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THE ENIGMATIC ECLIPSING BINARY W CRUCIS: AN APPEAL TO SOUTHERN OBSERVERS

W Crucis (HD 105998, α = 12h 09.6m, δ = -58° 30', epoch 1950.0) is one of the most puzzling eclipsing binaries in the sky. It is sufficiently bright to be easily accessible to observations (its V magnitude varies approximately between 8 and 9.5 mag), but its rather long period, 198.53 days, makes it less attractive to observers. Yet there are some most exciting rewards for those who take a look at it.

The next primary eclipse is predicted for 1984 July 11.88, if we accept the ephemeris T = 2440731.6 + 198.53 E, essentially based on O'Connell (1936). The difficulty with such a long-period system is that a small error or a small change in the period may shift the mid-eclipse by several days either way. The eclipse is broad and its duration hard to define, since the light variation, at least in the B spectral region, is continuous. From O'Connell's photographic light curve, it appears that the steep branches of the primary eclipse last some 30 days each, and the photographic magnitude variation is about 0.8 mag within this time interval.

An accurate location of the mid-eclipse is very desirable. According to O'Connell, there exists a brief period of totality, but its duration and, in fact, mere existence are strongly model-dependent, and it is almost certain that O'Connell did not (and could not, in 1936) find the correct photometric elements for this enigmatic system.

The mystery begins with the continuous light variation, which is usually labelled the "Beta Lyrae-type light curve"--a most unfortunate designation, but most likely quite fitting here. Why should such a large system contain stars so tidally distorted and apparently nearly in contact? The primary star (the one eclipsed at the primary eclipse) has a spectrum of a G1 Iab supergiant, and its radial velocity curve appears to be rather undistorted according to Woolf (1962) (who, incidentally, was the first one to call attention to the many puzzles discussed here). This radial velocity curve yields a large mass function, $f(m) = 5.8\ m_\odot$, implying that the secondary star must be fairly massive --in fact, more massive than the visible star! For example, if we assume 8 $m_\odot$ for the primary supergiant, then the secondary should have almost 15 $m_\odot$. Yet its spectral lines are absent, according to Woolf, even at primary mid-eclipse. Recently, Paul B. Etzel observed the system outside eclipse with the HCO spectral scanner at the 1.5m telescope of the CTIO, and his scan can be satisfactorily interpreted in terms of a single G1-type supergiant, reddened by an amount corresponding to $E(B-V) = 0.30$ mag. Yet the solutions of the light curve by O'Connell and later by Kopal (1941) postulate a secondary star somewhat cooler than the primary (about G8) but roughly twice as large, so that the flux from both stars should be comparable even in the blue!

The system displays Balmer emission lines between Hα and Hδ at all phases, which is something quite unusual for such a late spectral type, and this makes W Crucis rather similar to RX Cassiopeiae. Woolf also noted hydrogen shell lines indicating substantial gas streams inside the system, or mass outflow from it.

Many of these aspects are strongly reminiscent of Beta Lyrae. In Beta Lyrae, we also do not see any absorption lines of the secondary star, although its continous radiation is present. In the past, formal light curve solutions resulted in a later spectral type for the secondary (F5) than for the primary (B8), but today we know that the secondary is a disk which in the far ultraviolet has a higher color temperature than the primary. I have observed

W Crucis with the IUE, but I found no similar disk continuum in the ultraviolet. There is a weak continuum present, but it is probably due to optically thin radiation of a fairly hot circumstellar hydrogen cloud. Fairly strong emission lines of a rather hot circumstellar plasma are also present, mainly Si IV, Si III and Si II, C II and a weaker C IV, Al II and Al III, and Fe III. Observations near the primary eclipse indicate that the line emitting region is probably not much affected by the eclipse, but a cooler component of the circumstellar plasma is. In short, W Crucis is a W Serpentis system (Plavec 1980), but it is more similar to RX Cassiopeiae than to Beta Lyrae.

There is hope that more can be learned from the ultraviolet spectrum if observations are made in and near the predicted totality. For that, new and more accurate eclipse timing is necessary. But, since probably neither star is visible in the ultraviolet, the key to further substantial progress, as in the case of RX Cas, seems to lie in optical and infrared spectroscopy and photometry. I hope that the awareness of this fact will encourage the southern observers to look at W Crucis. A good timing of the forthcoming primary eclipse would be an important first step.

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