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Light Curves for AE Phoenicis

Since the discovery of its variable nature in 1964 (Strohmeier et al., 1964) the bright EW binary AE Phe has been the object of intense study. Recently Van Hamme and Wilson (1985) presented the results of a Wilson-Devinney (1971) analyses of Grønbech's (1976) uvby light curves and Duerbeck's (1977) radial velocity curves simultaneously. A contact model was reached, in which the asymmetry of the light curves (see Figure 1) was explained by a "Hot Spot", which was taken to arise from mass being transfered from the primary component. This bulletin details a preliminary analysis which assumes that the light curve asymmetry is due to a maculation ("Star spot") wave. The method and programs outlined by Budding and Zeilik (1987) were employed on the unpublished synthesized V band data obtained at the Canterbury University (NZ) Mount John Observatory in September 1985 by Dr Denis Sullivan and Mr M. Walkington (V.U.W.), who used the V.U.W.- Scanner. This instrument is documented by Sullivan (1976) and 'scans' a star's light across a multitude of fine bands, some of which can be judiciously combined to synthesize a wide band filter.

The effective stellar temperatures and mass ratio of Van Hamme and Wilson's final fit were adopted for our initial fit, modelling just the features expected in a standard eclipsing binary's light curve. The following photometric parameters were produced :

$$\text{Primary Luminosity } L_1 = 29.7 \pm 1.7\ \%$$
$$\text{Primary Radius } r_1 = 0.308 \pm 0.008$$
$$\text{Secondary Radius } r_2 = 0.568 \pm 0.057$$
$$\text{Inclination } i = 86.4 \pm 3.3^\circ$$

We then examined the difference curve obtained by subtracting this initial model from the light curve, and attempted to model it as a maculation wave. A single high latitude (75 °) dark spot of angular radius 37 ± 2 ° and longitude 276 ± 6 ° was found to fit the data best. The ratio of the spot flux to that of the surrounding photosphere was set to zero, thus producing a minimum area spot (Budding and Zeilik, 1987). High latitudes were clearly preferred by our relative χ^2 fitting procedure - the χ^2 values for an equatorial spot was double that of the best fit, with a clear χ^2 gradient in between (Banks, 1989).

High latitude spots appear to be a feature of chromospherically active stars (Rhodes, 1989) indeed II Peg (Vogt and Penrod, 1982) seems to have possessed a polar cap similar to that derived here for AE Phe. As stellar magnetic fields are dynamo dependent, it is not unreasonable to expect

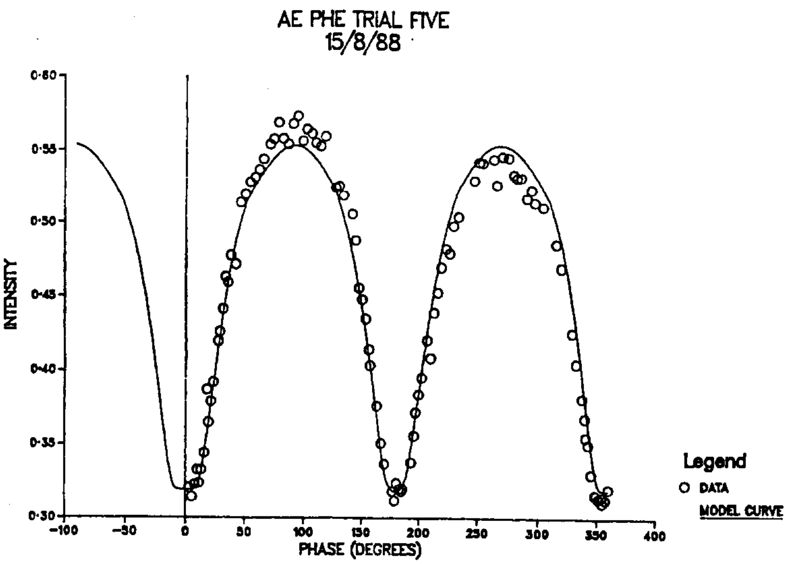

Figure 1: The "V band" data is plotted (dot symbols) against the light curve produced by the initial fit parameters (the smooth line).

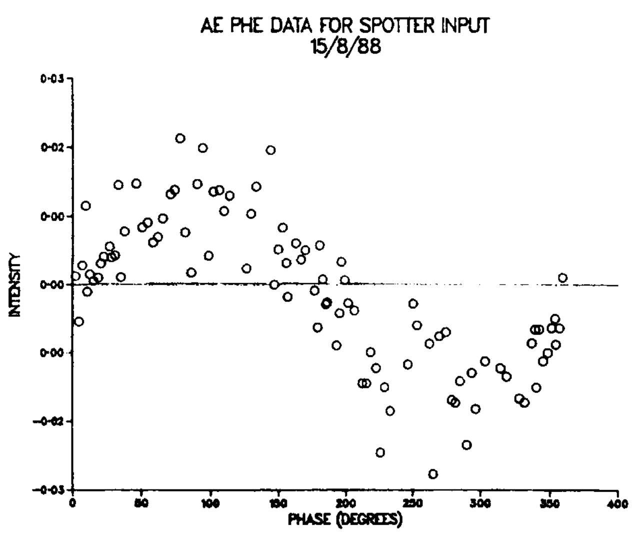

Figure 2: The difference curve resulting from the initial fit.

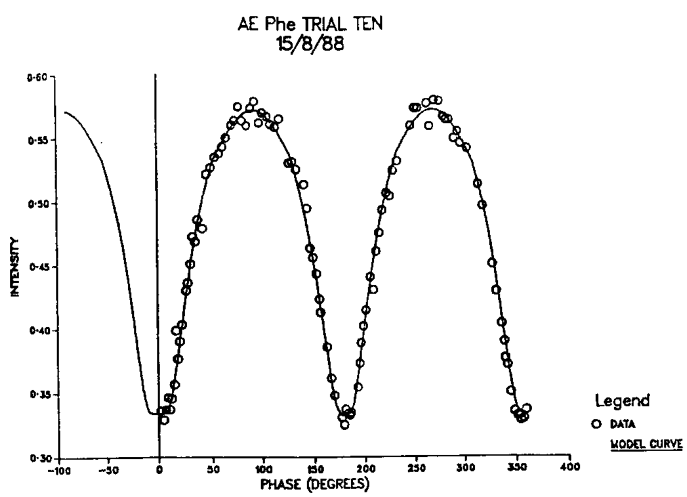

Figure 3: The final fit is plotted against the spot "corrected" data.

starspots, an indicator of such activity, in such short period cool (tidally locked) systems such as EW binaries (Eaton, 1986). However, we note that the existence of a common envelope complicates the matter somewhat.

The hot spot derived by Van Hamme and Wilson was equatorial, at longitude 140 °, and of angular radius 30 °. The parameters were set arbitrarily as these authors considered them not to be critical, as long as the light curve asymmetry was removed. The hot spot is essentially opposite our postulated dark spot, which could be expected as a sinusoidal distortion wave (see Figure 2) can be explained either by a hot spot or a dark region on opposite sides of the star.

The final light curves were formed by subtracting the calculated maculation effects from our original data. The basic parameters specifying this fit are :

Primary Luminosity $L_1 = 28.3 \pm 1.3$ %

Primary Radius $r_1 = 0.308 \pm 0.044$

Secondary Radius $r_2 = 0.483 \pm 0.082$

Inclination $i = 84.8 \pm 0.5$ °

These results are not different to the average parameters derived by Van Hamme and Wilson for their final fit incorporating the hot spot.

Primary Luminosity $L_1 = 31.3 \pm 1.0$ %

Side Primary Radius $r_1 = 0.303 \pm 0.016$

Side Secondary Radius $r_2 = 0.475 \pm 0.013$

Inclination $i = 86.3 \pm 0.3$ °

This result is pleasing, further supporting the contention (Banks and Budding, 1989) that the Wilson-Devinney codes are equivalent to our procedures. The final parameters should agree as they are independent of the method of accounting for the light curve asymmetry.

The 1975 - 1977 UBV observations of Walter and Duerbeck (1988) displayed marked, and relatively fast, variations with time, that could perhaps be explained in terms of spot evolution. An alternative explanation lies in fluctuations of the mass exchange rate postulated by Van Hamme and Wilson, although such a model requires a Coriolis "force" deflection of some 125 ° in a contact system! Indeed, Van Hamme and Wilson estimate 19% over-contact for AE Phe. To test either hypothesis would require further light curves of AE Phe to be obtained frequently in as short an observational period as possible, allowing similar analyses to these two studies to be performed.

Finally, we would like to note that such a sinusoidal difference wave resulting in an initial fit for a contact system, as we have seen here, might be better explained by a shock wave, presumably originating at the connecting neck between the components. Theoretical work on such an idea appears yet to be performed, and could prove rewarding.

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