γ And	805
39°06′.5	36°49′.5	39°03′.0	36°48′.8	2.8	0.7		φ Per	806
36°52′.0	35°21′.5	36°53′.8	35°23′.5	-1.5	-2.0		51 And	807
33°06′.0	28°59′.0	33°02′.6	28°58′.5	2.9	0.5	r	50υ And	808
33°23′.0	27°54′.5	33°21′.3	27°53′.9	1.5	0.6		53τ And	809
30°56′.0	36°20′.0	30°53′.0	36°20′.2	2.4	-0.2		42φ And	810
354°00′.0	57°19′.0	2°15′.5	43°44′.5	-358.0	814.6		1ο And	811
16°19′.5	24°20′.0	16°15′.4	24°20′.6	3.7	-0.6		31δ And	812
31°19′.0	16°49′.5	31°18′.8	16°47′.4	0.1	2.1		2α Tri	813
36°49′.5	20°33′.0	36°47′.0	20°33′.2	2.3	-0.2		4β Tri	814
37°59′.0	19°24′.0	37°55′.9	19°21′.1	2.9	2.9		8δ Tri	815
37°58′.0	18°57′.0	37°57′.6	18°55′.0	0.4	2.0		9γ Tri	816
39°31′.0	-7°50′.0	39°31′.3	-7°49′.5	-0.3	-0.5		91λ Cet	817
38°47′.0	-12°37′.0	38°44′.9	-12°37′.0	2.0	0.0		92α Cet	818
33°53′.5	-12°02′.5	33°52′.7	-12°01′.3	0.8	-1.2		86γ Cet	819
32°02′.0	-14°32′.0	31°59′.6	-14°29′.8	2.4	-2.2		82δ Cet	820
31°54′.0	-5°52′.0	31°53′.7	-5°53′.3	0.3	1.3		73ξ2 Cet	821
36°07′.0	-5°36′.0	36°20′.5	-5°35′.5	-13.4	-0.5		87μ Cet	822
28°29′.5	-4°19′.0	28°28′.4	-4°18′.0	1.1	-1.0		65ξ1 Cet	823
24°09′.0	-25°17′.0	24°07′.9	-25°16′.2	1.0	-0.8		72ρ Cet	824
24°31′.5	-28°31′.0	24°31′.6	-28°33′.1	-0.1	2.1		76σ Cet	825
28°11′.5	-28°16′.5	28°10′.1	-28°16′.7	1.3	0.2		89π Cet	826
27°47′.5	-25°58′.0	27°44′.8	-26°00′.2	2.4	2.2		83ϵ Cet	827
12°25′.0	-25°01′.0	12°22′.8	-24°59′.9	2.0	-1.1		52τ Cet	828
13°50′.0	-31°04′.0	13°49′.0	-31°02′.8	0.8	-1.2		59υ Cet	829
16°25′.0	-20°19′.0	16°21′.8	-20°21′.1	3.0	2.1		55ζ Cet	830
10°42′.5	-15°46′.5	10°39′.8	-15°46′.0	2.6	-0.5		45θ Cet	831
6°11′.5	-16°05′.0	6°10′.1	-16°06′.6	1.3	1.6	r	31η Cet	832
355°23′.0	-10°01′.0	355°20′.5	-10°01′.4	2.4	0.4		8ι Cet	833
356°56′.0	-20°47′.0	356°58′.2	-20°46′.9	-2.0	-0.1		16β Cet	834
42°45′.0	-14°30′.0	42°43′.3	-14°29′.6	1.6	-0.4		96κ1 Cet	835
15°04′.5	-21°55′.0	15°47′.3	-20°30′.4	-40.1	-84.6		53χ Cet	836
32°49′.5	-9°12′.5	32°49′.1	-9°12′.9	0.4	0.4		78ν Cet	837
78°11′.5	-13°26′.0	78°08′.3	-13°25′.3	3.1	-0.7		39λ Ori	838
78°06′.5	-13°54′.0	78°02′.3	-13°51′.7	4.1	-2.3		37ψ1 Ori	839
78°33′.5	-14°04′.5	78°33′.0	-14°02′.9	0.5	-1.6		40ψ2 Ori	840
83°12′.0	-16°06′.0	83°11′.1	-16°04′.8	0.9	-1.2		58α Ori	841
75°23′.0	-16°53′.0	75°22′.8	-16°52′.0	0.2	-1.0		24γ Ori	842
76°47′.0	-17°22′.0	76°49′.2	-17°20′.8	-2.1	-1.2		32A Ori	843
85°04′.5	-14°51′.0	85°02′.2	-13°50′.4	2.2	-60.6		61μ Ori	844
88°30′.5	-11°30′.0	88°31′.1	-11°10′.9	-0.6	-19.1		74k2 Ori	845
87°23′.5	-9°15′.0	87°21′.9	-9°15′.0	1.6	-0.0		70ξ Ori	846
86°21′.0	-8°44′.0	86°17′.1	-8°42′.5	3.9	-1.5		67ν Ori	847
87°22′.0	-7°20′.5	87°21′.1	-7°19′.7	0.9	-0.8		69f1 Ori	848
88°08′.5	-7°19′.0	88°09′.9	-7°17′.8	-1.4	-1.2		72f2 Ori	849
83°09′.0	-3°12′.5	83°08′.1	-3°12′.0	0.9	-0.5		54χ1 Ori	850

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	*m*	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
0271	4.42	4.58	5	9°02′.3	21°19′.7	9°01′.0	21°14′.7	1.3	5.0
0337	2.06	2.20	2	11°50′.5	33°31′.5	11°55′.0	33°29′.0	-3.8	2.5
0269	3.87	4.01	4	8°39′.0	37°20′.4	8°43′.5	36°19′.1	-3.6	61.4
0226	4.53	4.67	4	7°00′.7	38°52′.0	7°01′.8	38°53′.5	-0.8	-1.4
0603	2.16	2.30	2	24°53′.7	40°22′.7	24°56′.7	40°22′.3	-2.3	0.4
0496	4.07	4.21	5	19°48′.5	48°41′.1	19°47′.4	48°38′.5	0.8	2.6
0464	3.57	3.70	4	18°26′.8	46°32′.6	18°29′.4	46°34′.4	-1.8	-1.8
0458	4.09	4.23	5	18°27′.5	39°25′.0	18°25′.9	39°22′.7	1.2	2.4
0477	4.94	5.08	5	19°20′.5	38°33′.2	19°20′.6	38°31′.4	-0.1	1.8
0335	4.25	4.39	5	11°42′.5	45°06′.9	11°41′.3	45°05′.5	0.8	1.4
8762	3.62	3.76	4	324°10′.4	48°31′.2	340°56′.1	40°11′.9	-768.2	499.2
0165	3.27	3.42	3	4°36′.0	28°41′.2	4°33′.0	28°40′.0	2.6	1.3
0544	3.41	3.56	4	22°36′.9	27°38′.6	22°38′.6	27°35′.9	-1.5	2.8
0622	3.00	3.15	4	26°32′.8	33°05′.0	26°31′.4	33°03′.4	1.2	1.6
0660	4.87	5.02	5	28°15′.7	32°25′.7	28°14′.9	32°21′.0	0.7	4.7
0664	4.01	4.16	4	28°26′.5	32°00′.3	28°28′.1	31°57′.3	-1.3	3.0
0896	4.70	4.91	4	39°36′.4	7°16′.5	39°36′.7	7°15′.8	-0.3	0.7
0911	2.53	2.75	2	40°24′.6	2°30′.3	40°22′.7	2°28′.3	1.9	2.0
0804	3.47	3.70	3	35°41′.8	1°30′.7	35°40′.7	1°30′.4	1.1	0.3
0779	4.07	4.32	3	34°49′.7	-1°26′.5	34°46′.6	-1°26′.3	3.0	-0.1
0718	4.28	4.49	4	31°45′.5	6°40′.0	31°45′.8	6°37′.6	-0.3	2.4
0813	4.27	4.47	4	35°39′.5	8°19′.1	35°52′.4	8°22′.8	-12.8	-3.7
0649	4.37	4.57	4	28°00′.6	6°56′.5	27°59′.4	6°56′.1	1.2	0.4
0708	4.89	5.28	4	31°42′.3	-14°07′.1	31°40′.6	-14°07′.8	1.6	0.7
0740	4.75	5.20	4	33°17′.6	-16°59′.2	33°18′.0	-17°02′.2	-0.4	3.0
0811	4.25	4.67	4	36°19′.1	-15°33′.7	36°17′.5	-15°35′.5	1.5	1.9
0781	4.84	5.22	3	35°06′.4	-13°32′.4	35°04′.5	-13°36′.6	1.8	4.1
0509	3.50	3.98	4	21°26′.1	-18°03′.4	21°23′.1	-18°04′.0	2.9	0.6
0585	4.00	4.65	4	25°20′.0	-23°02′.5	25°17′.9	-23°02′.6	2.0	0.1
0539	3.73	4.08	3	22°59′.2	-12°16′.3	22°56′.8	-12°20′.3	2.3	4.0
0402	3.60	3.92	3	16°04′.4	-10°14′.8	16°01′.5	-10°16′.0	2.9	1.2
0334	3.45	3.80	3	12°08′.8	-12°16′.6	12°07′.8	-12°19′.0	1.0	2.4
0074	3.56	3.89	3	359°48′.6	-11°01′.1	359°46′.2	-11°02′.4	2.4	1.4
0188	2.04	2.57	2	5°51′.4	-20°12′.0	5°52′.6	-20°11′.3	-1.1	-0.7
0996	4.83	5.06	5	44°39′.5	1°52′.6	44°37′.9	1°51′.0	1.6	1.6
0531	4.67	5.04	5	22°27′.3	-14°14′.2	22°30′.1	-12°41′.5	-2.8	-92.7
0754	4.86	5.08	4	33°45′.7	3°50′.0	33°45′.5	3°48′.4	0.2	1.6
1879	3.49	3.69	4	78°21′.2	9°36′.8	78°18′.1	9°35′.3	3.1	1.5
1876	4.41	4.61	5	78°18′.7	9°08′.5	78°14′.4	9°08′.5	4.2	0.1
1907	4.09	4.28	5	78°46′.0	9°00′.2	78°45′.4	8°59′.7	0.5	0.5
2061	0.50	0.69	2	83°24′.9	7°16′.1	83°24′.0	7°15′.3	0.9	0.9
1790	1.64	1.85	2	75°57′.0	5°55′.7	75°56′.7	5°54′.7	0.3	1.0
1839	4.20	4.41	5	77°20′.1	5°34′.6	77°22′.1	5°34′.0	-2.0	0.6
2124	4.12	4.32	4	85°11′.1	8°35′.5	85°06′.8	9°34′.0	4.3	-58.5
2241	5.04	5.23	6	88°30′.3	12°01′.0	88°30′.8	12°18′.1	-0.4	-17.1
2199	4.48	4.66	4	87°20′.6	14°15′.1	87°19′.0	14°13′.0	1.6	2.0
2159	4.42	4.60	4	86°16′.2	14°44′.7	86°12′.1	14°44′.0	3.9	0.6
2198	4.95	5.13	6	87°16′.8	16°09′.5	87°15′.9	16°08′.2	0.9	1.3
2223	5.30	5.48	6	88°04′.8	16°11′.8	88°06′.3	16°11′.0	-1.4	0.8
2047	4.41	4.58	5	82°42′.8	20°08′.6	82°41′.8	20°07′.0	0.9	1.5

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
85°21′.5	-3°21′.0	85°21′.2	-3°20′.9	0.3	-0.1		62χ2 Ori	851
78°56′.5	-19°17′.5	78°56′.1	-19°16′.3	0.3	-1.2		47ω Ori	852
77°40′.0	-19°36′.5	77°37′.6	-19°34′.3	2.3	-2.2		38n2 Ori	853
76°46′.0	-19°52′.5	76°47′.6	-20°00′.6	-1.5	8.1	h	33n1 Ori	854
75°34′.0	-20°08′.5	75°36′.7	-20°08′.5	-2.6	0.0		30ψ2 Ori	855
67°53′.0	-8°17′.0	67°55′.4	-8°16′.3	-2.4	-0.7		4o1 Ori	856
68°48′.0	-9°07′.0	68°47′.0	-9°06′.7	1.0	-0.3		9o2 Ori	857
68°10′.0	-11°06′.0	68°08′.8	-11°09′.0	1.2	3.0		6g Ori	858
68°00′.5	-12°25′.5	68°01′.3	-12°24′.2	-0.8	-1.3		7π1 Ori	859
66°49′.0	-13°31′.5	66°47′.8	-13°31′.9	1.2	0.4		2π2 Ori	860
66°23′.0	-15°27′.0	66°18′.0	-15°25′.8	4.8	-1.2		1π3 Ori	861
66°33′.0	-16°50′.0	66°31′.8	-16°49′.4	1.1	-0.6		3π4 Ori	862
66°58′.0	-20°02′.0	66°55′.2	-20°03′.4	2.7	1.4		8π5 Ori	863
67°57′.0	-20°55′.5	67°58′.0	-20°54′.1	-1.0	-1.4		10π6 Ori	864
76°50′.5	-23°38′.0	76°47′.6	-23°36′.3	2.6	-1.7		34δ Ori	865
77°54′.0	-24°33′.5	77°53′.7	-24°33′.5	0.2	0.0		46ϵ Ori	866
79°06′.5	-25°21′.5	79°06′.8	-25°20′.7	-0.3	-0.8		50ζ Ori	867
74°37′.5	-25°36′.5	74°35′.3	-25°35′.1	2.0	-1.4		28η Ori	868
77°28′.0	-28°09′.5	77°33′.0	-28°12′.2	-4.4	2.7		45 Ori	869
77°24′.5	-28°45′.0	77°24′.8	-28°43′.9	-0.2	-1.1		41-43θ Ori	870
77°27′.5	-29°17′.0	77°25′.7	-29°15′.2	1.5	-1.9		44ι Ori	871
76°20′.0	-30°37′.5	76°20′.6	-30°35′.7	-0.5	-1.8		36υ Ori	872
78°23′.0	-30°38′.0	78°21′.0	-30°35′.2	1.7	-2.8		49d Ori	873
71°17′.0	-31°11′.5	71°15′.5	-31°10′.4	1.3	-1.1		19β Ori	874
72°15′.5	-29°53′.0	72°16′.7	-29°53′.3	-1.0	0.3		20τ Ori	875
74°02′.0	-31°00′.0	74°00′.5	-30°58′.1	1.3	-1.9		29e Ori	876
80°49′.5	-33°08′.0	80°49′.9	-33°07′.3	-0.4	-0.7		53κ Ori	877
78°39′.0	-26°00′.5	78°31′.7	-25°59′.0	6.6	-1.5		48σ Ori	878
74°34′.0	-19°40′.0	74°35′.0	-19°37′.8	-0.9	-2.2		23m Ori	879
74°45′.0	-24°06′.0	74°42′.1	-24°05′.9	2.7	-0.1		27p Ori	880
73°59′.0	-23°32′.0	74°00′.0	-23°31′.7	-0.9	-0.3		22o Ori	881
74°57′.0	-21°23′.0	74°58′.2	-21°21′.4	-1.2	-1.6		25ψ1 Ori	882
71°58′.0	-20°08′.0	72°00′.1	-20°07′.6	-2.0	-0.4		17ρ Ori	883
79°45′.0	-21°58′.0	79°43′.1	-21°56′.6	1.7	-1.4		51b Ori	884
82°25′.5	-21°39′.0	82°24′.2	-21°37′.3	1.2	-1.7		56 Ori	885
84°10′.0	-22°57′.0	84°07′.0	-22°56′.3	2.7	-0.7		60 Ori	886
73°36′.5	-11°45′.0	73°26′.1	-11°43′.8	10.1	-1.2		18 Ori	887
71°33′.5	-13°08′.0	71°36′.5	-13°05′.9	-2.9	-2.1		16h Ori	888
71°00′.0	-14°24′.0	71°07′.4	-14°23′.1	-7.1	-0.9		14i Ori	889
88°44′.0	-29°41′.0	88°41′.2	-29°42′.5	2.4	1.5	r	5γ Mon	890
92°43′.0	-29°49′.0	92°43′.6	-30°19′.0	-0.5	30.0		11β Mon	891
92°22′.0	-28°04′.0	92°20′.1	-28°03′.7	1.7	-0.3		10 Mon	892
91°08′.0	-18°47′.0	90°41′.6	-18°46′.2	25.0	-0.8		8ϵ Mon	893
92°58′.0	-15°56′.5	92°55′.2	-15°54′.9	2.7	-1.6		13 Mon	894
94°50′.0	-13°15′.0	94°48′.1	-13°13′.5	1.8	-1.5		15 Mon	895
92°58′.0	-18°24′.0	92°55′.5	-18°23′.8	2.3	-0.2		12 Mon	896
96°36′.0	-14°59′.0	96°34′.1	-14°57′.2	1.8	-1.8		17 Mon	897
97°14′.5	-20°33′.0	97°13′.0	-20°32′.8	1.4	-0.2		18 Mon	898
104°00′.0	-22°47′.0	103°58′.7	-22°46′.2	1.2	-0.8		22δ Mon	899
69°40′.0	-31°35′.5	69°38′.4	-31°35′.6	1.3	0.1		69λ Eri	900

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	*m*	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
2135	4.63	4.80	5	85°03′.9	20°05′.7	85°03′.7	20°03′.7	0.2	2.0
1934	4.57	4.79	5	79°32′.8	3°49′.9	79°32′.4	3°49′.1	0.4	0.8
1872	5.36	5.58	6	78°22′.3	3°25′.1	78°19′.8	3°25′.2	2.4	-0.0
1842	5.46	5.69	6	77°33′.0	3°04′.7	77°35′.2	2°54′.8	-2.2	9.9
1811	4.59	4.82	5	76°27′.1	2°42′.3	76°29′.7	2°40′.5	-2.6	1.7
1556	4.74	4.91	4	67°28′.1	13°31′.4	67°30′.7	13°30′.5	-2.5	0.8
1580	4.07	4.25	4	68°31′.1	12°50′.2	68°30′.2	12°48′.4	0.8	1.7
1569	5.19	5.38	6	68°11′.5	10°46′.9	68°10′.9	10°41′.9	0.6	5.0
1570	4.65	4.85	4	68°14′.4	9°26′.9	68°15′.1	9°26′.5	-0.7	0.4
1544	4.36	4.56	4	67°15′.1	8°10′.9	67°14′.1	8°08′.5	1.0	2.4
1543	3.19	3.40	4	67°08′.6	6°12′.9	67°03′.8	6°11′.4	4.8	1.5
1552	3.69	3.91	4	67°31′.5	4°52′.5	67°30′.3	4°51′.0	1.2	1.4
1567	3.72	3.95	4	68°25′.3	1°46′.6	68°22′.9	1°43′.0	2.4	3.7
1601	4.47	4.70	4	69°28′.1	1°02′.2	69°28′.9	1°01′.8	-0.8	0.4
1851	2.21	2.46	2	77°57′.7	-0°39′.5	77°54′.9	-0°40′.0	2.8	0.5
1903	1.70	1.95	2	79°00′.3	-1°29′.7	79°00′.1	-1°31′.8	0.3	2.0
1948	1.91	2.17	2	80°09′.7	-2°12′.4	80°09′.9	-2°13′.5	-0.2	1.2
1788	3.36	3.62	3	76°09′.0	-2°49′.3	76°06′.8	-2°50′.2	2.2	0.8
1901	5.26	5.54	5	78°55′.5	-5°06′.9	79°00′.1	-5°11′.2	-4.6	4.3
1893	4.46	4.74	3	78°55′.5	-5°42′.6	78°55′.6	-5°43′.4	-0.1	0.8
1899	2.77	3.06	3	79°01′.0	-6°14′.2	78°59′.2	-6°14′.5	1.7	0.3
1855	4.62	4.93	4	78°09′.7	-7°39′.7	78°10′.0	-7°39′.9	-0.3	0.2
1937	4.80	5.10	5	79°56′.1	-7°30′.9	79°54′.1	-7°30′.3	2.0	-0.6
1713	0.12	0.44	1	73°52′.6	-8°42′.7	73°51′.1	-8°43′.8	1.5	1.1
1735	3.60	3.90	4	74°33′.1	-7°18′.5	74°34′.1	-7°20′.6	-1.0	2.2
1784	4.14	4.44	5	76°13′.0	-8°14′.3	76°11′.4	-8°14′.6	1.6	0.3
2004	2.06	2.39	3	82°12′.7	-9°51′.4	82°12′.9	-9°52′.8	-0.3	1.3
1931	3.81	4.07	4	79°48′.0	-2°53′.1	79°41′.3	-2°54′.1	6.7	1.0
1770	5.00	5.23	6	75°28′.0	3°04′.8	75°28′.7	3°05′.2	-0.7	-0.3
1787	5.08	5.32	6	76°06′.2	-1°18′.6	76°03′.6	-1°20′.8	2.7	2.1
1765	4.73	4.98	5	75°20′.7	-0°49′.3	75°21′.6	-0°50′.9	-0.8	1.6
1789	4.95	5.18	5	76°00′.2	1°24′.7	76°01′.2	1°24′.4	-1.0	0.2
1698	4.46	4.68	4	73°05′.3	2°20′.1	73°07′.2	2°18′.8	-1.9	1.3
1963	4.91	5.14	5	80°29′.9	1°13′.2	80°28′.1	1°12′.4	1.8	0.8
2037	4.78	5.00	5	82°57′.5	1°41′.4	82°56′.3	1°41′.0	1.3	0.4
2103	5.22	5.46	5	84°37′.8	0°28′.0	84°35′.0	0°26′.5	2.8	1.4
1718	5.50	5.69	6	73°39′.7	10°50′.8	73°29′.4	10°48′.9	10.1	2.0
1672	5.43	5.63	6	71°48′.8	9°13′.9	71°51′.6	9°14′.4	-2.7	-0.5
1664	5.34	5.54	6	71°26′.2	7°54′.3	71°33′.3	7°54′.1	-7.0	0.1
2227	3.98	4.26	4	88°53′.6	-6°09′.8	88°51′.2	-6°13′.4	2.4	3.6
2356	3.92	4.22	4	92°22′.3	-6°18′.8	92°22′.2	-6°50′.8	0.0	32.0
2344	5.06	5.34	5	92°05′.7	-4°33′.5	92°04′.0	-4°35′.2	1.7	1.7
2298	4.31	4.53	4	91°04′.6	4°44′.2	90°39′.5	4°43′.2	25.0	1.1
2385	4.50	4.70	4	92°52′.6	7°33′.2	92°49′.9	7°32′.9	2.7	0.3
2456	4.66	4.86	4	94°46′.8	10°11′.7	94°44′.9	10°11′.2	1.8	0.5
2382	5.84	6.05	5	92°49′.6	5°05′.7	92°47′.2	5°04′.0	2.3	1.7
2503	4.77	4.96	5	96°26′.6	8°23′.6	96°24′.8	8°23′.5	1.8	0.2
2506	4.47	4.69	4	96°47′.2	2°48′.2	96°45′.8	2°46′.5	1.4	1.7
2714	4.15	4.39	4	102°53′.3	0°06′.9	102°52′.1	0°05′.9	1.2	1.1
1679	4.27	4.59	4	72°32′.8	-9°17′.7	72°31′.4	-9°19′.9	1.4	2.3

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
69°42′.0	-27°54′.5	69°43′.0	-27°54′.3	-0.9	-0.2		67β Eri	901
67°39′.0	-29°52′.0	67°38′.1	-29°48′.9	0.8	-3.1		65ψ Eri	902
65°29′.5	-27°51′.5	65°28′.5	-27°50′.9	0.9	-0.6		61ω Eri	903
63°45′.5	-25°34′.0	63°45′.7	-25°25′.0	-0.1	-9.0		57μ Eri	904
61°14′.5	-25°11′.5	61°14′.4	-25°10′.4	0.1	-1.1		48ν Eri	905
48°18′.0	-33°13′.5	48°16′.7	-33°14′.0	1.1	0.5		34γ Eri	906
45°22′.5	-31°09′.0	45°22′.3	-31°10′.0	0.2	1.0		26π Eri	907
45°17′.0	-28°46′.5	45°15′.9	-28°48′.1	0.9	1.6	r	23δ Eri	908
42°45′.0	-27°47′.0	42°42′.1	-27°47′.3	2.6	0.3		18ϵ Eri	909
33°10′.0	-24°34′.0	33°09′.9	-24°33′.4	0.1	-0.6		3η Eri	910
35°36′.0	-23°58′.5	35°37′.4	-23°56′.8	-1.3	-1.7		10ρ3 Eri	911
38°16′.0	-25°59′.0	38°14′.6	-25°58′.0	1.3	-1.0		13ζ Eri	912
45°23′.0	-31°09′.0	45°22′.3	-31°10′.0	0.6	1.0		26π Eri	913
53°49′.0	-30°25′.0	53°45′.4	-30°57′.4	3.1	32.4		39A Eri	914
53°53′.0	-27°32′.0	53°51′.0	-27°30′.6	1.7	-1.4		38ο1 Eri	915
54°58′.0	-28°09′.5	54°58′.0	-28°09′.0	0.0	-0.5		40ο2 Eri	916
57°46′.0	-25°03′.0	57°44′.5	-25°01′.5	1.4	-1.5		42ξ Eri	917
46°25′.5	-18°26′.0	46°24′.9	-18°26′.1	0.5	0.1		10 Tau	918
50°07′.0	-22°45′.0	50°02′.9	-22°46′.0	3.8	1.0		32 Eri	919
70°14′.5	-34°34′.0	70°10′.8	-34°46′.2	3.0	12.2		3ι Lep	920
70°20′.5	-35°54′.0	70°20′.0	-35°51′.7	0.4	-2.3		4κ Lep	921
72°27′.0	-35°18′.0	72°25′.2	-35°23′.5	1.4	5.5		7ν Lep	922
72°14′.0	-36°14′.0	72°12′.4	-36°14′.4	1.3	0.4		6λ Lep	923
69°49′.0	-39°04′.0	69°48′.9	-39°05′.9	0.1	1.9		5μ Lep	924
66°25′.5	-45°00′.0	66°28′.5	-45°00′.4	-2.1	0.4		2ϵ Lep	925
75°49′.5	-41°05′.5	75°48′.6	-41°06′.6	0.7	1.1		11α Lep	926
74°06′.5	-43°57′.5	74°06′.1	-43°57′.4	0.3	-0.1		9β Lep	927
79°21′.5	-45°49′.5	79°19′.6	-45°49′.8	1.3	0.3		13γ Lep	928
81°36′.0	-44°18′.0	81°34′.1	-44°16′.6	1.3	-1.4		15δ Lep	929
80°26′.5	-38°16′.0	80°25′.3	-38°16′.1	0.9	0.1		14ζ Lep	930
83°27′.5	-37°40′.5	83°20′.5	-37°40′.3	5.6	-0.2		16η Lep	931
86°22′.0	-38°26′.0	86°20′.2	-38°25′.1	1.4	-0.9		18θ Lep	932
98°35′.5	-39°30′.0	98°35′.4	-39°31′.0	0.1	1.0		9α CMa	933
101°01′.5	-34°50′.0	100°38′.9	-34°45′.9	18.6	-4.1		14θ CMa	934
101°27′.0	-36°43′.0	101°29′.5	-36°42′.3	-2.0	-0.7		18μ CMa	935
104°06′.0	-38°02′.5	104°03′.4	-38°02′.4	2.0	-0.1		23γ CMa	936
102°03′.0	-39°30′.0	101°58′.3	-39°41′.6	3.6	11.6		20ι CMa	937
96°32′.5	-42°12′.5	96°27′.2	-41°19′.9	4.0	-52.6	h	8ν3 CMa	938
91°42′.5	-41°18′.5	91°37′.9	-41°18′.3	3.5	-0.2		2β CMa	939
105°30′.5	-46°09′.5	105°27′.6	-46°10′.6	2.0	1.1		24ο2 CMa	940
102°36′.5	-46°39′.5	102°37′.0	-46°49′.4	-0.3	9.9		16ο1 CMa	941
107°55′.0	-48°30′.0	107°51′.4	-48°30′.0	2.4	-0.0		25δ CMa	942
105°21′.5	-51°24′.5	105°13′.4	-51°24′.5	5.1	-0.0		21ϵ CMa	943
91°07′.0	-51°46′.5	91°49′.4	-53°25′.5	-25.3	99.0		1ζ CMa	944
114°11′.5	-50°41′.3	114°00′.3	-50°39′.1	7.1	-2.2		31η CMa	945
106°39′.5	-13°33′.5	106°38′.1	-13°31′.7	1.4	-1.8		3β CMi	946
110°18′.5	-15°57′.0	110°17′.2	-15°56′.4	1.3	-0.6		10α CMi	947
106°49′.0	-12°51′.0	106°47′.5	-12°52′.1	1.5	1.1		4γ CMi	948
106°42′.5	-9°46′.0	106°42′.3	-9°45′.5	0.2	-0.5		6 CMi	949
110°57′.5	-10°19′.5	110°57′.6	-10°18′.0	-0.1	-1.5		11π CMi	950

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
1666	2.79	3.07	3	72°03′.4	-5°38′.6	72°04′.2	-5°40′.2	-0.8	1.6
1617	4.81	5.12	5	70°33′.4	-7°50′.6	70°32′.1	-7°49′.6	1.3	-1.0
1560	4.39	4.68	5	68°21′.2	-6°09′.8	68°20′.1	-6°11′.2	1.1	1.4
1520	4.02	4.29	4	66°25′.6	-4°10′.3	66°24′.1	-4°03′.2	1.5	-7.0
1463	3.93	4.20	4	64°07′.0	-4°13′.4	64°06′.6	-4°14′.1	0.4	0.7
1231	2.95	3.34	3	54°53′.1	-14°39′.6	54°51′.9	-14°42′.0	1.2	2.4
1162	4.42	4.78	4	51°50′.2	-13°21′.9	51°50′.0	-13°24′.5	0.2	2.6
1136	3.54	3.88	3	51°03′.6	-11°06′.8	51°02′.9	-11°10′.2	0.7	3.4
1084	3.73	4.06	3	48°35′.5	-10°49′.0	48°32′.8	-10°51′.7	2.6	2.6
0874	3.89	4.22	3	39°15′.4	-10°31′.3	39°14′.8	-10°32′.0	0.6	0.8
0925	5.26	5.58	4	41°10′.6	-9°13′.3	41°11′.0	-9°12′.7	-0.4	-0.6
0984	4.80	5.13	3	44°09′.5	-10°20′.4	44°07′.6	-10°21′.2	1.8	0.8
1162	4.42	4.78	4	51°50′.6	-13°21′.8	51°50′.0	-13°24′.5	0.6	2.7
1318	4.87	5.21	5	58°47′.3	-10°44′.5	58°52′.0	-11°18′.5	-4.5	34.0
1298	4.04	4.34	4	58°08′.9	-7°55′.7	58°06′.7	-7°56′.4	2.2	0.7
1325	4.44	4.74	4	59°14′.2	-8°18′.6	59°14′.0	-8°19′.9	0.3	1.3
1383	5.17	5.45	5	60°59′.9	-4°43′.4	60°58′.1	-4°44′.0	1.8	0.6
1101	4.28	4.52	4	49°09′.3	-0°53′.6	49°08′.8	-0°55′.4	0.5	1.8
1211	4.51	4.78	4	53°38′.3	-4°08′.1	53°34′.8	-4°11′.7	3.5	3.6
1696	4.45	4.82	5	73°27′.3	-12°10′.4	73°25′.8	-12°24′.9	1.4	14.4
1705	4.36	4.74	5	73°43′.6	-13°29′.0	73°42′.7	-13°28′.7	0.9	-0.3
1757	5.30	5.67	6	75°23′.4	-12°39′.8	75°22′.5	-12°47′.4	0.9	7.6
1756	4.29	4.68	5	75°19′.8	-13°36′.7	75°18′.4	-13°39′.2	1.4	2.5
1702	3.31	3.76	5	73°45′.7	-16°40′.6	73°45′.7	-16°44′.4	-0.0	3.8
1654	3.19	3.84	4	72°07′.0	-22°56′.0	72°09′.1	-22°58′.0	-1.9	2.0
1865	2.58	3.06	3	78°48′.2	-18°07′.1	78°47′.4	-18°10′.2	0.7	3.2
1829	2.84	3.42	3	77°48′.2	-21°06′.4	77°47′.7	-21°08′.3	0.4	1.9
1983	3.60	4.25	3	81°59′.3	-22°35′.8	81°57′.8	-22°38′.3	1.4	2.5
2035	3.81	4.37	3	83°34′.3	-20°57′.8	83°32′.7	-20°58′.5	1.5	0.7
1998	3.55	3.96	4	82°14′.6	-15°00′.0	82°13′.6	-15°02′.1	1.0	2.2
2085	3.71	4.10	4	84°39′.7	-14°16′.3	84°33′.9	-14°18′.3	5.6	2.0
2155	4.67	5.08	4	87°03′.3	-14°56′.7	87°01′.8	-14°57′.9	1.5	1.1
2491	-1.46	-1.02	1	96°53′.6	-16°10′.9	96°53′.5	-16°13′.8	0.1	3.0
2574	4.07	4.41	4	99°13′.4	-11°39′.7	98°54′.9	-11°36′.2	18.1	-3.5
2593	5.00	5.37	5	99°25′.3	-13°34′.0	99°27′.5	-13°35′.5	-2.1	1.5
2657	4.12	4.53	3	101°27′.7	-15°04′.7	101°25′.7	-15°06′.4	1.9	1.7
2596	4.37	4.82	4	99°40′.0	-16°22′.8	99°35′.3	-16°36′.0	4.5	13.2
2443	4.43	4.89	5	95°06′.9	-18°48′.0	95°05′.4	-17°57′.3	1.4	-50.7
2294	1.98	2.46	2	91°20′.9	-17°47′.5	91°17′.2	-17°49′.2	3.5	1.8
2653	3.02	3.72	5	101°37′.8	-23°15′.6	101°35′.6	-23°18′.5	2.0	2.9
2580	3.87	4.55	5	99°24′.3	-23°32′.7	99°23′.8	-23°44′.6	0.5	11.9
2693	1.84	2.70	3	103°05′.1	-25°47′.3	103°02′.7	-25°49′.0	2.1	1.6
2618	1.50	2.71	3	100°49′.9	-28°27′.7	100°44′.4	-28°29′.0	4.8	1.4
2282	3.02	4.53	3	90°47′.1	-28°15′.2	91°15′.2	-29°56′.5	-24.4	101.3
2827	2.45	3.68	3	107°12′.0	-28°36′.2	107°04′.9	-28°34′.7	6.3	-1.5
2845	2.90	3.10	3	106°23′.4	9°01′.2	106°22′.1	9°01′.2	1.2	0.0
2943	0.38	0.59	2	109°36′.8	6°11′.9	109°35′.5	6°10′.8	1.3	1.1
2854	4.32	4.51	6	106°37′.7	9°42′.4	106°36′.0	9°39′.6	1.7	2.8
2864	4.54	4.72	6	106°53′.4	12°46′.8	106°53′.1	12°45′.4	0.3	1.4
3008	5.30	5.49	5	111°03′.6	11°40′.5	111°03′.7	11°40′.1	-0.2	0.4

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
125°53′.5	-43°18′.5	125°52′.3	-43°18′.5	0.9	0.0		15ρ Pup	951
120°35′.5	-44°58′.5	120°30′.5	-44°58′.7	3.5	0.2		7ξ Pup	952
118°00′.0	-47°28′.0	117°55′.7	-47°27′.4	2.9	-0.6		k Pup	953
123°06′.5	-32°07′.0	123°01′.5	-32°07′.0	4.3	-0.0	r	19 Pup	954
124°27′.0	-38°31′.0	124°25′.3	-38°21′.1	1.4	-9.9		16 Pup	955
132°26′.5	-32°56′.0	132°25′.0	-32°55′.2	1.3	-0.8		9 Hya	956
132°51′.5	-30°18′.0	132°48′.6	-30°18′.3	2.5	0.3		12 Hya	957
130°01′.5	-24°29′.0	129°59′.4	-24°28′.3	1.9	-0.7		F Hya	958
119°26′.0	-21°39′.0	119°35′.2	-22°37′.6	-8.4	58.6	r	29ζ Mon	959
124°20′.5	-22°29′.5	124°18′.5	-22°28′.9	1.9	-0.6	r	C Hya	960
113°44′.0	-30°30′.0	113°44′.4	-30°29′.6	-0.3	-0.4	r	26α Mon	961
125°39′.5	-14°37′.0	125°39′.2	-14°38′.2	0.3	1.2		5σ Hya	962
126°46′.0	-14°16′.5	126°44′.9	-14°17′.1	1.1	0.6		7η Hya	963
126°48′.0	-11°08′.0	126°48′.3	-11°07′.7	-0.2	-0.3		11ϵ Hya	964
127°22′.5	-11°36′.0	127°21′.1	-11°35′.0	1.4	-1.0		13ρ Hya	965
129°00′.5	-11°01′.0	129°01′.6	-11°00′.1	-1.1	-0.9		16ζ Hya	966
131°51′.5	-11°05′.5	131°50′.2	-11°03′.7	1.3	-1.8		18ω Hya	967
134°41′.5	-13°05′.0	134°42′.4	-13°03′.2	-0.9	-1.8		22θ Hya	968
140°11′.5	-15°00′.0	140°11′.0	-14°59′.7	0.5	-0.3		32τ2 Hya	969
142°04′.0	-14°17′.5	142°04′.7	-14°17′.8	-0.7	0.3		35ι Hya	970
139°53′.5	-16°46′.0	140°00′.9	-16°43′.8	-7.1	-2.2	f	31τ1 Hya	971
141°45′.5	-22°24′.0	141°44′.0	-22°24′.6	1.4	0.6		30α Hya	972
147°12′.0	-26°33′.5	147°08′.2	-26°37′.0	3.4	3.5		38κ Hya	973
150°09′.0	-26°12′.0	150°08′.7	-26°05′.6	0.3	-6.4		39υ1 Hya	974
152°48′.0	-23°13′.0	152°47′.0	-23°11′.6	0.9	-1.4		40υ2 Hya	975
153°51′.0	-21°58′.0	153°50′.3	-22°00′.6	0.7	2.6		41λ Hya	976
159°31′.5	-24°38′.0	159°30′.2	-24°40′.0	1.2	2.0		42μ Hya	977
162°31′.5	-23°31′.0	162°31′.0	-23°30′.3	0.5	-0.7	r	ϕ3 Hya	978
164°51′.0	-21°48′.5	164°49′.2	-21°49′.6	1.7	1.1		ν Hya	979
124°45′.5	-12°27′.0	124°45′.1	-12°25′.6	0.4	-1.4		4δ Hya	980
173°01′.5	-25°36′.0	173°00′.4	-25°37′.5	1.0	1.5		11β Crt	981
173°49′.0	-30°17′.0	173°48′.3	-30°16′.1	0.6	-0.9		χ1 Hya	982
201°24′.5	-13°43′.0	201°27′.4	-13°43′.3	-2.8	0.3		46γ Hya	983
199°24′.0	-14°37′.0	199°17′.2	-14°32′.7	6.6	-4.3		45ψ Hya	984
118°44′.0	-10°19′.0	118°42′.0	-10°19′.3	2.0	0.3		17β Cnc	985
168°13′.0	-22°41′.0	168°12′.1	-22°42′.6	0.9	1.6		7α Crt	986
173°43′.0	-19°39′.0	173°41′.8	-19°39′.5	1.2	0.5		15γ Crt	987
171°10′.5	-17°25′.0	171°09′.6	-17°35′.2	0.9	10.2		12δ Crt	988
170°41′.0	-13°30′.0	170°41′.8	-13°28′.2	-0.8	-1.8		14ϵ Crt	989
173°02′.0	-11°17′.0	173°02′.5	-11°17′.9	-0.5	0.9		21θ Crt	990
178°30′.0	-18°16′.0	178°30′.9	-18°17′.2	-0.8	1.2		27ζ Crt	991
180°33′.0	-16°02′.0	180°33′.0	-16°04′.7	-0.0	2.7		30η Crt	992
174°55′.0	-14°09′.0	174°54′.2	-14°13′.5	0.7	4.5		24ι Crt	993
186°08′.0	-19°39′.0	186°07′.4	-19°39′.4	0.5	0.4		2ϵ Crv	994
185°13′.0	-14°25′.0	185°11′.3	-14°28′.9	1.6	3.9		4γ Crv	995
187°55′.0	-12°07′.0	187°54′.6	-12°09′.4	0.4	2.4		7δ Crv	996
191°49′.0	-17°59′.0	191°48′.8	-18°01′.2	0.2	2.2		9β Crv	997
186°38′.0	-21°46′.0	186°41′.1	-21°44′.1	-2.9	-1.9		1α Crv	998
188°14′.0	-18°14′.0	188°15′.5	-18°16′.2	-1.5	2.2		5ζ Crv	999
188°21′.5	-11°38′.0	188°18′.0	-11°38′.9	3.5	0.9	r	8η Crv	1000

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
3185	2.81	3.49	3	117°39′.0	-23°10′.8	117°38′.4	-23°12′.4	0.5	1.6
3045	3.34	4.05	3	113°11′.3	-23°53′.4	113°07′.8	-23°54′.7	3.1	1.3
2948	3.81	4.70	3	110°40′.0	-25°56′.3	110°37′.3	-25°56′.9	2.4	0.7
3211	4.72	5.07	4	118°12′.2	-11°47′.2	118°08′.1	-11°48′.1	4.0	0.8
3192	4.40	4.89	4	117°46′.9	-18°16′.0	117°48′.3	-18°07′.9	-1.3	-8.1
3441	4.88	5.27	6	125°48′.9	-14°33′.1	125°48′.2	-14°33′.7	0.7	0.6
3484	4.32	4.67	4	126°55′.0	-12°07′.2	126°52′.8	-12°08′.4	2.2	1.2
3459	4.62	4.90	4	126°02′.4	-5°50′.6	126°00′.8	-5°51′.1	1.6	0.5
3188	4.34	4.59	4	117°10′.8	-0°52′.1	117°07′.7	-1°53′.0	3.2	60.9
3314	3.90	4.16	3	121°27′.1	-2°39′.1	121°25′.4	-2°39′.8	1.7	0.7
2970	3.93	4.24	3	110°32′.1	-8°39′.4	110°32′.6	-8°41′.0	-0.5	1.5
3418	4.44	4.65	5	124°28′.4	4°43′.7	124°27′.7	4°41′.0	0.6	2.7
3454	4.30	4.52	4	125°36′.0	4°48′.4	125°34′.7	4°46′.4	1.3	2.0
3482	3.38	3.58	4	126°23′.5	7°50′.9	126°23′.7	7°49′.5	-0.1	1.4
3492	4.36	4.57	5	126°49′.8	7°15′.5	126°48′.5	7°15′.2	1.3	0.3
3547	3.11	3.31	4	128°32′.4	7°25′.5	128°33′.5	7°24′.5	-1.1	1.0
3613	4.97	5.17	6	131°14′.5	6°37′.4	131°13′.5	6°38′.0	0.9	-0.6
3665	3.88	4.10	4	133°22′.0	3°56′.8	133°23′.2	3°56′.8	-1.2	0.0
3787	4.57	4.81	5	137°54′.4	0°32′.8	137°54′.0	0°31′.8	0.4	1.0
3845	3.91	4.14	4	139°51′.0	0°39′.3	139°51′.6	0°37′.5	-0.5	1.8
3759	4.60	4.85	5	137°05′.5	-1°02′.9	137°12′.9	-1°04′.3	-7.5	1.4
3748	1.98	2.26	1	137°00′.8	-6°56′.9	136°59′.5	-6°58′.4	1.3	1.5
3849	5.06	5.43	4	140°22′.0	-12°30′.4	140°17′.8	-12°33′.8	4.1	3.4
3903	4.12	4.49	5	143°02′.1	-13°05′.7	143°04′.5	-13°00′.8	-2.4	-4.9
3970	4.60	4.95	5	146°25′.6	-11°10′.4	146°25′.6	-11°09′.9	0.0	-0.5
3994	3.61	3.94	4	147°48′.5	-10°21′.6	147°47′.2	-10°24′.9	1.3	3.3
4094	3.81	4.20	4	151°43′.9	-14°47′.3	151°42′.5	-14°49′.7	1.4	2.4
4171	4.91	5.31	5	154°47′.5	-14°49′.8	154°47′.8	-14°49′.8	-0.3	0.0
4232	3.11	3.49	4	157°31′.4	-14°06′.6	157°29′.8	-14°07′.7	1.6	1.1
3410	4.16	4.37	4	124°07′.2	7°02′.3	124°07′.1	7°02′.1	0.2	0.2
4343	4.48	5.05	4	163°02′.8	-20°38′.3	163°01′.9	-20°39′.8	0.8	1.5
4314	4.94	5.75	5	161°32′.5	-25°09′.9	161°33′.2	-25°09′.5	-0.7	-0.5
5020	3.00	3.57	3	194°17′.8	-21°02′.2	194°21′.2	-21°03′.0	-3.2	0.8
4958	4.95	5.51	6	191°59′.9	-21°04′.8	191°56′.1	-20°57′.8	3.6	-7.0
3249	3.52	3.71	3	118°44′.4	10°22′.7	118°42′.1	10°21′.0	2.2	1.7
4287	4.08	4.50	4	160°06′.9	-16°09′.8	160°06′.0	-16°11′.6	0.9	1.8
4405	4.08	4.50	4	166°16′.2	-15°29′.8	166°15′.4	-15°30′.3	0.7	0.5
4382	3.56	3.92	4	164°56′.4	-12°28′.5	164°51′.8	-12°38′.0	4.5	9.5
4402	4.83	5.13	4	166°05′.8	-8°41′.8	166°07′.6	-8°41′.0	-1.7	-0.8
4468	4.70	5.00	4	169°07′.0	-7°34′.8	169°07′.3	-7°36′.3	-0.3	1.4
4514	4.73	5.15	4	171°08′.7	-16°06′.5	171°09′.5	-16°08′.3	-0.8	1.8
4567	5.18	5.59	4	173°57′.3	-14°53′.3	173°56′.7	-14°55′.9	0.6	2.7
4488	5.48	5.82	5	169°39′.1	-10°56′.6	169°37′.0	-11°00′.8	2.1	4.2
4630	3.00	3.54	4	177°26′.0	-20°23′.7	177°26′.1	-20°23′.9	-0.1	0.2
4662	2.59	3.01	3	178°53′.6	-15°16′.4	178°50′.9	-15°19′.4	2.5	3.0
4757	2.95	3.35	3	182°20′.8	-14°15′.2	182°20′.0	-14°17′.1	0.8	2.0
4786	2.65	3.23	3	183°24′.2	-21°09′.1	183°23′.8	-21°10′.8	0.4	1.8
4623	4.02	4.67	4	176°55′.1	-22°30′.5	176°59′.7	-22°30′.1	-4.2	-0.4
4696	5.21	5.76	5	179°59′.3	-19°56′.9	180°00′.5	-19°59′.6	-1.1	2.7
4775	4.31	4.70	5	182°57′.4	-13°59′.3	182°54′.3	-13°58′.6	3.0	-0.7

Table 21: Tycho's Catalog D, Explicit Ecliptical, 1601.03

λ_D	β_D	λ	β	$\Gamma\lambda$	$\Delta\beta$	x	Name	D
211°27′.0	-21°49′.0	212°28′.6	-21°33′.9	-57.3	-15.1	fm	2g Cen	1001
210°59′.0	-19°08′.0	212°14′.6	-18°56′.2	-71.5	-11.8	fm	4h Cen	1002
210°12′.0	-20°51′.0	211°10′.2	-20°32′.1	-54.5	-18.9	fm	1i Cen	1003
211°03′.0	-20°12′.0	212°22′.9	-20°01′.9	-75.0	-10.1	fm	3k Cen	1004

Table 21: Tycho's Catalog D, Implicit Equatorial, 1601.03

HR	m	μ	m	α_D	δ_D	α	δ	$\Gamma\alpha$	$\Delta\delta$
5192	4.19	6.47	5	200°28′.7	-32°16′.9	201°39′.2	-32°25′.3	-59.5	8.4
5221	4.73	6.23	5	201°15′.5	-29°38′.8	202°37′.6	-29°55′.2	-71.2	16.4
5168	4.23	6.02	5	199°41′.1	-30°55′.7	200°49′.2	-30°59′.5	-58.4	3.8
5210	4.32	6.13	5	200°50′.2	-30°39′.1	202°16′.2	-30°58′.7	-73.7	19.6

Table 22: Tycho's Select Stars, Implicit Ecliptical, 1601.03

λ_S	β_S	λ	β	$\Gamma\lambda$	$\Delta\beta$	Name	D	S
32°17′.7	46°35′.1	32°15′.2	46°35′.6	1.8	-0.5	α Cas	571	1
83°01′.6	66°01′.9	82°59′.4	66°03′.2	0.9	-1.4	α UMi	336	2
356°55′.6	-20°46′.8	356°58′.2	-20°46′.9	-2.4	0.2	β Cet	834	3
38°27′.4	48°45′.6	38°24′.0	48°46′.7	2.2	-1.1	γ Cas	573	4
24°48′.9	25°59′.6	24°50′.7	25°56′.0	-1.6	3.7	β And	802	5
42°20′.0	46°22′.2	42°21′.6	46°23′.1	-1.1	-0.9	δ Cas	574	6
27°36′.7	7°09′.1	27°37′.1	7°08′.8	-0.4	0.3	γ Ari	1	7
16°24′.9	-20°18′.6	16°21′.8	-20°21′.1	3.0	2.5	ζ Cet	830	8
28°23′.2	8°28′.7	28°24′.2	8°28′.2	-0.9	0.5	β Ari	2	9
38°40′.2	27°46′.3	38°40′.4	27°46′.5	-0.2	-0.1	γ And	805	10
23°48′.3	-9°04′.0	23°48′.1	-9°05′.3	0.3	1.3	α Psc	318	11
32°05′.7	9°57′.2	32°05′.2	9°57′.2	0.4	0.1	α Ari	3	12
38°47′.0	-12°38′.4	38°44′.9	-12°37′.0	2.0	-1.3	α Cet	818	13
50°37′.2	22°22′.3	50°36′.6	22°23′.0	0.6	-0.7	β Per	626	14
56°30′.2	30°03′.9	56°31′.4	30°04′.8	-1.0	-1.0	α Per	621	15
54°24′.0	4°00′.3	54°25′.5	4°00′.6	-1.5	-0.3	η Tau	53	16
60°11′.8	-5°46′.0	60°13′.5	-5°46′.6	-1.6	0.6	γ Tau	32	17
62°52′.8	-2°37′.5	62°53′.1	-2°36′.7	-0.4	-0.9	ϵ Tau	36	18
64°12′.5	-5°31′.4	64°13′.0	-5°29′.7	-0.5	-1.6	α Tau	35	19
76°16′.2	22°50′.5	76°17′.2	22°51′.6	-0.9	-1.1	α Aur	650	20
71°15′.7	-31°11′.6	71°15′.5	-31°10′.4	0.2	-1.2	β Ori	874	21
76°59′.4	5°20′.4	77°00′.4	5°21′.1	-0.9	-0.7	β Tau	42	22
75°24′.0	-16°53′.8	75°22′.8	-16°52′.0	1.2	-1.8	γ Ori	842	23
74°06′.4	-43°57′.1	74°06′.1	-43°57′.4	0.2	0.3	β Lep	927	24
76°50′.9	-23°37′.5	76°47′.6	-23°36′.3	3.0	-1.2	δ Ori	865	25
78°11′.2	-13°26′.8	78°08′.3	-13°25′.3	2.8	-1.5	λ Ori	838	26
79°11′.5	-2°14′.4	79°13′.0	-2°14′.7	-1.5	0.3	ζ Tau	40	27
77°54′.7	-24°33′.8	77°53′.7	-24°33′.5	0.9	-0.3	ϵ Ori	866	28
79°06′.9	-25°21′.2	79°06′.8	-25°20′.7	0.1	-0.5	ζ Ori	867	29
84°25′.1	21°27′.0	84°20′.9	21°27′.4	4.0	-0.3	β Aur	651	30
83°13′.1	-16°06′.2	83°11′.1	-16°04′.8	2.0	-1.4	α Ori	841	31
93°30′.3	-6°48′.8	93°32′.0	-6°47′.3	-1.7	-1.5	γ Gem	81	32
98°34′.7	-39°30′.2	98°35′.4	-39°31′.0	-0.5	0.8	α CMa	933	33
104°35′.9	10°01′.6	104°41′.2	10°03′.7	-5.2	-2.2	α Gem	65	34
110°18′.7	-15°56′.9	110°17′.2	-15°56′.4	1.5	-0.5	α CMi	947	35
107°43′.8	6°37′.9	107°42′.8	6°39′.3	1.0	-1.4	β Gem	66	36
125°53′.6	-43°18′.7	125°52′.3	-43°18′.5	1.0	-0.2	ρ Pup	951	37
121°46′.4	1°13′.7	121°46′.1	1°15′.3	0.2	-1.6	Praesepe	95	38
121°55′.9	3°07′.9	121°58′.7	3°09′.5	-2.8	-1.7	γ Cnc	98	39
123°07′.4	0°03′.3	123°09′.0	0°03′.8	-1.6	-0.5	δ Cnc	99	40
141°45′.7	-22°24′.0	141°44′.0	-22°24′.6	1.5	0.5	α Hya	972	41
142°19′.5	4°51′.3	142°20′.0	4°50′.5	-0.5	0.8	η Leo	116	42
144°17′.1	0°26′.9	144°17′.2	0°27′.1	-0.2	-0.2	α Leo	117	43
141°56′.9	11°49′.7	141°59′.1	11°50′.4	-2.2	-0.7	ζ Leo	114	44
143°58′.0	8°46′.7	144°00′.1	8°47′.7	-2.1	-1.0	γ Leo	115	45
133°43′.5	45°03′.8	133°49′.0	45°05′.7	-3.9	-1.9	β UMa	373	46
129°34′.5	49°39′.7	129°35′.6	49°39′.6	-0.7	0.1	α UMa	372	47
155°40′.8	14°19′.8	155°42′.9	14°19′.7	-2.1	0.2	δ Leo	129	48
166°03′.8	12°18′.3	166°05′.1	12°17′.8	-1.3	0.5	β Leo	136	49
144°44′.9	47°06′.5	144°50′.8	47°06′.7	-4.1	-0.2	γ UMa	375	50

Table 22: Tycho's Select Stars, Explicit Equatorial, 1601.03

HR	*m*	μ	m	α_S	δ_S	α	δ	$\Gamma\alpha$	$\Delta\delta$
0168	2.23	2.36	3	4°36′.0	54°21′.0	4°35′.9	54°20′.2	0.1	0.8
0424	2.02	2.18	2	5°47′.0	87°09′.5	5°56′.6	87°08′.7	-0.5	0.8
0188	2.04	2.57	2	5°51′.0	-20°12′.0	5°52′.6	-20°11′.3	-1.5	-0.7
0264	2.47	2.61	3	8°21′.0	58°33′.0	8°19′.6	58°32′.3	0.7	0.7
0337	2.06	2.20	2	11°50′.0	33°32′.0	11°55′.0	33°29′.0	-4.1	3.0
0403	2.68	2.82	3	15°03′.0	58°07′.0	15°06′.9	58°07′.8	-2.1	-0.8
0545	4.04	4.21	4	22°56′.0	17°19′.0	22°57′.0	17°18′.2	-0.9	0.8
0539	3.73	4.08	3	22°59′.0	-12°16′.0	22°56′.8	-12°20′.3	2.1	4.3
0553	2.64	2.81	4	23°10′.0	18°50′.0	23°11′.6	18°49′.3	-1.5	0.7
0603	2.16	2.30	2	24°55′.0	40°23′.0	24°56′.7	40°22′.3	-1.3	0.7
0595	3.94	4.18	3	25°22′.0	0°50′.0	25°22′.3	0°48′.0	-0.3	2.0
0617	2.00	2.16	3	26°13′.0	21°33′.0	26°13′.1	21°32′.1	-0.1	0.9
0911	2.53	2.75	2	40°25′.0	2°29′.0	40°22′.7	2°28′.3	2.3	0.7
0936	2.12	2.26	3	40°38′.0	39°22′.0	40°38′.3	39°21′.2	-0.2	0.8
1017	1.79	1.93	2	44°02′.0	48°22′.0	44°04′.6	48°21′.9	-1.7	0.1
1165	2.87	3.03	3	50°57′.0	22°49′.0	50°59′.1	22°48′.1	-1.9	0.9
1346	3.65	3.83	3	59°16′.0	14°37′.0	59°18′.0	14°35′.5	-1.9	1.5
1409	3.53	3.70	3	61°21′.0	18°14′.0	61°21′.5	18°13′.1	-0.5	0.9
1457	0.85	1.02	1	63°16′.5	15°38′.0	63°16′.9	15°37′.9	-0.4	0.1
1708	0.08	0.21	1	71°49′.0	45°30′.0	71°50′.7	45°29′.3	-1.2	0.7
1713	0.12	0.44	1	73°51′.5	-8°43′.0	73°51′.1	-8°43′.8	0.4	0.8
1791	1.65	1.80	2	75°16′.0	28°12′.0	75°17′.2	28°10′.9	-1.1	1.1
1790	1.64	1.85	2	75°58′.0	5°55′.0	75°56′.7	5°54′.7	1.3	0.3
1829	2.84	3.42	3	77°48′.0	-21°06′.0	77°47′.7	-21°08′.3	0.3	2.3
1851	2.21	2.46	2	77°58′.0	-0°39′.0	77°54′.9	-0°40′.0	3.1	1.0
1879	3.49	3.69	4	78°21′.0	9°36′.0	78°18′.1	9°35′.3	2.9	0.7
1910	3.00	3.17	3	78°26′.0	20°51′.0	78°27′.8	20°48′.8	-1.7	2.2
1903	1.70	1.95	2	79°01′.0	-1°30′.0	79°00′.1	-1°31′.8	0.9	1.8
1948	1.91	2.17	2	80°10′.0	-2°12′.0	80°09′.9	-2°13′.5	0.1	1.5
2088	1.90	2.04	2	82°40′.0	44°50′.0	82°34′.7	44°48′.1	3.8	1.9
2061	0.50	0.69	2	83°26′.0	7°16′.0	83°24′.0	7°15′.3	2.0	0.7
2421	1.93	2.11	2	93°38′.0	16°40′.0	93°39′.8	16°39′.4	-1.7	0.6
2491	-1.46	-1.02	1	96°53′.0	-16°11′.0	96°53′.5	-16°13′.8	-0.5	2.8
2890	1.58	1.73	2	107°09′.0	32°41′.0	107°15′.1	32°40′.6	-5.1	0.4
2943	0.38	0.59	2	109°37′.0	6°12′.0	109°35′.5	6°10′.8	1.5	1.2
2990	1.14	1.29	2	110°13′.0	28°55′.0	110°11′.7	28°54′.6	1.1	0.4
3185	2.81	3.49	3	117°39′.0	-23°11′.0	117°38′.4	-23°12′.4	0.5	1.4
3428	5.69	5.85	n	124°20′.0	21°02′.0	124°19′.7	21°02′.0	0.3	0.0
3449	4.66	4.82	4	124°58′.0	22°51′.0	125°00′.9	22°50′.3	-2.7	0.7
3461	3.94	4.10	4	125°27′.0	19°35′.0	125°28′.3	19°33′.5	-1.3	1.5
3748	1.98	2.26	1	137°01′.0	-6°57′.0	136°59′.5	-6°58′.4	1.5	1.4
3975	3.52	3.69	3	146°22′.0	18°42′.0	146°21′.8	18°40′.2	0.2	1.8
3982	1.35	1.53	1	146°45′.5	13°53′.5	146°45′.4	13°52′.8	0.1	0.7
4031	3.44	3.60	3	148°33′.0	25°23′.0	148°34′.9	25°22′.1	-1.7	0.9
4057	2.30	2.46	2	149°25′.5	21°50′.0	149°27′.4	21°49′.4	-1.8	0.6
4295	2.37	2.51	2	159°12′.0	58°31′.0	159°17′.1	58°29′.8	-2.7	1.2
4301	1.79	1.92	2	159°37′.0	63°54′.0	159°34′.3	63°52′.8	1.2	1.2
4357	2.56	2.72	2	163°10′.0	22°43′.0	163°11′.4	22°41′.6	-1.3	1.4
4534	2.14	2.32	1	172°09′.0	16°49′.0	172°09′.6	16°47′.9	-0.5	1.1
4554	2.44	2.58	2	173°03′.0	55°57′.0	173°06′.1	55°54′.6	-1.8	2.4

Table 22: Tycho's Select Stars, Implicit Ecliptical, 1601.03

λ_S	β_S	λ	β	$\Gamma\lambda$	$\Delta\beta$	Name	D	S
145°24′.3	51°36′.7	145°25′.4	51°37′.6	-0.7	-0.9	δ UMa	374	51
185°54′.9	8°41′.3	185°55′.9	8°39′.2	-1.0	2.1	δ Vir	159	52
153°11′.1	54°17′.3	153°16′.8	54°17′.8	-3.3	-0.4	ϵ UMa	381	53
184°23′.8	16°15′.0	184°23′.3	16°13′.7	0.5	1.3	ϵ Vir	162	54
198°15′.7	-1°59′.1	198°16′.7	-2°01′.5	-1.0	2.4	α Vir	163	55
159°56′.8	56°21′.5	160°02′.1	56°21′.8	-2.9	-0.3	ζ UMa	382	56
171°11′.9	54°24′.6	171°18′.6	54°23′.9	-3.9	0.7	η UMa	383	57
198°39′.8	31°02′.6	198°40′.1	31°00′.7	-0.3	1.8	α Boo	469	58
192°05′.9	49°33′.0	192°04′.1	49°33′.8	1.2	-0.7	γ Boo	459	59
219°31′.0	0°25′.8	219°31′.4	0°23′.0	-0.5	2.8	α Lib	189	60
223°47′.8	8°34′.7	223°48′.6	8°32′.6	-0.8	2.1	β Lib	191	61
216°37′.4	44°22′.4	216°40′.3	44°22′.0	-2.1	0.5	α CrB	497	62
226°29′.5	25°36′.2	226°28′.7	25°32′.6	0.7	3.6	α Ser	720	63
237°35′.7	1°04′.9	237°37′.3	1°03′.5	-1.6	1.4	β Sco	207	64
236°46′.0	17°19′.6	236°43′.8	17°18′.3	2.1	1.2	δ Oph	694	65
244°12′.9	-4°27′.4	244°11′.8	-4°31′.0	1.1	3.6	α Sco	214	66
235°27′.4	42°48′.5	235°31′.0	42°45′.2	-2.7	3.3	β Her	506	67
243°38′.8	11°30′.2	243°39′.5	11°26′.3	-0.7	3.9	ζ Oph	700	68
252°20′.1	7°17′.8	252°23′.9	7°14′.3	-3.7	3.5	η Oph	699	69
250°32′.6	37°22′.2	250°34′.8	37°20′.0	-1.7	2.2	α Her	505	70
249°10′.2	47°47′.1	249°11′.1	47°45′.3	-0.7	1.8	δ Her	509	71
256°49′.1	35°57′.5	256°51′.7	35°54′.7	-2.0	2.8	α Oph	688	72
259°45′.2	28°01′.1	259°46′.5	27°58′.5	-1.1	2.6	β Oph	689	73
262°26′.1	75°03′.5	262°24′.8	74°58′.6	0.4	4.9	γ Dra	416	74
279°44′.9	61°47′.6	279°43′.6	61°45′.2	0.6	2.3	α Lyr	533	75
280°43′.1	1°30′.2	280°41′.1	1°29′.4	2.0	0.8	π Sgr	223	76
284°16′.1	36°16′.5	284°14′.8	36°14′.6	1.1	1.8	ζ Aql	742	77
295°44′.5	49°01′.9	295°43′.1	49°00′.6	0.9	1.3	β Cyg	544	78
296°09′.1	29°22′.2	296°08′.9	29°19′.0	0.1	3.2	α Aql	736	79
310°51′.6	64°27′.7	310°45′.0	64°26′.7	2.9	1.1	δ Cyg	549	80
298°17′.3	7°02′.6	298°17′.3	6°58′.4	0.0	4.3	α Cap	231	81
298°30′.3	4°40′.3	298°28′.7	4°37′.8	1.6	2.5	β Cap	233	82
319°26′.2	57°09′.4	319°20′.6	57°09′.1	3.0	0.3	γ Cyg	547	83
306°11′.7	8°08′.8	306°09′.5	8°07′.3	2.2	1.6	ϵ Aqr	266	84
329°53′.4	59°56′.6	329°50′.7	59°55′.4	1.4	1.1	α Cyg	548	85
322°09′.9	49°26′.0	322°09′.2	49°25′.8	0.5	0.3	ϵ Cyg	553	86
317°50′.3	8°41′.5	317°49′.9	8°38′.7	0.4	2.8	β Aqr	262	87
316°13′.4	-2°26′.3	316°12′.2	-2°31′.1	1.2	4.9	γ Cap	253	88
30°12′.4	71°07′.0	30°05′.5	71°07′.2	2.2	-0.2	β Cep	444	89
326°21′.8	22°07′.9	326°20′.0	22°07′.3	1.7	0.6	ϵ Peg	767	90
318°00′.4	-2°29′.3	317°57′.4	-2°32′.0	3.0	2.7	δ Cap	254	91
327°48′.1	10°42′.0	327°47′.6	10°41′.0	0.5	1.0	α Aqr	260	92
328°11′.7	-20°59′.1	328°14′.7	-21°05′.1	-2.8	5.9	α PsA	299	93
353°50′.4	31°07′.7	353°48′.5	31°08′.0	1.6	-0.3	β Peg	784	94
347°57′.6	19°25′.3	347°55′.9	19°24′.9	1.6	0.4	α Peg	783	95
345°50′.6	7°17′.2	345°48′.8	7°17′.5	1.7	-0.3	γ Psc	301	96
8°46′.8	25°41′.6	8°45′.5	25°41′.2	1.2	0.5	α And	790	97
29°35′.6	51°14′.2	29°32′.9	51°14′.1	1.7	0.2	β Cas	581	98
3°38′.6	12°34′.5	3°36′.0	12°35′.3	2.5	-0.8	γ Peg	785	99
355°23′.4	-10°01′.1	355°20′.5	-10°01′.4	2.8	0.3	ι Cet	833	100

Table 22: Tycho's Select Stars, Explicit Equatorial, 1601.03

HR	*m*	μ	m	α_S	δ_S	α	δ	$\Gamma\alpha$	$\Delta\delta$
4660	3.31	3.45	2	178°50′.0	59°15′.0	178°48′.8	59°15′.2	0.6	-0.2
4910	3.38	3.58	3	188°53′.0	5°37′.0	188°52′.9	5°34′.9	0.1	2.1
4905	1.77	1.91	2	189°01′.0	58°10′.0	189°03′.0	58°08′.4	-1.1	1.6
4932	2.83	3.01	3	190°36′.0	13°08′.0	190°34′.6	13°07′.3	1.3	0.7
5056	0.98	1.30	1	196°04′.0	-9°01′.0	196°04′.3	-9°03′.2	-0.3	2.2
5054	2.06	2.20	2	196°54′.0	57°03′.0	196°55′.3	57°01′.8	-0.7	1.2
5191	1.86	2.00	2	202°54′.0	51°22′.0	202°55′.8	51°19′.8	-1.1	2.2
5340	-0.04	0.12	1	209°23′.5	21°18′.5	209°22′.3	21°17′.7	1.1	0.8
5435	3.03	3.17	3	214°02′.0	40°03′.0	213°59′.8	40°05′.3	1.7	-2.3
5530	2.64	3.04	2	217°14′.5	-14°18′.0	217°14′.4	-14°19′.9	0.1	1.9
5685	2.61	2.92	2	223°54′.5	-7°50′.0	223°54′.8	-7°51′.2	-0.3	1.2
5793	2.23	2.38	2	229°26′.0	28°06′.0	229°27′.3	28°06′.4	-1.1	-0.4
5854	2.65	2.85	2	231°12′.0	7°46′.0	231°10′.1	7°44′.3	1.8	1.7
5984	2.50	3.00	2	235°34′.0	-18°38′.0	235°35′.6	-18°38′.5	-1.6	0.5
6056	2.74	2.99	3	238°25′.0	-2°37′.0	238°22′.8	-2°36′.0	2.2	-1.0
6134	0.96	1.76	1	241°18′.0	-25°26′.0	241°16′.4	-25°28′.0	1.5	2.0
6148	2.77	2.93	3	243°15′.0	22°27′.0	243°16′.6	22°25′.0	-1.4	2.0
6175	2.56	2.89	3	243°49′.0	-9°39′.0	243°49′.1	-9°41′.1	-0.1	2.1
6378	2.43	2.84	3	251°50′.0	-15°07′.0	251°53′.6	-15°09′.0	-3.4	2.0
6406	3.31	3.48	3	254°06′.0	14°55′.0	254°07′.3	14°54′.6	-1.3	0.4
6410	3.14	3.30	3	254°40′.0	25°22′.0	254°40′.1	25°22′.0	-0.1	-0.0
6556	2.08	2.26	3	259°05′.0	12°56′.0	259°06′.7	12°55′.0	-1.7	1.0
6603	2.77	2.98	3	260°56′.0	4°49′.0	260°56′.9	4°48′.3	-0.9	0.7
6705	2.23	2.36	3	266°52′.0	51°37′.0	266°50′.6	51°34′.1	0.9	2.9
7001	0.03	0.17	1	275°52′.0	38°28′.0	275°51′.6	38°27′.6	0.3	0.4
7264	2.89	3.49	4	281°32′.0	-21°35′.0	281°29′.8	-21°34′.5	2.0	-0.5
7235	2.99	3.18	3	281°47′.0	13°20′.0	281°46′.2	13°20′.0	0.8	-0.0
7417	2.92	3.07	3	288°40′.0	27°10′.0	288°39′.6	27°10′.5	0.3	-0.5
7557	0.77	0.98	2	292°49′.0	7°54′.0	292°49′.5	7°52′.7	-0.5	1.3
7528	2.87	3.01	3	293°10′.0	44°12′.0	293°07′.6	44°11′.8	1.7	0.2
7754	3.57	3.95	3	298°57′.0	-13°40′.0	298°57′.6	-13°42′.8	-0.6	2.8
7776	3.08	3.50	3	299°39′.0	-15°57′.0	299°37′.6	-15°58′.4	1.3	1.4
7796	2.20	2.34	3	302°01′.5	39°01′.0	301°58′.9	39°01′.3	2.0	-0.3
7950	3.77	4.11	4	306°32′.0	-10°53′.0	306°30′.0	-10°53′.8	1.9	0.8
7924	1.25	1.39	2	306°57′.5	43°53′.5	306°57′.8	43°53′.5	-0.2	0.0
7949	2.46	2.60	3	307°31′.0	32°30′.0	307°31′.4	32°31′.2	-0.3	-1.2
8232	2.91	3.20	3	317°37′.0	-7°15′.0	317°37′.3	-7°16′.7	-0.3	1.7
8278	3.68	4.17	3	319°28′.0	-18°21′.0	319°27′.9	-18°25′.0	0.1	4.0
8238	3.23	3.37	3	320°46′.0	68°50′.0	320°47′.8	68°49′.2	-0.6	0.8
8308	2.39	2.58	3	321°10′.0	8°05′.0	321°08′.8	8°05′.2	1.2	-0.2
8322	2.87	3.35	3	321°16′.0	-17°51′.0	321°13′.5	-17°53′.5	2.4	2.5
8414	2.96	3.21	3	326°19′.0	-2°13′.0	326°18′.8	-2°13′.3	0.2	0.3
8728	1.16	3.24	1	338°46′.0	-31°39′.0	338°51′.0	-31°42′.8	-4.2	3.8
8775	2.42	2.57	2	341°09′.0	25°56′.0	341°08′.2	25°56′.2	0.8	-0.2
8781	2.49	2.68	2	341°15′.0	13°05′.0	341°14′.1	13°04′.6	0.9	0.4
8852	3.69	3.92	4	344°09′.0	1°07′.0	344°07′.3	1°07′.1	1.7	-0.1
0015	2.06	2.22	2	356°59′.0	26°54′.0	356°59′.1	26°53′.2	-0.0	0.8
0021	2.27	2.40	3	357°05′.0	56°58′.0	357°05′.9	56°56′.9	-0.5	1.1
0039	2.38	2.57	2	358°14′.0	12°58′.0	358°11′.8	12°57′.8	2.2	0.2
0074	3.56	3.89	3	359°49′.0	-11°01′.0	359°46′.2	-11°02′.4	2.8	1.4

Table 23: Tycho's Select Stars, Implicit Ecliptical, 1701.03

λ_S	β_S	λ	β	$\Gamma\lambda$	$\Delta\beta$	Name	D	S
33°42′.7	46°35′.4	33°38′.3	46°36′.0	3.0	-0.6	α Cas	571	1
84°29′.0	65°59′.4	84°23′.2	66°04′.0	2.3	-4.5	α UMi	336	2
358°21′.2	-20°46′.7	358°22′.5	-20°47′.0	-1.3	0.3	β Cet	834	3
39°53′.0	48°45′.9	39°47′.1	48°47′.2	3.9	-1.3	γ Cas	573	4
26°13′.9	25°59′.5	26°14′.2	25°56′.1	-0.3	3.4	β And	802	5
43°46′.6	46°21′.9	43°45′.3	46°23′.4	0.9	-1.5	δ Cas	574	6
29°02′.3	7°08′.8	29°00′.8	7°09′.0	1.6	-0.2	γ Ari	1	7
17°49′.9	-20°18′.7	17°45′.7	-20°20′.9	3.9	2.2	ζ Cet	830	8
29°47′.6	8°28′.9	29°47′.8	8°28′.4	-0.2	0.5	β Ari	2	9
40°03′.7	27°46′.3	40°03′.8	27°46′.9	-0.1	-0.7	γ And	805	10
25°12′.9	-9°04′.4	25°11′.9	-9°04′.9	1.0	0.5	α Psc	318	11
33°31′.4	9°56′.7	33°29′.0	9°57′.3	2.3	-0.6	α Ari	3	12
40°07′.9	-12°37′.7	40°08′.6	-12°36′.6	-0.7	-1.1	α Cet	818	13
52°02′.5	22°21′.7	52°00′.1	22°23′.7	2.2	-1.9	β Per	626	14
57°41′.8	30°04′.6	57°54′.9	30°05′.5	-11.4	-0.9	α Per	621	15
55°48′.8	4°00′.3	55°49′.2	4°01′.2	-0.4	-0.9	η Tau	53	16
61°36′.2	-5°45′.9	61°37′.3	-5°45′.9	-1.1	0.1	γ Tau	32	17
64°14′.3	-2°35′.8	64°17′.0	-2°36′.0	-2.6	0.2	ϵ Tau	36	18
65°37′.5	-5°31′.2	65°36′.7	-5°29′.3	0.8	-1.9	α Tau	35	19
77°39′.7	22°50′.6	77°40′.9	22°51′.7	-1.1	-1.1	α Aur	650	20
72°43′.7	-31°11′.5	72°39′.2	-31°09′.7	3.8	-1.9	β Ori	874	21
78°25′.6	5°20′.1	78°24′.1	5°21′.6	1.6	-1.5	β Tau	42	22
76°46′.5	-16°53′.5	76°46′.4	-16°51′.2	0.1	-2.2	γ Ori	842	23
75°31′.2	-43°57′.0	75°29′.8	-43°56′.8	1.0	-0.2	β Lep	927	24
78°15′.3	-23°37′.2	78°11′.3	-23°35′.5	3.6	-1.7	δ Ori	865	25
79°34′.6	-13°26′.1	79°32′.0	-13°24′.5	2.6	-1.6	λ Ori	838	26
80°36′.9	-2°13′.8	80°36′.7	-2°14′.0	0.2	0.2	ζ Tau	40	27
79°19′.6	-24°33′.9	79°17′.4	-24°32′.7	2.0	-1.2	ϵ Ori	866	28
80°31′.1	-25°21′.6	80°30′.5	-25°19′.9	0.6	-1.6	ζ Ori	867	29
85°52′.8	21°27′.2	85°44′.5	21°28′.2	7.8	-1.0	β Aur	651	30
84°37′.9	-16°05′.7	84°34′.8	-16°04′.0	3.0	-1.7	α Ori	841	31
94°55′.2	-6°48′.3	94°55′.7	-6°46′.6	-0.5	-1.6	γ Gem	81	32
99°58′.3	-39°29′.9	99°57′.9	-39°32′.3	0.3	2.4	α CMa	933	33
106°05′.6	10°01′.7	106°04′.7	10°04′.3	0.9	-2.6	α Gem	65	34
111°42′.4	-15°57′.3	111°39′.8	-15°57′.6	2.4	0.3	α CMi	947	35
109°07′.6	6°37′.9	109°05′.5	6°39′.7	2.1	-1.9	β Gem	66	36
127°17′.0	-43°18′.0	127°15′.2	-43°17′.9	1.3	-0.0	ρ Pup	951	37
123°10′.8	1°14′.1	123°09′.7	1°15′.9	1.0	-1.8	Praesepe	95	38
123°21′.5	3°07′.8	123°22′.3	3°10′.0	-0.8	-2.2	γ Cnc	98	39
124°31′.9	0°03′.2	124°32′.7	0°04′.0	-0.9	-0.8	δ Cnc	99	40
143°10′.6	-22°24′.0	143°07′.4	-22°24′.2	3.0	0.2	α Hya	972	41
143°47′.8	4°53′.0	143°43′.8	4°50′.9	4.0	2.2	η Leo	116	42
145°42′.2	0°27′.0	145°40′.5	0°27′.3	1.6	-0.3	α Leo	117	43
143°23′.5	11°50′.5	143°23′.0	11°50′.8	0.5	-0.4	ζ Leo	114	44
145°23′.7	8°47′.4	145°24′.5	8°48′.0	-0.8	-0.6	γ Leo	115	45
135°08′.8	45°03′.8	135°13′.4	45°06′.3	-3.3	-2.5	β UMa	373	46
130°59′.6	49°39′.7	130°59′.8	49°39′.9	-0.1	-0.2	α UMa	372	47
157°10′.9	14°20′.4	157°07′.1	14°19′.8	3.7	0.7	δ Leo	129	48
167°28′.7	12°17′.9	167°28′.2	12°17′.4	0.5	0.5	β Leo	136	49
146°09′.9	47°06′.2	146°15′.4	47°07′.2	-3.8	-1.0	γ UMa	375	50

Table 23: Tycho's Select Stars, Explicit Equatorial, 1701.03

HR	m	μ	m	α_S	δ_S	α	δ	$\Gamma\alpha$	$\Delta\delta$
0168	2.23	2.36	3	5°58′.0	54°55′.0	5°57′.1	54°53′.5	0.5	1.5
0424	2.02	2.18	2	9°46′.0	87°43′.5	8°50′.6	87°41′.9	2.2	1.6
0188	2.04	2.56	2	7°08′.0	-19°38′.0	7°08′.4	-19°38′.0	-0.3	0.0
0264	2.47	2.61	3	9°48′.0	59°07′.0	9°45′.1	59°05′.3	1.5	1.7
0337	2.06	2.20	2	13°13′.0	34°05′.0	13°16′.9	34°01′.5	-3.2	3.5
0403	2.68	2.82	3	16°38′.0	58°40′.0	16°39′.4	58°39′.9	-0.8	0.1
0545	4.04	4.21	4	24°19′.0	17°50′.0	24°18′.1	17°48′.7	0.9	1.3
0539	3.73	4.07	3	24°14′.0	-11°45′.0	24°10′.7	-11°49′.7	3.2	4.7
0553	2.64	2.81	4	24°32′.0	19°21′.0	24°33′.1	19°19′.7	-1.1	1.3
0603	2.16	2.30	2	26°24′.0	40°53′.0	26°26′.0	40°52′.4	-1.5	0.6
0595	3.94	4.17	3	26°40′.0	1°20′.0	26°39′.3	1°18′.1	0.7	1.9
0617	2.00	2.16	3	27°38′.0	22°03′.0	27°36′.2	22°01′.7	1.7	1.3
0911	2.53	2.75	2	41°40′.0	2°54′.0	41°40′.4	2°53′.4	-0.4	0.6
0936	2.12	2.26	3	42°15′.0	39°47′.0	42°13′.3	39°46′.2	1.3	0.8
1017	1.79	1.93	2	45°30′.0	48°43′.0	45°48′.1	48°45′.5	-11.9	-2.5
1165	2.87	3.03	3	52°26′.0	23°10′.0	52°26′.9	23°08′.7	-0.9	1.3
1346	3.65	3.83	3	60°41′.0	14°54′.0	60°42′.5	14°52′.2	-1.4	1.8
1409	3.53	3.70	3	62°45′.0	18°31′.0	62°48′.2	18°28′.7	-3.0	2.3
1457	0.85	1.02	1	64°43′.0	15°53′.0	64°42′.2	15°52′.2	0.8	0.8
1708	0.08	0.21	1	73°38′.0	45°40′.0	73°40′.2	45°38′.5	-1.6	1.5
1713	0.12	0.43	1	75°07′.0	-8°33′.5	75°02′.8	-8°34′.8	4.1	1.3
1791	1.65	1.80	2	76°53′.0	28°20′.0	76°51′.4	28°18′.6	1.4	1.4
1790	1.64	1.85	2	77°17′.0	6°03′.0	77°16′.8	6°02′.5	0.2	0.5
1829	2.84	3.41	3	78°53′.0	-20°59′.0	78°51′.7	-21°01′.7	1.2	2.7
1851	2.21	2.46	2	79°15′.0	-0°32′.0	79°11′.3	-0°33′.4	3.7	1.4
1879	3.49	3.69	4	79°43′.0	9°43′.0	79°40′.4	9°41′.7	2.6	1.3
1910	3.00	3.17	3	79°57′.0	20°58′.0	79°57′.0	20°55′.1	-0.0	2.9
1903	1.70	1.95	2	80°18′.0	-1°24′.0	80°15′.9	-1°25′.7	2.1	1.7
1948	1.91	2.17	2	81°26′.0	-2°07′.0	81°25′.3	-2°08′.2	0.7	1.2
2088	1.90	2.04	2	84°35′.0	44°54′.0	84°24′.3	44°51′.9	7.6	2.1
2061	0.50	0.69	2	84°48′.0	7°20′.0	84°45′.0	7°18′.8	3.0	1.2
2421	1.93	2.11	2	95°06′.0	16°38′.0	95°06′.5	16°36′.8	-0.5	1.2
2491	-1.46	-1.02	1	98°00′.0	-16°15′.0	97°59′.7	-16°20′.2	0.3	5.2
2890	1.58	1.73	2	108°53′.0	32°30′.0	108°51′.8	32°30′.0	1.0	-0.0
2943	0.38	0.59	2	110°57′.0	6°00′.0	110°54′.4	5°57′.5	2.6	2.5
2990	1.14	1.29	2	111°47′.0	28°43′.0	111°44′.4	28°42′.5	2.3	0.5
3185	2.81	3.51	3	118°43′.0	-23°26′.0	118°42′.3	-23°28′.1	0.7	2.1
3428	5.69	5.85	n	125°48′.0	20°43′.0	125°46′.8	20°42′.7	1.1	0.3
3449	4.66	4.82	4	126°28′.0	22°31′.0	126°28′.7	22°30′.7	-0.7	0.3
3461	3.94	4.10	4	126°54′.0	19°15′.0	126°54′.5	19°13′.3	-0.5	1.7
3748	1.98	2.27	1	138°16′.0	-7°22′.0	138°13′.4	-7°23′.1	2.6	1.1
3975	3.52	3.69	3	147°50′.0	18°14′.0	147°44′.6	18°12′.1	5.2	1.9
3982	1.35	1.53	1	148°08′.0	13°25′.0	148°06′.0	13°24′.6	1.9	0.4
4031	3.44	3.60	3	150°01′.0	24°54′.0	149°59′.7	24°53′.4	1.2	0.6
4057	2.30	2.46	2	150°51′.0	21°21′.0	150°51′.3	21°20′.2	-0.3	0.8
4295	2.37	2.51	2	160°49′.0	57°59′.0	160°52′.4	57°58′.4	-1.8	0.6
4301	1.79	1.92	2	161°18′.0	63°22′.0	161°13′.2	63°21′.2	2.1	0.8
4357	2.56	2.72	2	164°37′.0	22°09′.0	164°32′.2	22°09′.2	4.5	-0.2
4534	2.14	2.32	1	173°28′.0	16°15′.0	173°26′.6	16°14′.5	1.3	0.5
4554	2.44	2.58	2	174°26′.0	55°23′.0	174°28′.4	55°21′.3	-1.4	1.7

Table 23: Tycho's Select Stars, Implicit Ecliptical, 1701.03

λ_S	β_S	λ	β	$\Gamma\lambda$	$\Delta\beta$	Name	D	S
146°50′.4	51°37′.2	146°50′.2	51°38′.1	0.1	-0.9	δ UMa	374	51
187°20′.6	8°41′.0	187°19′.0	8°38′.6	1.6	2.4	δ Vir	159	52
154°35′.6	54°17′.7	154°41′.8	54°18′.1	-3.6	-0.4	ϵ UMa	381	53
185°49′.2	16°15′.5	185°46′.7	16°13′.3	2.4	2.1	ϵ Vir	162	54
199°40′.7	-1°59′.1	199°40′.3	-2°01′.9	0.4	2.8	α Vir	163	55
161°21′.7	56°21′.9	161°27′.2	56°22′.0	-3.0	-0.1	ζ UMa	382	56
172°37′.4	54°25′.0	172°43′.1	54°23′.8	-3.3	1.2	η UMa	383	57
200°04′.5	31°02′.3	200°03′.8	30°56′.6	0.6	5.7	α Boo	469	58
193°30′.3	49°33′.9	193°28′.2	49°33′.6	1.4	0.3	γ Boo	459	59
220°55′.7	0°25′.5	220°55′.0	0°22′.3	0.8	3.2	α Lib	189	60
225°12′.9	8°34′.9	225°12′.1	8°31′.9	0.8	3.0	β Lib	191	61
218°02′.9	44°23′.5	218°04′.8	44°21′.3	-1.3	2.1	α CrB	497	62
227°55′.2	25°36′.3	227°52′.8	25°32′.1	2.1	4.2	α Ser	720	63
239°01′.2	1°04′.8	239°01′.0	1°02′.8	0.2	2.1	β Sco	207	64
238°14′.8	17°19′.8	238°07′.5	17°17′.4	6.9	2.4	δ Oph	694	65
245°37′.7	-4°27′.6	245°35′.4	-4°31′.8	2.2	4.2	α Sco	214	66
236°51′.9	42°48′.4	236°54′.8	42°44′.5	-2.2	4.0	β Her	506	67
245°03′.6	11°29′.8	245°03′.2	11°25′.6	0.4	4.2	ζ Oph	700	68
253°09′.6	7°13′.8	253°47′.6	7°13′.7	-37.7	0.1	η Oph	699	69
251°55′.9	37°23′.0	251°58′.5	37°19′.3	-2.1	3.7	α Her	505	70
250°21′.1	47°46′.4	250°35′.0	47°44′.2	-9.3	2.1	δ Her	509	71
258°15′.1	35°56′.7	258°15′.6	35°53′.6	-0.5	3.1	α Oph	688	72
261°07′.8	28°01′.0	261°10′.1	27°57′.9	-2.0	3.0	β Oph	689	73
263°50′.8	75°03′.2	263°48′.3	74°57′.8	0.6	5.4	γ Dra	416	74
281°08′.1	61°47′.9	281°07′.6	61°44′.9	0.3	3.0	α Lyr	533	75
282°08′.2	1°31′.0	282°04′.8	1°28′.6	3.4	2.4	π Sgr	223	76
285°44′.8	36°16′.9	285°38′.2	36°13′.8	5.3	3.1	ζ Aql	742	77
297°08′.9	49°01′.8	297°06′.3	49°00′.0	1.7	1.8	β Cyg	544	78
297°37′.9	29°21′.1	297°33′.5	29°18′.8	3.8	2.3	α Aql	736	79
312°17′.7	64°28′.0	312°07′.6	64°26′.2	4.3	1.8	δ Cyg	549	80
299°42′.1	7°01′.8	299°41′.0	6°57′.7	1.1	4.1	α Cap	231	81
299°56′.0	4°40′.0	299°52′.4	4°37′.2	3.6	2.8	β Cap	233	82
320°49′.5	57°09′.5	320°43′.2	57°08′.7	3.4	0.8	γ Cyg	547	83
307°29′.6	8°09′.1	307°33′.1	8°06′.7	-3.5	2.4	ϵ Aqr	266	84
331°17′.9	59°56′.6	331°13′.1	59°55′.2	2.4	1.4	α Cyg	548	85
323°34′.1	49°26′.4	323°33′.3	49°25′.6	0.5	0.7	ϵ Cyg	553	86
319°15′.8	8°42′.0	319°13′.5	8°38′.2	2.2	3.8	β Aqr	262	87
317°39′.2	-2°26′.6	317°36′.1	-2°31′.7	3.1	5.1	γ Cap	253	88
31°36′.3	71°07′.0	31°27′.4	71°07′.7	2.9	-0.7	β Cep	444	89
327°49′.7	22°06′.2	327°43′.4	22°07′.0	5.9	-0.8	ϵ Peg	767	90
319°25′.8	-2°29′.2	319°21′.3	-2°33′.0	4.5	3.9	δ Cap	254	91
329°14′.6	10°42′.0	329°11′.1	10°40′.6	3.5	1.4	α Aqr	260	92
329°36′.2	-20°59′.8	329°39′.1	-21°05′.9	-2.7	6.1	α PsA	299	93
355°14′.6	31°07′.8	355°12′.1	31°08′.1	2.1	-0.3	β Peg	784	94
349°22′.1	19°25′.3	349°19′.4	19°24′.8	2.6	0.5	α Peg	783	95
347°15′.0	7°17′.7	347°13′.5	7°17′.0	1.4	0.7	γ Psc	301	96
10°11′.7	25°41′.8	10°08′.9	25°41′.1	2.5	0.7	α And	790	97
31°00′.2	51°14′.6	30°56′.5	51°13′.8	2.3	0.8	β Cas	581	98
5°02′.0	12°35′.3	4°59′.5	12°35′.5	2.4	-0.2	γ Peg	785	99
356°48′.5	-10°01′.1	356°44′.3	-10°01′.4	4.1	0.3	ι Cet	833	100

Table 23: Tycho's Select Stars, Explicit Equatorial, 1701.03

HR	*m*	μ	m	α_S	δ_S	α	δ	$\Gamma\alpha$	$\Delta\delta$
4660	3.31	3.45	2	180°10′.0	58°41′.0	180°06′.3	58°41′.8	1.9	-0.8
4910	3.38	3.59	3	190°11′.0	5°03′.0	190°08′.3	5°01′.8	2.7	1.2
4905	1.77	1.91	2	190°10′.0	57°37′.0	190°11′.1	57°35′.4	-0.6	1.6
4932	2.83	3.01	3	191°53′.0	12°35′.0	191°49′.4	12°34′.5	3.5	0.5
5056	0.98	1.31	1	197°23′.5	-9°33′.5	197°22′.5	-9°35′.3	1.0	1.8
5054	2.06	2.20	2	197°57′.0	56°31′.0	197°57′.1	56°29′.8	-0.0	1.2
5191	1.86	2.00	2	203°56′.0	50°51′.0	203°55′.7	50°49′.1	0.2	1.9
5340	-0.04	0.12	1	210°34′.5	20°49′.0	210°30′.5	20°45′.4	3.7	3.6
5435	3.03	3.17	3	215°04′.0	39°36′.0	215°00′.4	39°38′.0	2.8	-2.0
5530	2.64	3.04	2	218°37′.5	-14°45′.0	218°36′.2	-14°46′.4	1.3	1.4
5685	2.61	2.92	2	225°16′.0	-8°14′.0	225°14′.6	-8°15′.0	1.4	1.0
5793	2.23	2.38	2	230°31′.0	27°45′.0	230°30′.6	27°44′.7	0.3	0.3
5854	2.65	2.85	2	232°27′.0	7°25′.0	232°23′.6	7°23′.7	3.4	1.3
5984	2.50	3.01	2	237°02′.0	-18°57′.0	237°01′.8	-18°57′.0	0.2	0.0
6056	2.74	2.99	3	239°48′.0	-2°55′.0	239°40′.8	-2°53′.5	7.2	-1.5
6134	0.96	1.78	1	242°50′.0	-25°42′.0	242°47′.2	-25°43′.7	2.5	1.7
6148	2.77	2.93	3	244°20′.0	22°12′.0	244°20′.8	22°10′.2	-0.7	1.8
6175	2.56	2.89	3	245°12′.0	-9°54′.0	245°11′.1	-9°55′.5	0.9	1.5
6378	2.43	2.85	3	252°40′.0	-15°17′.0	253°19′.0	-15°18′.9	-37.6	1.9
6406	3.31	3.48	3	255°14′.0	14°47′.0	255°15′.5	14°45′.8	-1.4	1.2
6410	3.14	3.30	3	255°32′.0	25°14′.0	255°41′.5	25°13′.2	-8.6	0.8
6556	2.08	2.27	3	260°16′.0	12°49′.0	260°16′.1	12°48′.6	-0.1	0.4
6603	2.77	2.98	3	262°09′.0	4°44′.0	262°10′.8	4°43′.6	-1.8	0.4
6705	2.23	2.36	3	267°27′.0	51°35′.0	267°25′.2	51°32′.4	1.1	2.6
7001	0.03	0.17	1	276°42′.0	38°32′.0	276°42′.3	38°31′.8	-0.3	0.2
7264	2.89	3.49	4	283°03′.0	-21°27′.0	282°59′.4	-21°27′.5	3.4	0.5
7235	2.99	3.17	3	283°00′.0	13°28′.0	282°55′.1	13°27′.0	4.8	1.0
7417	2.92	3.07	3	289°41′.0	27°21′.0	289°40′.1	27°21′.5	0.8	-0.5
7557	0.77	0.97	2	294°06′.0	8°07′.0	294°02′.8	8°06′.6	3.1	0.4
7528	2.87	3.01	3	293°58′.0	44°26′.0	293°54′.5	44°25′.3	2.5	0.7
7754	3.57	3.94	3	300°22′.0	-13°24′.0	300°21′.4	-13°26′.3	0.5	2.3
7776	3.08	3.50	3	301°06′.0	-15°40′.0	301°02′.6	-15°41′.5	3.3	1.5
7796	2.20	2.34	3	302°55′.0	39°19′.0	302°52′.6	39°19′.2	1.8	-0.2
7950	3.77	4.11	4	307°48′.0	-10°34′.0	307°51′.8	-10°33′.7	-3.8	-0.3
7924	1.25	1.39	2	307°49′.0	44°14′.0	307°48′.8	44°13′.8	0.2	0.2
7949	2.46	2.60	3	308°31′.0	32°51′.0	308°31′.9	32°52′.3	-0.8	-1.3
8232	2.91	3.20	3	318°58′.0	-6°49′.0	318°56′.8	-6°51′.8	1.2	2.8
8278	3.68	4.16	3	320°54′.0	-17°55′.0	320°52′.0	-17°59′.4	1.9	4.4
8238	3.23	3.37	3	321°08′.0	69°16′.0	321°09′.6	69°15′.2	-0.6	0.8
8308	2.39	2.58	3	322°28′.0	8°31′.0	322°22′.5	8°31′.4	5.4	-0.4
8322	2.87	3.33	3	322°41′.0	-17°24′.0	322°37′.2	-17°27′.7	3.6	3.7
8414	2.96	3.21	3	327°39′.0	-1°44′.0	327°36′.2	-1°45′.3	2.8	1.3
8728	1.16	3.03	1	340°11′.0	-31°08′.0	340°15′.5	-31°11′.7	-3.8	3.7
8775	2.42	2.57	2	342°21′.0	26°28′.0	342°20′.0	26°28′.2	0.9	-0.2
8781	2.49	2.67	2	342°30′.0	13°37′.0	342°28′.4	13°36′.3	1.5	0.7
8852	3.69	3.92	4	345°26′.0	1°40′.0	345°25′.0	1°39′.4	1.0	0.6
0015	2.06	2.22	2	358°16′.0	27°28′.0	358°15′.3	27°26′.3	0.6	1.7
0021	2.27	2.41	3	358°20′.0	57°32′.0	358°22′.1	57°30′.0	-1.2	2.0
0039	2.38	2.57	2	359°30′.0	13°32′.0	359°28′.3	13°31′.2	1.6	0.8
0074	3.56	3.89	3	1°07′.0	-10°27′.0	1°02′.8	-10°29′.0	4.2	2.0

References

Almajest. Compiled Ptolemy c.160 AD. Eds: Manitius 1912-3; Toomer 1984.
John Christianson 2000. *On Tycho's Island: TB & His Ass'ts*, Cambr U.
Copernicus 1543. *De Revolutionibus*. Repr. Bruxelles 1966.
DSB = *Dictionary of Scientific Biography*, Ed: C.Gillispie, NYC.
J.Dreyer 1890. *Tycho Brahe: a Picture of Scientific Work in the 16th Century*, Edinburgh.
J.Evans 1987. JHA *18*:155 & 233.
J.Evans 1998. *History & Practice of Ancient Astronomy*, Oxford U.
B.B.Goldstein 1967. *Arabic Version of Ptolemy's PlanHyp*, AmPhilosSocTrans *57.4*.
Gerd Graßhoff 1990. *History of Ptolemy's Star Catalogue*, NYC.
A.Hirshfeld, R.Sinnott, & F.Ochsenbein *Sky Catalogue 2000.0*, 2nd ed. Cambridge 1991.
D.Hoffleit & C.Jaschek *Bright Star Catalogue*, 4th ed. Yale U 1982.
Johannes Kepler Gesammelte Werke. Eds: Caspar, etc., Munich 1937-.
Karl Manitius 1912-3, Ed. *Handbuch der Astronomie* [*Almajest*], Leipzig.
K.Moesgaard 1989. Centaurus *32*:310.
R.Newton 1979-84. *The Moon's Acceleration* . . . , Johns Hopkins U.
Norton's 2000.0 Star Atlas & Reference Handbook. Ed: I.Ridpath, NYC 1989.
OO = J.Dreyer, Ed. *Tychonis Brahe Dani Opera Omnia* 15 vols Copenhagen 1913-1929.
PK = C.Peters & E.Knobel 1915. *Ptolemy's Catalogue of Stars*, Carnegie Inst., Publ.#86.
Planetary Hypotheses. Comp. Ptolemy c.170 AD. Eds: Heiberg 1907; B.Goldstein 1967.
H.Ræder & E.&B.Strömgren 1946, Eds. *TB's Descr[1598]Instrs&Sci Work*, Copenhagen.
D.Rawlins 1981L. Astronomy *9*:24.
D.Rawlins 1982C. Publications of the Astronomical Society of the Pacific *94*:359.
D.Rawlins 1987. American Journal of Physics *55*:235.
D.Rawlins 1991H. DIO *1.1* ‡6.
D.Rawlins 1992T. DIO *2.1* ‡4.
Przemysław Rybka 1984. *Katalog Gwiazdowy Heweliusza*, Warsaw.
Smithsonian Astrophysical Observatory Star Catalog Smithsonian Inst 1966.
Victor Thoren 1990. *Lord of Uraniborg*, Cambridge U.
Hugh Thurston 1994E. *Early Astronomy*, NYC.
Gerald Toomer 1984, Ed. *Ptolemy's Almagest*, NYC.
TBmss = Tycho Brahe orig records, Royal Library, Copenhagen.
Yale Catalog = D.Hoffleit & C.Jaschek 1982.

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