THE VW CEPHEI SYSTEM

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It is well known that the original Lucy CCE model (Lucy, 1968a, 1968b) was unable to represent W-subclass light curves of W Ursae Majoris stars. Lucy's zero order barotropic model, with gray atmosphere limb darkening produces a deeper transit eclipse and zero color variation with phase. These predictions disagree with observation. Changing the limb darkening coefficient alone, within acceptable limits, cannot deepen occultation eclipse enough to make it deeper than the transit eclipse, as observations require.

Changing the bolometric albedo, A, and the gravity brightening coefficient, b, from their barotropic values of 0.0 produces a baroclinic photosphere. The hydrodynamic consequences have not been investigated. Part of the controversy between Lucy and Shu (Lucy, 1976; Lucy and Wilson, 1979; Shu, 1980; Shu and Lubow, 1981) involves a disagreement over the proper theoretical values of these coefficients. Lucy asserts that A = 0.5 and b = 0.08 (Lucy, 1967, 1973). Shu and associates (Anderson and Shu, 1977, 1978) maintain that A = 1.0 and b = 0.0.

Light synthesis studies of VW Cephei show that values of A and b within these ranges cannot reproduce the observed light curves, assuming nominal limb darkening of 0.6 and an orbital inclination of $i = 66.7^\circ$, adopted from Lucy's original solution (Linnell, 1982b). Shu and associates suggest a reduction in limb darkening to zero. This would deepen the occultation eclipse relative to the transit eclipse, but zero limb darkening is objectionable on physical grounds.

Wilson and Biermann (1976) have generated W-type light curves by assuming von Zeipel values, b = 0.25 or larger, together with large positive A values, or negative A values in some cases. Since von Zeipel gravity brightening violates zero radiative flux divergence on equipotential surfaces, and leads to Eddington-Sweet circulation currents which tend toward isothermal equipotentials, b values approaching 0.25 lack theoretical justification, even for radiative envelopes.

The canonical explanation of W-subclass light curves, using the postulate of a hot secondary, by Rucinski (1973,1974), meets difficulty in a uv study of W UMa, as Eaton, Wu, and Rucinski (1980) have shown. Light synthesis simulation demonstrates that a hot secondary model produces a color change at secondary minimum opposite to that observed

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(Linnell, 1982b). The hot secondary model, in its simplest form, therefore is inadmissible.

A possible model adopts elevated temperatures on the facing hemispheres. This model produces acceptable color curves and light curves (Linnell, 1982b). Two physical interpretations of this model are possible. One attributes the observational effects to starspots on the more massive component, in accordance with a theoretical model by Mullan (1975). There is separate evidence for starspot activity in this star (Linnell, 1982a). However, an exclusive interpretation in terms of starspots would require an extremely smooth underlying starspot distribution, with starspots at all longitudes but concentrated on the opposed hemisphere of the primary, together with localized starspot development in time intervals of a few days. The starspot concentration is opposite to that expected theoretically. The exclusive starspot hypothesis would leave no room for thermal effects of a mass circulation model, such as that proposed by Webbink (1977). Some form of mass circulation model is necessary to explain the Lucy paradox. The second physical model adopts localized starspot activity to explain cycle-to-cycle light curve changes and the O'Connell effect. The temporally stable temperature excesses on facing hemispheres, and the observationally-indicated transverse temperature gradient then prospectively become the observational signature of the energy transfer process.

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