WANTED: ASTROMETRIC AND PHOTOELECTRIC OBSERVATIONS OF GAMMA VIRGINIS AND ZETA HERCULIS

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Abstract

Gamma Virginis and zeta Herculis are both binary stars discovered by William Herschel. In 1836 one component of gamma Virginis was observed to have eclipsed the other; similarly one component of zeta Herculis was suspected of having eclipsed the other in 1795 and 1826-31. Modern orbits for these binaries suggest that future eclipses, or close apparent approaches, should occur in the first decade of the 21st century.

1. Introduction

In her autobiography Mary Somerville (1876) called attention to two double stars in which one of the components had occulted the other. Gamma Virginis and zeta Herculis were among pairs of stars selected by William Herschel for the purpose of obtaining the relative parallaxes of the components; he assumed that all such pairs represented only chance proximity in the sky of stars at different distances. By 1802 Herschel (1803) was aware that the relative motions of the components of some pairs signified that they were physical double stars (Clerke 1895). Later observations of these two pairs by skilled observers of their time indicated that one component of gamma Virginis had eclipsed the other in 1836; similarly, the two components of zeta Herculis were merged or eclipsing one-another in 1828-31. Modern orbits suggest that future eclipses or close separations might occur in the first decade of the 21st century. Moreover, both gamma Virginis and zeta Herculis are listed as suspected variable stars in the recent NSV, the *New Catalogue of Suspected Variable Stars* (Kholopov *et al.* 1982). The amplitudes are on the order of 0.05V and the variations, if real, are presumably of short period, hence unrelated to the long-period orbital motions.

The following sections give some of the details of the history of the observations of these two systems.

2. Gamma Virginis = 29 Vir, ADS 8630 (3.48 F0V, 3.50 F0V, 171.85yrs), BD -0° 2601, HR 4825-6, HD 110379-80, NSV 5859 (2.72-2.78V F0), at $12^h39^m07^s$ -1° 10.5' (1950)

The separation of the components of gamma Virginis had been noted by Bradley in 1718 (Crossley *et al.* 1879) when the components were so far apart they were assumed to be purely optical. The binary nature was discovered by Sir William Herschel in 1802. After selecting pairs of stars in close proximity from which he expected to obtain their relative parallax, he discovered instead that their changes in separation indicated they were physical doubles. Then in 1836, W. H. Smyth, John Herschel, and other ace observers of the time independently noted that one component had occulted the other (Smyth 1844). (Mrs. Somerville (1878), although quoting a letter from Smyth, instead of using his and Herschel's word occulted, adopted the synonym eclipsed, now more commonly used to describe the obscuration of one component of a binary star by the other.) Smyth (1847) characterized gamma Virginis as

"that remarkable system, which promises comparatively to be to double stars what Halley's comet is to that class of bodies."

The upper strip of Figure 1, taken from F. G. W. Struve (1837), shows how his son, Otto W. Struve, had pictured his observations between 1833.38 and 1836.42. The lower strip similarly shows the observations by W. H. Smyth between 1831.38 and 1843.33. F. G. W. Struve remarked that Otto Struve's observations on 3 June 1836 were not round, as expected for a total eclipse, but "cuneus" or wedge-shaped. Note that Smyth's observation for 1836.39 occurs close to the time of Otto Struve's last observation and is consistent with it. However, Smyth had obtained an observation at apparent totality on 1836.06, approximately January 22.

Numerous orbits have been computed for gamma Virginis. The two most recent are by Strand (1937), indicating a period of 171.37 years, and by Wolf (1949), 171.85 years. On the assumption that the orbit is stable and there has been no rotation of the line of apsides nor unrecognized perturbations, the next eclipse, or near eclipse, should occur in about 2007.

Otto W. Struve estimated that the difference in brightness of the two components varied by about 0.7 magnitude. Crossley *et al.* (1879) and E. Zinner (1931) cite Otto Struve as having suspected both components of gamma Virginis of varying in a period of a few days. A few other observers (e.g., Dembowski 1884) reported variations amounting to a few tenths of a magnitude. However, the evidence from simple eye estimates was at best only marginal. Gamma Virginis is now listed in the NSV with an indicated variation from 2.72 to 2.78V. Unfortunately these values, apparently taken from the USNO *Photoelectric Catalogue* (Blanco *et al.* 1970), do not necessarily represent the amplitude but rather the maximum discordance between different observers. The maximum amplitude reported from any single source is only 0.03V (Abt and Golson 1962) from only eight estimates.

Obviously the suspected variability of either component, or of the blended images, is unrelated to the observed or predicted occultations of one component by the other. From now through periastron in about 2008 the separation of the two components should decrease steadily from about 2". It is hoped that the astrometric progression shown by Smyth in the 1880s will be closely repeated in the early 21st century, and will be accompanied by precise magnitude determinations.

3. Zeta Herculis = 40 Her, ADS 10157 (2.90 F9IV, 5.53 G7V, 34.49 yrs), BD +31° 2884, HR 6212, HD 150680. NSV 7915 (2.78-2.83V), at $16^h39^m24^s$ +31° 41.5' (1950)

In 1782 William Herschel first discovered zeta Herculis as an assumed optical binary suitable for parallax work (J. F. W. Herschel 1866). In 1795 he suspected zeta Herculis of being variable, observing it as "less bright than usual" on September 16, 1795 (Dryer 1918). In 1802, unable to resolve the companion, he concluded (W. Herschel 1803), "My observations of this star furnish us with a phenomenon which is new in astronomy; it is the occultation of one star by another. This epoch, whatever be the cause of it, will be equally remarkable whether owing to solar parallax, proper motion, or motion in an orbit whose plane is nearly coincident with the visual ray." In 1802, when he was unable to resolve the companion, he inferred an occultation. This puzzled later investigators when orbital computations indicated that the separation of the components in 1802 should have been 1.24" (Lewis 1901).

A modern orbit for zeta Herculis by Baize (1976) gives a period of 34.487 years. F. G. W. Struve (1837; Dawes 1867) records that the star appeared single 1828-31. If the period is correct and the orbit suffered no perturbations (possible in view of a suspected third companion) then an eclipse should have occurred between about 1793.5 and 1796.5, in agreement with Herschel's suggested 1795 time of minimum

light. Later occultations would have been expected in 1862-66, 1897-1900, 1931-35, 1966-69, and 2000-04. Otto Struve (1879) records separations observed between 1839 and 1874. They reach minimum values of 0.82" to 0.97" between 1861.6 and 1866.74, though not progressing smoothly. Dembowski (1884), on the other hand, notes that the image appeared wedge-shaped 1862-63 and single 1864-65. In view of the difficulties in measuring the separations of such close pairs, these observations are in good agreement with the computed orbit. The observations published by Baize indicate a minimum separation of about 0.5" in 1967.5 (Figure 2); if there was an eclipse it would therefore not have been total.

Zinner (1931) summarized controversies that had arisen as to whether or not zeta Herculis is actually variable. Zinner considered the range of Herschel's estimates as being well within their probable errors. Backhouse (1902) made some 95 observations between 1874 and 1897. The extreme values ranged from 2.75 to 3.18V, but most of the observations were close to their average. Although he concluded that the star varied slightly at short intervals, the evidence is not convincing. T. Lewis (1901) considered the primary as a double varying in a period of about 17 years, but this was refuted by other observers. Now component A is a known spectroscopic binary with a period close to that of the visual double (Batten *et al.* 1987). The NSV catalogue gives a range 2.78-2.85V but the source is obscure. The USNO *Photometric Catalogue* (Blanco *et al.* 1979) gives values ranging only from 2.79 to 2.82, while Mermilliod (1983) gives 2.835V.

In view of the 2.6 magnitude difference between the two components, the expected amplitude of combined light in the event of an eclipse would be well within the uncertainties of the early visual or photographic observations. Nevertheless, I quickly scanned about 300 Harvard patrol plates bracketing intervals when eclipses might have occurred, but found no significant variation.

As both gamma Virginis and zeta Herculis are included in the NSV, I requested that AAVSO records be searched for possible observations. Michael Saladyga has conscientiously made a thorough search of all records and archival materials at the AAVSO but could find no observations of these stars.

4. Summary

The variability or otherwise of either gamma Virginis nor zeta Herculis has never been adequately confirmed. Photoelectric observers are urged to make observations frequently over a period of at least a year or two to establish or refute short period variations. In the first decade of the 21st century not only photometry but also astrometry is to be encouraged for precise observations of both magnitudes and separations of the components in order to ascertain just how closely they appear to approach one-another.

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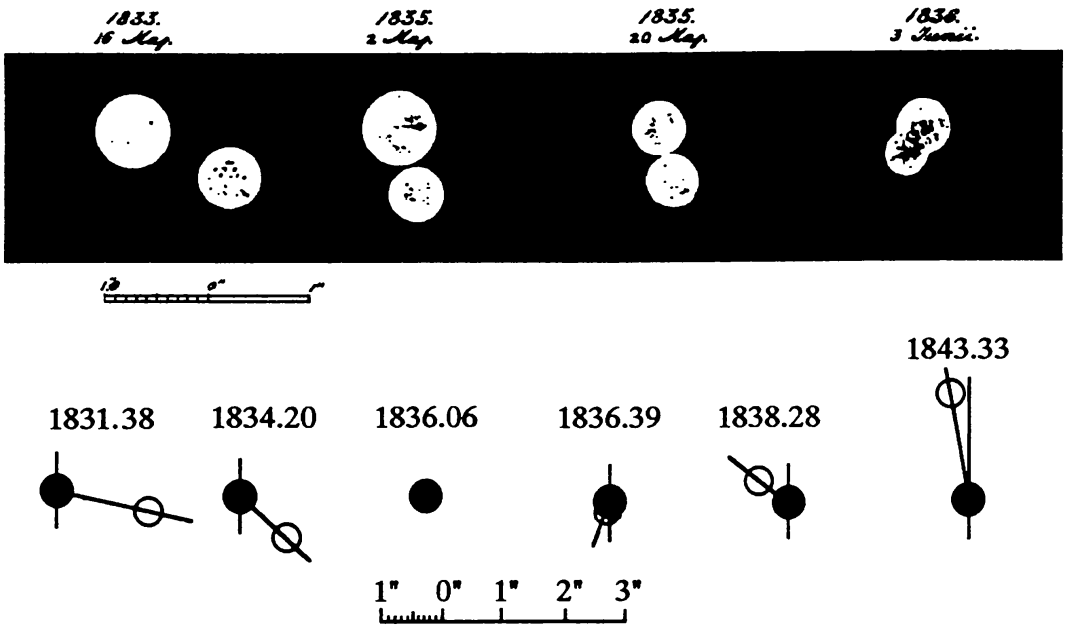

Figure 1. Upper strip: observations by Otto W. Struve of separations and position angles for gamma Virginis. Lower strip: the observations by W. H. Smyth.

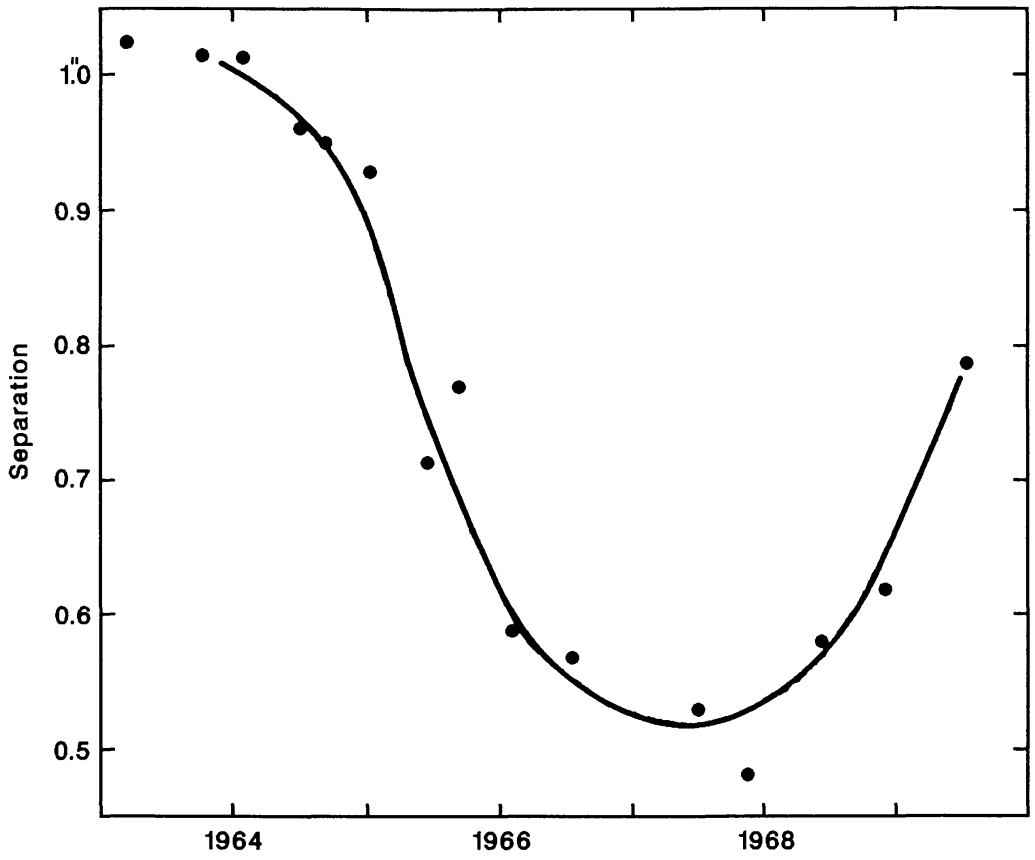

Figure 2. The separations of the two components of zeta Herculis according to Baize for the years 1963 to 1970, showing that an eclipse could not have been total.