

Tycho: 1st to Predict 100 Star-Places 100^y Ahead

Tycho's Exposure of 1000-Star Theft Enables Pioneer Advance

High-Accuracy Achievement Without Telescope or Reliable Timepieces

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A Tycho's Accusation Against Ptolemy Leads to the First Revelation of Correct Precession

A1 Tycho Brahe is best remembered among scientists for his improvement of the theory of the Moon's motion, reducing lunar tabular errors from the order of a degree to a matter of a few arcmin. When attempting like improvement in stellar astronomy, he found that the prediction of stars' places was confused by medieval theories ("trepidation"), simultaneously complicated, contrived, & inadequate. He discerned that the confusion's source was simple: Ptolemy's clumsy fakes, whose grossly false star positions were due to his having stolen Hipparchos' 1025 star catalog, while mis-precessing its celestial longitudes — causing a mean error exceeding a full degree in Ptolemy's version!

A2 Over the 2 2/3 century interval since Hipparchos' 128 BC catalog, Ptolemy for his own 137 AD catalog had precessed Hipparchos' stars at 1°/century instead of the correct rate, 1°.38/century. So, upon realizing that Ptolemy had "usurped" (J.Dreyer, Ed. 1913-1929 *Tychonis Brahe Opera Omnia* 3:337) Hipparchos' catalog, Tycho removed Ptolemy's 1°-flawed frauds from his data-base and thereby made the epochal discovery that precession was virtually constant. He ultimately figured that precession during the interval from Hipparchos to his own time had been 51"/year (vs actual average 50".00/year over the 17 1/4 centuries), an error in precession of merely 2% (vs Ptolemy's error of nearly 30%).

B A Few Fakes

B1 By an odd irony a few stars ended up in Tycho's 1004-star catalog which were faked Ptolemy's way: precess the longitudes & leave the latitudes alone. The positions of six stars in Ophiuchus and the longitudes of all four in Centaurus were so generated. The methods of these fabrications are obvious from *DIO 2.1* ¶4 Tables 1&2 (1992).

B2 While Tycho — as catalog supervisor — is technically responsible, it seems most improbable that someone of such rigorously high standards would pollute with fakes his sacred mission of measuring the universe. His assistant, Christen Longberg ("Longomontanus") presumably knew that some among Tycho's team had cut corners, for he later issued a catalog that was a 777-star selection from Tycho's stars, eliminating the suspect ones (and then some).

B3 The moral difference between Ptolemy and Tycho is bought home by realization that Ptolemy's star catalog is 99% fabricated-plagiarized from Hipparchos' — while Tycho's is 99% non-fabricated.

C Other Shortcomings

C1 Despite the high precision of so much of Tycho's work, there are some oddities. His solar parallax (*DIO 3* fn 70) was, ironically, for a solar distance of c.1000 Earth-radii, Hipparchos' value (*DIO 1.3* eq.23), whose accuracy was exceeded even in antiquity by the 10000 Earth-radii distance of Aristarchos-Archimedes and Poseidonios (www.dioi.org/au.pdf, §C4).

C2 Generally, Tycho's adopted obliquity was (*DIO 3* fnn 39&49) 23°31'1/2 for zodiacal stars, 23°31' elsewhere (though the actual obliquity then was 23°29'1/2) — curiously erroneous for a fundamental quantity, presumably caused (*DIO 3* fn 70) by his error (§C1) in solar parallax.

C3 Tycho pretended not to be a heretical heliocentrist, by proposing that planets other than Earth went around the Sun — but ducking persecution by claiming that his planet-dominating Sun goes around the Earth!

C4 But, combining this oddity with his extremely high opinion of Copernicus, one may reasonably guess that Tycho was a heliocentrist who chose not to risk his good and productive life by saying so publicly.

D Daring to Predict: The Magic That Astronomy Pioneered

D1 Based on his 51"/year precession (vs 50".20/year actually), Tycho precessed — 100^y into the future — a selection of 100 stars' positions taken from his decades-long-compiled 1601.03-epoch catalog of 1004 stars. The 100-star tables for 1601.03 & 1701.03 can be conveniently found at *DIO 3* Tables 22&23 (1993), in both equatorial&ecliptical coordinates, along with great-circle errors.

D2 Impressively, only 5 of the 100 stars in the 1701.03 table exhibited great-circle errors exceeding 0°.1. (None of the 100 stars were that erroneous for 1601.03.) No one in the history of astronomy had previously been so able — not to mention so daring — as to commit himself that confidently. And justly. Such courage was characteristic of Tycho's forceful, aggressive personality. He defied convention by, e.g., neglecting to wed the mother of his children, and fighting a 1566/12/29 blade-duel with M.Parsbjerg that cost Tycho much of his nose. (See historian-of-science Victor Thoren's admirable 1990 biography of Tycho, *Lord of Uraniborg*, University of Cambridge.) One realizes the rôle of chance in history by contemplating how close Parsbjerg's sword approached to the eyeballs of the scientist who was to revolutionize precision in empirical astronomy.

D3 Tycho's achievements were the product of rigorous perfectionism, which resulted in a star catalog that was a virtual miracle, considering that its creation occurred without the use of pendulum clocks or telescopes. By repeated scrupulous measurements using Venus as a stepping-stone, the longitude of his catalog's anchor star, Hamal (α Ari), was correctly placed with respect to the Sun (whose northward crossing of the Equator determines 0° longitude, the Vernal Equinox) — *to a minor fraction of a arcmin*. This was far better than competitor Wilhelm IV's 6' systematic error (J.Dreyer *Tycho Brahe: a Picture of Scientific Work in the 16th Century* pp.352-353) in his smaller star catalog — whose random error was, however, slightly better than Tycho's (Przemysław Rybka *Katalog Gwiazdowy Heweliusza*, Warsaw, Chap.4).

D4 Tycho's perfectionism inevitably led to aggravation that his star catalog had unavoidably missed all the stars south of the antarctic circle of his home island (Hven). He even went so far as to seek funds for cataloging stars around the celestial South Pole. (H.Ræder & E.&B.Strömngren 1946, Eds., Tycho Brahe's 1598 *Description . . . Instruments & Scientific Work* pp.114-115.)

E A Driven and Principled Man

E1 Tycho's rigor inclined him to principles that bear repeating today. One of his mottos was

It's not what you seem, but what you are.

(On the wall of the Tycho Museum, pointed out by Danish scientist Hanne Dalgas Christiansen, during the 1994 May 28 Rawlins family visit.)

E2 And, directly to the heart of scholarship's value, lure, and transcendence (*DIO 3* p.3):

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