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1 PER : A NEW ECLIPSING BINARY WITH A LONG PERIOD AND AN ELLIPTICAL ORBIT

The bright star 1 Persei (HD 11241, BS 533, m_V = 5.52, Sp B1.5V) was used as a standard star in the Geneva photometric system. 192 reliable measurements have been made in that system during the last twenty years. All but a few gather around V = 5.519 with a reasonable r.m.s. deviation of 0.012. In 1975 already, three discrepant measures lead one of us (F. Rufener) to suspect this star of being an eclipsing binary. Since 1975 the star was monitored visually by a group of French amateur astronomers directed by A. Figer (the GEOS), who were able to observe both minima and managed to derive a correct period and to prove the excentricity of the orbit. In the meantime, Kurtz (1977) published partial photometric results, showing part of a descending branch in the primary minimum, and part of the ascending branch of the secondary minimum; this proved definitely the binary nature of 1 Per but was not sufficient in itself to give the period. Many attempts were made to observe this star in the Geneva system from Gornergrat, but bad weather prevented us to obtain more than an ascending branch in the primary minimum, and the ascending wing of the secondary.

The results from both Kurtz and Geneva group are displayed in Fig. 1-3. Kurtz's measures (made in the y filter of the uvby system) were adjusted to ours by adding $0^m.031$. Points were plotted according to the ephemeris

$$\text{H.J.D. (short min.)} = \underset{\pm .003}{2443562.853} + \underset{\pm .0005}{25.9359}\ E$$

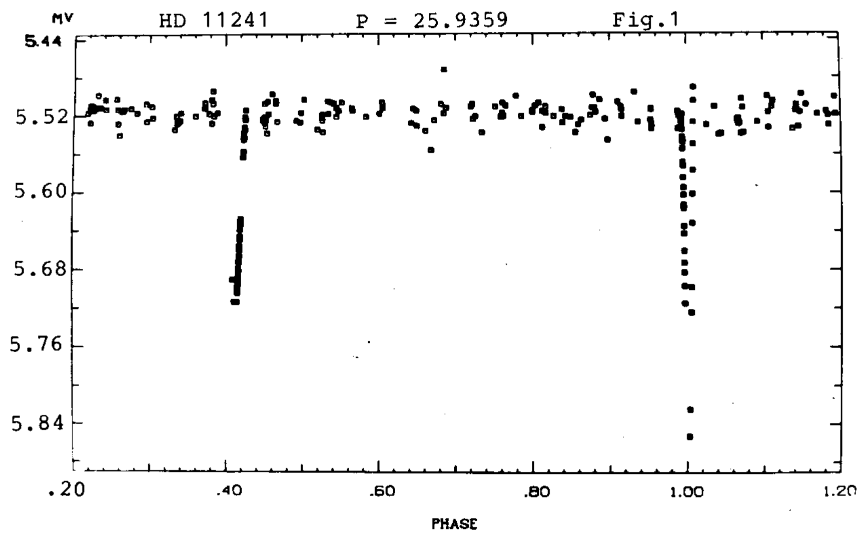

Fig. 1 : Lightcurve of 1 Per plotted according to the ephemeris HJD (short min) = 2443562.853 + 25.9359 E. Open squares: Geneva observations. Full squares: Kurtz's data corrected by $0^m.031$.

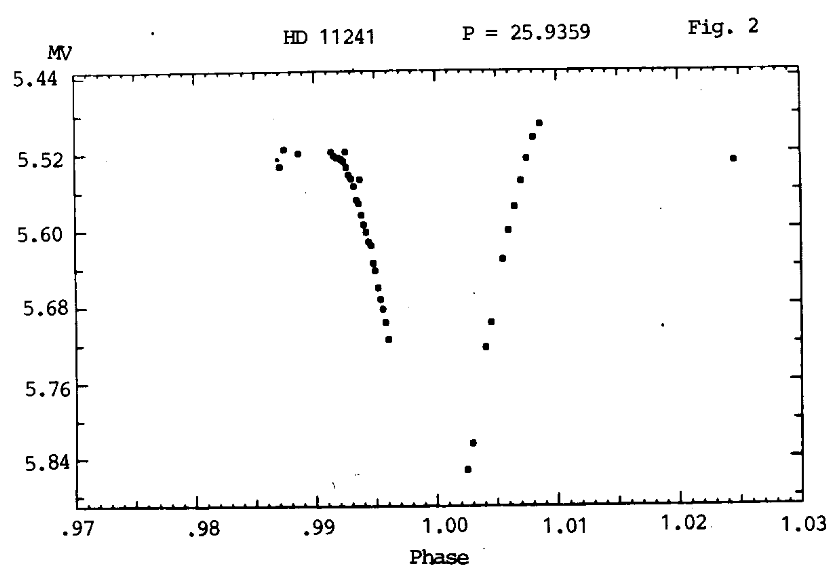

Fig. 2 Primary minimum. Same symbols as in Figure 1.

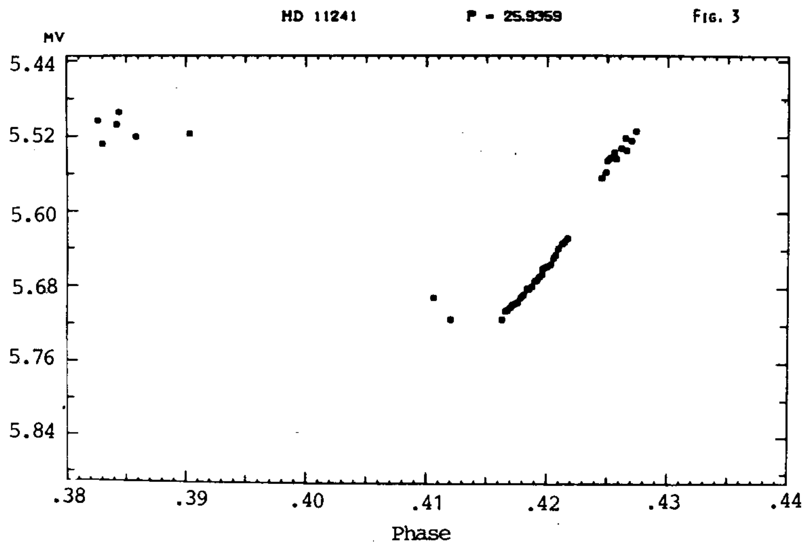

Fig.3 Secondary minimum. Same symbols as in Fig.1.

The secondary minimum is at phase $\phi = 0.4141 \pm .0004$, which lead to an approximate value of the projected excentricity: $e \cos\omega = .135$. The durations of the eclipses are respectively $D_I = 10.6$ hours and $D_{II} = 16.5$ hours (if we admit the secondary minimum to be symmetrical), but these values are rather lower boundaries to the real durations defined by the (external) tangential contact. No obvious colour changes have been noticed during eclipses, apart from a possible effect in [U-B] during the ascending branch of the primary minimum, which was observed differentially with HD 11215 in the night of 21-22 January, 1981. If this effect is real (only a rough reduction has been made, and the night was not of top quality), then it amounts only to $0\overset{m}{.}01$ or $0\overset{m}{.}015$, and indicates that the occulting star is very slightly hotter than its companion. Nothing can be said about possible colour changes in the secondary minimum, since it was not measured with sufficient accuracy (only three measures of absolute Geneva photometry fall in the bottom of it; Kurtz's measures have been made in y only).

The depth of the minimum may be estimated to about $0^m_.40$ for the primary and $0^m_.21$ for the secondary. It was found that this light curve is consistent with the following model:

Two identical B2V stars with $M = 10\ M_\odot$ and $R = 4.3\ R_\odot$, revolving on an excentric orbit with $e = .30$, $\omega = 116^\circ_.7$ or $296^\circ_.7$ (depending on which star is taken as the primary), $i = 87^\circ_.9$ and $a = 100\ R_\odot$. The durations of the eclipses obtained with such a model are respectively 12.2 and 18.8 hours, which may be slightly too long (but it is realistic; see the remark above). A model involving two slightly different stars would be more realistic of course, but the orbital parameters and the radii would not be drastically changed. Anyway, the absence of colour effect greater than $0^m_.015$ forces the companion to be not cooler than about B2V; a B6V companion wold not change the colours, but would be too faint to produce the amplitudes observed. An interesting result is the rather low value of the radii involved: although the model is very rough, it seems difficult to admit radii greater than $4.5\ R_o$ and masses lower than $9\ M_o$ (given the spectral type). So 1 Per would be very near the ZAMS (see e.g. "Basic Astronomical Data", K.Aa. Strand, Ed., Chicago, 1963, p. 290).

It is interesting to consider the radial velocities. They are certainly ill-defined because of the non-recognized binary nature, and because of the rather wide lines. The binarity was however suspected by Batten (1967), who classified this star as B3+B2V, but finally rejected it from his catalogue of spectroscopic binaries; it was classified as B2V by Blaauw and Van Albada (1963) and as B1.5V by Lesh (1968). At least three authors published radial velocities of this star: Cannon (1920) gives eight values in 1914 and 1916, Blaauw and Van Albada (1963) give sixteen observations made in 1956, and Beardsley (1969) fifty-nine values based on old plates taken at Allegheny between 1912 and 1915. A period search was made using the discrete Fourier transform method proposed by Deeming (1975), on the data from Beardsley (1969) and Cannon (1920). A peak arises at P = 25.789 days, very near our photometric period (Fig. 4), which is most encouraging. However, the corresponding radial velocity curve is far from conclusive (Fig. 5) because of its high noise and low amplitude. The above-mentioned model would lead to a peak-to-peak amplitude of about 200 km/s, more than two times what we have! But if there is a blend of two nearly identical lines, such a result is expected. Radial velocities from Blaauw and Van Albada (1963) are also very noisy and are roughly consistent with the others; the 15.6 d period these authors tentatively proposed is surely wrong. According to the above-mentioned model, the stars are at

Fig. 4

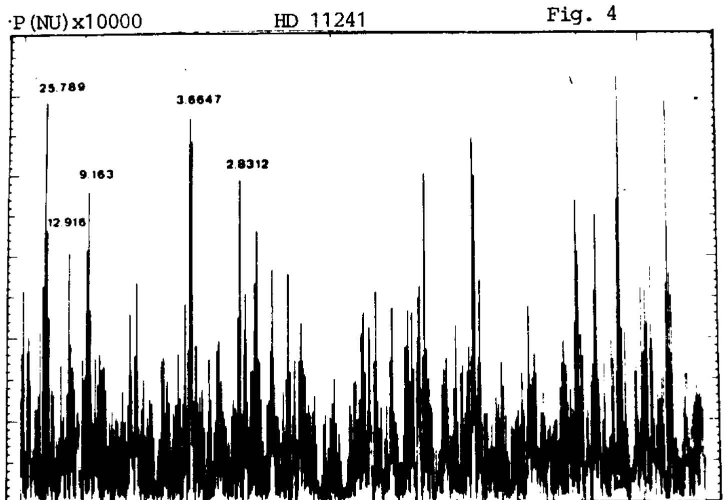

Fig. 5

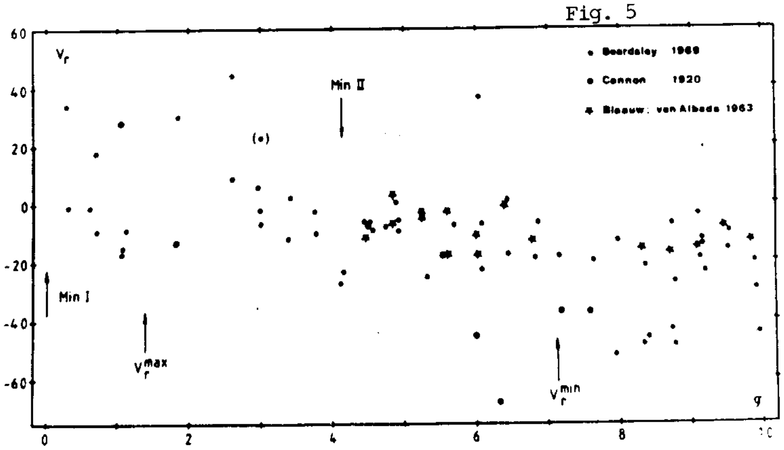

Fig. 4 : Periodogram of radial velocities published by Cannon (1920) and Beardsley (1969). Figures indicate the periods in days.

Fig. 5 : Published radial velocities as a function of the photometric phase.

periastron at phase .039; the maximum radial velocity is +116.7 km/s + V_0 and takes place at phase .138, while the minimum value (-89.0 + V_0) occurs at phase .714. All these values concern the star which is the occulting one at the primary minimum; it is also probably the bluer and the brighter, if both stars are not quite identical.

The rotational velocity has been measured by Sletteback and Howard (1955) who found 210 km/s. As no other measurement has been made, it is not possible to know whether the enlargement of the lines is due to axial rotation or to orbital movement of two identical companions. The latter hypothesis is quite acceptable: the rotational velocity of π And, which is a well known SBII, was once estimated at 250 km/s regardless the duplicity, the real value being less than 50 km/s (Slettebak, 1949 and Slettebak and Howard, 1955).

We think this object is interesting, because high-mass, well separated eclipsing binaries are not very numerous. Here there is no significant deformation or reflection effect, nor mass exchange, etc. Photometrists should complete the light curve and may also try to detect a colour change in the minima. Spectroscopists should also observe this star at high dispersion and try to deconvolve the lines in order to get the individual radial velocities of each component.

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