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DISCOVERY OF AN ATMOSPHERIC ECLIPSE OF τ PER

We report the discovery of an atmospheric eclipse of the 4.15 year spectroscopic binary τ Per. This G5 III + A2 V system has a highly eccentric orbit ($e = 0.74$) and is oriented such that superior conjunction of the secondary occurs near periastron. The astrometric orbit by McAlister (1981) from speckle observations indicates the inclination is high ($i = 95^\circ \pm 2\overset{\circ}{.}4$). Using an updated spectroscopic orbit kindly provided by M. Fletcher (D.A.O.), we predicted that the A star companion would pass within a projected distance of 2 stellar radii of the G-type primary and behind it on 21.04 November 1984 (JD 2446025.54). This distance is small enough to observe an eclipse of the A star passing behind the outer atmosphere of the primary. With the appulse occurring near periastron, the event would be less than two days long. Since the eclipse depth would be strongly wavelength dependent, being deepest in the ultraviolet region where the A star dominates the composite light, a monitoring program with both the *International Ultraviolet Explorer* satellite and various optical observers was arranged soon after the eclipse predictions from the Fletcher elements were calculated.

Daily observations with the *IUE* began on 17 November 1984, sharing time with other observing programs so that various exposures with the LWP ($\lambda\lambda$3200 – 2000) and SWP ($\lambda\lambda$2000 – 1200) cameras were obtained each day depending on the configuration of the spacecraft. The data are absolutely calibrated to flux levels at the earth. Fine Error Sensor (FES) measurements made in acquiring the star were transformed to broadband V magnitudes to supplement the groundbased optical data.

Broadband photoelectric photometry began at several observatories, weather permitting, on 18-19 November 1984, the same night the eclipse prediction was made known. The telescope apertures were 14-inch for Barksdale, 16-inch for Fried, 8-inch for Hopkins, 8-inch for Landis, and 11-inch for Louth. Differential

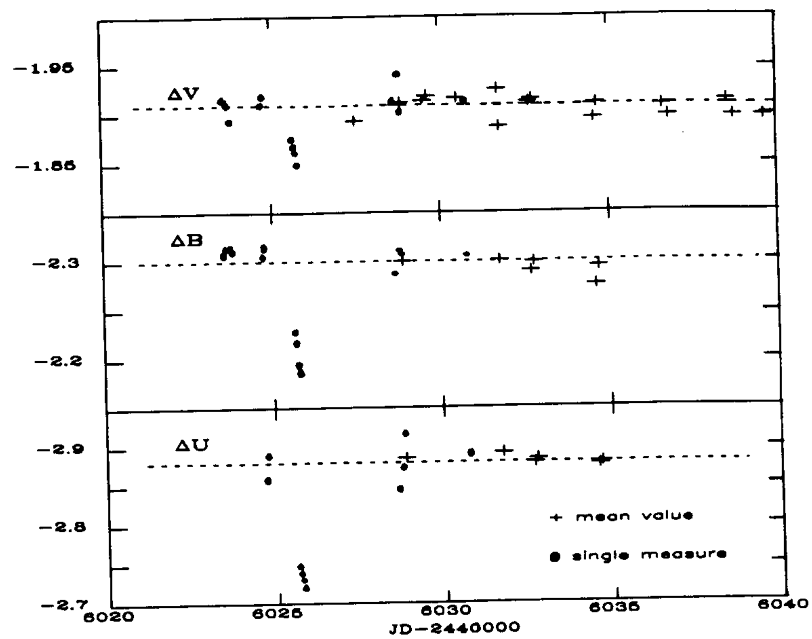

Figure 1

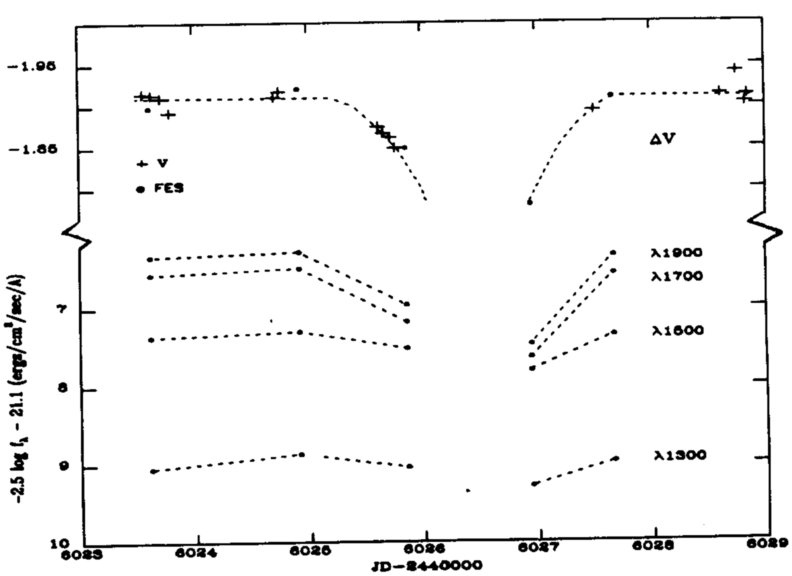

Figure 2

measures were made with either HR 787 or γ Per as comparison stars. The resulting differential magnitudes, corrected for extinction and transformed to the UBV system, have been sent to the *I.A.U. Commission 27 Archive for Unpublished Observations of Variable Stars* (Breger 1982), where they are available as file no. 140.

Figure 1 shows the light curve in UBV from JD 2446022 to 2446040, although observations continued through 2446057. The mean differential magnitude outside eclipse was $\Delta V = -1^m.91$, $\Delta B = -2^m.30$, and $\Delta U = -2^m.88$ for the observations using HR 787 as the comparison star; the corresponding values for those using γ Per were $\Delta V = +1^m.00$, $\Delta B = +1^m.06$, and $\Delta U = +1^m.11$. These differences (all consistent, within a couple of hundredths of a magnitude, with those derived from UBV magnitudes in the 1982 *Yale Bright Star Catalogue*) were used to plot all differential magnitudes on the same ordinate in figure 1, even though two different comparison stars were used. For those points which are means of 2 to 4 individual differential measures, the internal errors are typically $\pm 0^m.004$; the external errors of course are larger, but probably no more than about $\pm 0^m.01$. FES measurements were transformed to magnitudes using the dead-time correction in Holm and Rice (1981) and were plotted with the differential V observations by requiring the first three pre-eclipse measures to average $\Delta V = -1^m.91$. Internal errors are $\pm 0^m.01$, but the repeatibility of the FES is known to be only about $\pm 0^m.03$.

It is clear from figure 1 that a portion of the descending branch was observed on one night, with the eclipse depth increasing with decreasing wavelength. As of JD 2446025.764, the lowest ingress point, the light had dropped by $0^m.06$ in V, $0^m.12$ in B, and $0^m.16$ in U. With the FES measures, the V light curve shows 2 and perhaps 3 points on the ascending branch prior to fourth contact. On JD 2446026.94, the eclipse depth is at least $0^m.13$ in V. If we require the eclipse to be symmetric, the center occurred on JD 2446026.48 $\pm 0^d.05$ and the total duration lasted between 2.3 and 3.1 days. The central part was insufficiently covered to discover whether it was total or partial.

In the ultraviolet continuum, the eclipse depth (figure 2) increases from $0^m.35$ at 3200 Å to $1^m.15$ at 2500 Å, where it remains constant until 1600 Å. Shortward of this, the eclipse becomes shallower with decreasing wavelength, being only $0^m.25$ deep at 1250 Å. The UV spectra during eclipse are found to have added line absorption due to the atmosphere of the G star superimposed on the A-type spectrum. Low-excitation lines of Mg I, Cr II, Mn II, Fe I and Fe II have been identified, which are characteristic of atmospheric eclipsing systems such as 22 Vul (Ake, Parsons, and Kondo 1985). In such a situation, we would expect that the eclipse *duration* should increase towards the ultraviolet, but our observations are insufficient to show this was the case. By themselves, the *UBV* data alone are no inconsistent with the eclipse being strictly geometric.

T. B. AKE[1]
Computer Sciences Corporation
Space Telescope Science Institute
Baltimore, MD 21218 U.S.A.

F. C. FEKEL, JR.[1] and D. S. HALL
Dyer Observatory
Vanderbilt University
Nashville, TN 37235 U.S.A.

W. S. BARKSDALE
633 Balmoral Road
Winter Park, FL 32789 U.S.A.

H. J. LANDIS
A. A. V. S. O.
50 Price Road, West
Locust Grove, GA 30248 U.S.A.

R. E. FRIED
Braeside Observatory
P. O. Box 906
Flagstaff, AZ 86002 U.S.A.

H. LOUTH
2199 Hathaway Road
Seeho Woolley, WA 98284 U.S.A.

J. L. HOPKINS
Hopkins-Phoenix Observatory
7812 West Clayton Drive
Phoenix, AZ 85033 U.S.A.

[1] Guest Observer, *International Ultraviolet Explorer*

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