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HISTORICAL ARCHIVE PHOTOMETRY OF μ CEPHEI

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One aspect of proposed “virtual observatory” schemes that is largely ignored is making available archival data in the published literature. In the case of variable stars these provide a crucial element missing from the mass of contemporary data: significant temporal baselines. For many variables the actual published dataset is quite meager. For short-period variables (*e.g.* RR Lyrae and eclipsing variables), often only times of minimum/maximum are published, but not the observations from which these were derived. Thus the data cannot be reanalyzed with current methods to measure phase and period changes, for example. Nevertheless, the total number of observations available is comparable to the all the amateur visual data collected by international variable-star organizations. Yet it remains “hidden” both by incomplete on-line bibliographic indexing and by the simple fact that much of the data are in what are now considered to be obscure journals and observatory publications, most no longer published at all.

As a way of indicating what is available for one bright, well-studied variable, I have collected visual estimates and BV photoelectric photometry for μ Cephei (HR 8316 = HD 206936), Herschel’s “Garnet Star”, the fourth-magnitude M-supergiant in southern Cepheus near the IC 1396 nebula complex. The star has been well-observed visually for over 150 years, despite its rather small amplitude, which makes meaningful visual magnitude estimates difficult.

The historical visual data has been thoroughly summarized by Hassenstein (1938), who provided about 2100 mean values from some 10,000 observations by numerous observers. About half the data are by a single observer, Joseph Plassmann, whose remarkable and consistent series covers a 55-year interval. The data in Hassenstein’s monograph extend from the year 1848 to 1938, and include dense series of visual observations in the 1930s by Plassmann and by the well-known astronomer Dean McLaughlin (1946), as well by Hassenstein himself. Roughly another 5000 observations are worked over. The whole collection is placed on a common photometric zero-point, which from internal evidence turns out to be very nearly $m_v = V + 0.2$. About half a dozen individual observations spanning $\sim 20^d$ goes into each mean value. I have excluded most of the data given only in the text (rather than the main table of the appendix), since these add very little, and are often noted by Hassenstein as being unsatisfactory (just too scattered) even after systematic errors are taken into account.

Hassenstein’s compendium has no large gaps apart from a span of somewhat more than a year in 1866-67, and the ten years ending in 1882, when Plassmann started observing

the star. Several hundred important early observations were made by Julius Schmidt, Friedrich Argelander, and Eduard Heis.

The 1938 monograph and a later paper (Hassenstein 1954) include some 200 *photoelectric* observations made using the Potsdam 30cm refractor with an unfiltered blue-sensitive tube. The magnitude differences supplied for the comparison stars (the red giants 12 Cep = HD 207528 and 20 Cep = HD 209960) match the standard B system within 0^m01 , so I have used modern B magnitudes for those stars to derive B for μ Cep in the lists. (Hassenstein published magnitudes with the zero-point adjusted to that of the visual system of the 1938 monograph—reasonable at the time—but luckily he also showed magnitude *differences* in his tables.) The night-to-night *rms* scatter in these data is 0^m03 to 0^m05 , versus $\sim 0^m15$ for the visual data. The main value in the photoelectric data is to show that the visual observations by Plassmann and McLaughlin in the 1930s are excellent, and to extend the dataset until 1940.

Larsson-Leander (1963) obtained about five years of V and $P - V$ (similar to $B - V$) photoelectric observations of high-quality (*rms* $\sim 0^m015$ in V) in the late 1950s. The data density is such that it can replace the visual record of the star for this interval. Indeed, Larsson-Leander compares the contemporaneous AAVSO lightcurve with his photoelectric series, showing that the visual data indicate spurious activity when the star was constant—another indication of the difficulty of visual observations of small-amplitude variables.

More recently, photoelectric observations have been made rather intermittently, but even so, a significant range of Julian dates is covered with data that is superior to the visual record. Useful series have been published by Johnson *et al.* (1966), Coyne & Kruszewski (1968), and by Krisciunas (1986). A longer series has been published by Dombrovsky *et al.* (1968, 1970, 1971, 1972, 1974), and continued by Polyakova (1975, 1978), as part of work on the variability of polarization in this and other late-type variables.

To the best of my knowledge this is the sum of published visual and broadband photoelectric data on the star not included in amateur variable-star databases, and is not published electronically (*e.g.* Hipparcos). Percy *et al.* (1996) describe photoelectric observations obtained by members of the AAVSO. These 456 observations cover an interval of 2200 days (Dec. 1986–Dec. 1992); the data were not published with the paper, but are available by request from the AAVSO. In a recent conference poster, Percy *et al.* (2001) indicate they have obtained a further ten-year series of photoelectric observations using robotic telescopes, which will significantly extend the photometric record for the star.

The archival data have been analyzed many times (*e.g.* Ashbrook *et al.* 1954, Sharpless *et al.* 1966, Polyakova 1975). It is worth noting that Ashbrook *et al.* and Sharpless *et al.* use only the Plassmann data from the Hassenstein monograph, but interpolated it so as to produce a uniform 40^d sampling interval, reducing the dataset to some 500 points, which was required for their relatively primitive lightcurve analysis. Even the more elaborate analysis of Mantegazza (1982) restricts itself to this coarsely-binned dataset excluding all modern data. Polyakova is the only author to include photoelectric data in her analysis. Finally, an analysis of recent visual data by Brelstaff *et al.* (1997) remains the best available despite its restricted dataset. Specifically, they show that periods found by others near 700^d and 950^d are aliases of a $\sim 850^d$ period nearly always present in the data since 1848, where the star dips down to $m_v = 5.0$ – 5.2 .

The historical data files are separated into four sections as follows:

5015-t1.txt (62 kB),
5015-t2.txt (11 kB),
5015-t3.txt (7 kB),
5015-t4.txt (7 kB).

These are plain ASCII tables showing Julian Dates, magnitudes, colors, and bibliographic information. 5015-t1.txt contains the bulk of the old visual observations assessed and homogenized by Hassenstein; 5015-t2.txt gives Hassenstein's own visual and photoelectric observations, including delta-magnitude values; 5015-t3.txt lists Larsson-Leander's photoelectric observations; 5015-t4.txt shows photoelectric observations from other sources mentioned above. The files are accessible in the IBVS website, and copies of the files have been submitted to the 'vsnet' service (<http://www.kusastro.kyoto-u.ac.jp/vsnet>), and will also be kept at the Lowell Observatory ftp area (<ftp://ftp.lowell.edu/pub/bas/varseq>).

In any future study of the star's variability, these data should of course be merged with the visual observations that continue to be collected nightly by amateur observers worldwide, and archived by various international variable-star organizations. Indeed, it is easy to propose that groups such as the AAVSO, BBSAG, AFOEV, and the Kyoto 'vsnet' organization should spearhead the effort to get the old data into machine-readable form and perform the task of reducing them to a homogeneous photometric scale. Large numbers of fields presently have photoelectric/CCD sequences published to facilitate this. More generally, for stars brighter than about 11^m it is now possible to use the Tycho-2 photometry, corrected to the Johnson system (*e.g.* Bessell 2000), to make zero-point and scale adjustments to the comparison stars and observations of visual and photographic data. Upcoming photometric surveys should allow this calibration to be extended to the faintest variable stars in the literature.

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