

SHAKESPEARE AND THE NORTHERNMOST CEPHEID

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Abstract

Long considered constant, how constant has Polaris really been? Further observations are still warranted.

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"I am constant as the Northern Star"

- Shakespeare, **Julius Caesar**, Act III, Scene I, Line 60.

Until the middle of the 19th century Polaris was thought to be constant in light as well as position in the night sky. This seeming utter reliability and constancy was echoed in 1599 by Shakespeare when he penned the above words. At that point in **Julius Caesar**, Caesar proclaims his inflexibility in enforcing the laws and policies of his empire by refusing to reconsider the exile of Publius Cimber. In fact, the request for leniency by Caesar's cabinet that prompted his statement was a ploy to demonstrate publicly the incorrigibility and pride of their leader, and served as the final illustration of the motivation for his assassination shortly thereafter.

We now know that not only does Polaris move on the sky because of its small distance from the North Celestial Pole and the procession of the Earth's rotation axis, but that it is also a variable star. Its variability was initially suspected in the mid-1850's. In 1889 A. Pannekoek began systematic naked-eye observations of Polaris, and determined a period of about 4 days. The radial velocity variation of Polaris was discovered by W. W. Campbell in 1898, with a period of 3.968 days. Hertzsprung in 1911 photographically determined the period of the light variations to be the same as the spectroscopic variations, with an amplitude of 0.17 magnitude. Photoelectric photometry by Stebbins in 1911 and 1912 showed 0.07 magnitude amplitude variability. At a meeting of the Amsterdam Academy on February 22, 1913, Pannekoek demonstrated that all photometric observations up to that time were consistent with a period of 3.9681 days, and first identified Polaris as a Cepheid variable (Pannekoek 1913). The most recent study of the variation of Polaris is by Arellano Ferro (1983) and shows that Polaris is the Cepheid with the smallest known photometric amplitude (0.05 magnitude), and has a period that increases at the rate of 316^S per century.

The period of Polaris allows us to estimate its distance using the period-luminosity relationship for Cepheids. The visual magnitude at maximum light quoted by Arellano Ferro is about 1.946 and the mean magnitude 1.975. The period-luminosity relationship of Sandage and Tammann (1968) gives the following absolute visual magnitudes: $M_V = -3.4 \pm 0.3$ for maximum, -3.0 ± 0.3 for the mean light. A visual magnitude of 2.0 then yields distances of 390 ± 50 and 326 ± 40 light years, respectively.

We note that if the absolute visual magnitude of Polaris is -2.95 (which lies well within the quoted uncertainties), then an apparent magnitude of 1.97 corresponds to a distance of 314 light years, well

within the range of uncertainty of the astronomical determination. Thus the photons that rained down on Amsterdam during the meeting at which Pannekoek identified Polaris as a Cepheid variable may have left Polaris 314 years earlier, in 1599, at the time that Shakespeare first put the words "constant as the North Star" into the mouth of the ill-fated Julius Caesar!

An amplitude of less than 0.5 visual magnitude would have been undetectable in the times of Caesar or Shakespeare, who would thus be wholly justified in considering this star as a constant. Even as late as 1910 F. Schlesinger and R. H. Baker commented that Polaris "is perhaps the star in all the sky of whose constancy in light we may be most certain." And Stebbins (1912) stated, "One thing however seems certain, namely that in spite of its variability Polaris is still a first class object for a photometric standard, since its changes can be accurately predicted." However, the star should still continue to be monitored with the highest precision available, for its photoelectrically determined amplitude appears to have been decreasing from 0.07V in 1911 to 0.04V in 1984 (Kholopov 1987). The amplitude in radial velocity has likewise been decreasing.

The distances to Polaris estimated from numerous available sources are very discordant and all are uncertain. The values from the period-luminosity relation range from 314 to 390 light years. The forthcoming new Yale catalogue of trigonometric parallaxes gives a mean value of 0".0026, yielding a distance of 385 parsecs or about 1250 light years. However, this result is meaningless as the standard deviation from about a dozen independent parallax determinations ranging from about -0.010 to +0.010 is ± 0.0037 ! A dynamic parallax of 0".006 gives 545 light years. The spectral class F7Ib corresponds to an absolute magnitude of -4.7 (Allen 1972), yielding a distance of over 700 light years. Thus hardly any observed parameter of Polaris is sufficiently accurate for a reliable distance determination. Bad as the distance estimates are, they nevertheless indicate that Polaris is more nearby than any other naked-eye classical Cepheid. Of the 36 with known periods in the **Bright Star Catalogue** all have apparent magnitudes fainter than Polaris and, according to the Sandage-Tammann period-luminosity relation, are more than 2.5 times as far away as Polaris.

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