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The Unusual Interacting S Star Binary HR 1105

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Abstract. *IUE* observations of HR 1105 over its 596-day orbit show strong orbital modulation of both continuum and emission lines. These are most intense just before both conjunctions and nearly disappear near quadratures, the most intense phase being just before the hot component passes in front of the S star. High dispersion observations exhibit a blue-shifted absorption feature in Mg II, representing an outflow of material of about 55 km s^{-1}. These observations are consistent with the UV source being an optically thin gas stream between the components of the system (Shcherbakov & Tuominen 1992), which is partially eclipsed when the S star is in front.

1. Introduction

HR 1105 is a symbiotic-like, interacting binary comprised of an S3.5/2 red-giant primary and a hot compact companion. The orbit of the primary was determined by Griffin (1984) to be nearly circular at 596 days. Peery (1986) discovered the hot secondary with *IUE*, and Ake et al. (1988) found evidence for orbital modulation of the UV flux, although they could not distinguish between possible sources of the emission (an accretion disk, streaming, or atmospheric heating of the red giant by the hot star). Shcherbakov & Tuominen (1992) found that He I λ10830 has a complex variation of the absorption-emission profile over the orbit, which they argued is due to gas-streaming near the inner Lagrangian point of system. Thus HR 1105 is a prime example of a Tc-deficient S star that is not a thermally pulsing AGB star, but rather is a system where mass transfer has modified the composition of the red giant when the secondary component, which is now a white dwarf, was on the AGB (Johnson et al. 1993, and references therein).

We have undertaken further *IUE* observations of HR 1105 over nearly a complete orbit from 1992–1993, including critical phases near conjunctions of

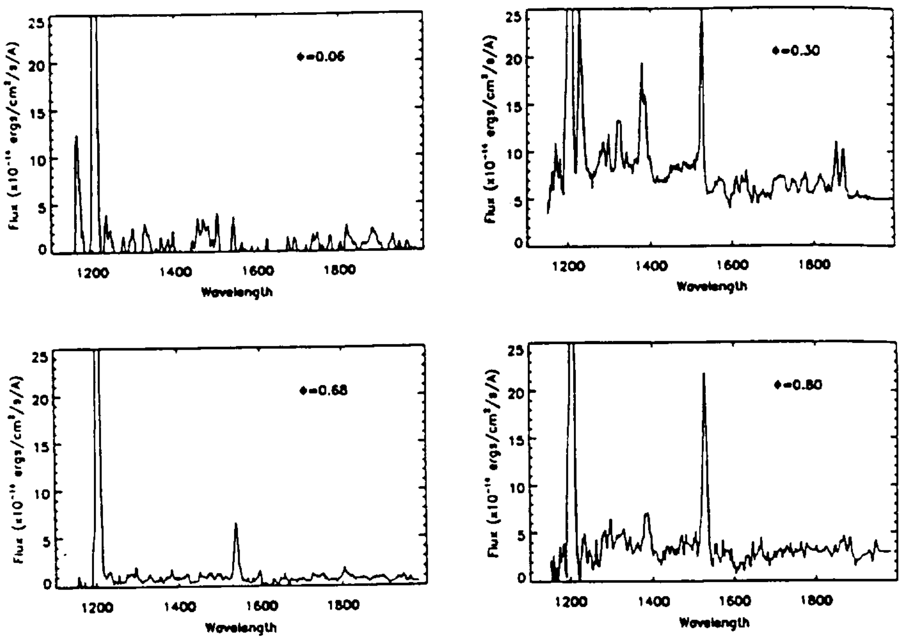

Figure 1. SWP spectra of HR 1105. Phases are determined from the Griffin (1984) orbit, such that the secondary is in front of the S star at $\phi = 0.33$, and the S star is in front at $\phi = 0.88$ The other two figures are near quadratures.

the components and at velocity quadratures. Using other observations taken over several different cycles, we now have *IUE* data over the full orbit.

2. Observations and Analysis

In our *IUE* monitoring program, we obtained low dispersion SWP and LWP/R spectra, and LWP/R high dispersion images of the Mg II emission lines. Because the red giant contributes significant UV light in the LW region, the SWP spectra show the most dramatic variations (Fig. 1). The UV line and continuous emission is most intense near inferior conjunction of the hot companion ($\phi = 0.3$), but reaches a secondary maximum half a cycle later ($\phi = 0.8$). This secondary maximum rules out the UV source as being due to atmospheric heating of the S star by a hot companion since it occurs when the heated face faces away from the observer. At the brightest phases, lines due to N V λ1240, O I λ1300, C II λ1335, S IV λ1400, C IV λ1550, Si III] λ1892, and C III] λ1909 are present. However at $\phi = 0.8$, N V disappears, indicating that the hottest area of the UV source is occulted by the red giant.

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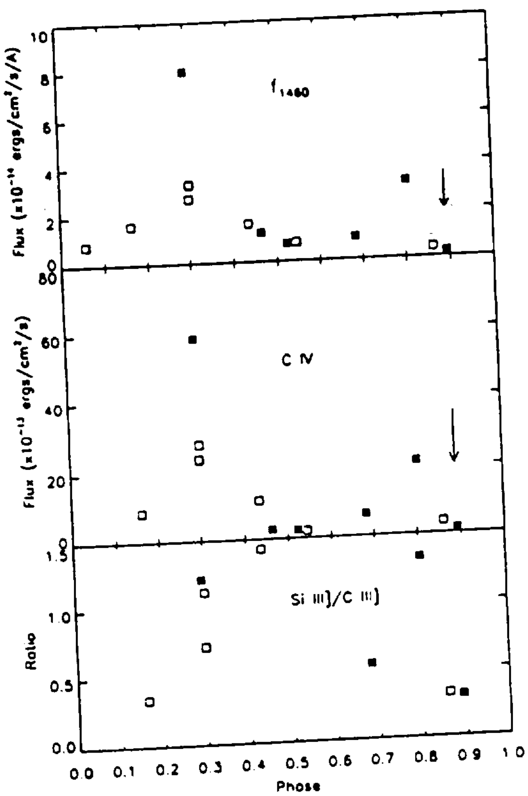

Figure 2. Continuum and line measurements as a function of orbital phase. Open squares are data from 1982-1989 taken over 4 orbits; closed squares are during the same orbit in 1992-1993. The arrow indicates the phase at which the secondary object should be eclipsed.

In Figure 2, we show the orbital variations of various SWP features. We use a 100 Å region centered at λ1460 as a continuum point, f_{1460}, since it is relatively free of emission lines. Other measurements were made of the net integrated line fluxes of the various emission lines. We find that the continuum and emission lines (as illustrated by the behavior of C IV) vary together, reaching maxima near to, but not at, the conjunctions. The Si III]/C III] ratio, which increases with increasing N_e, is also highest at these phases, indicating we are seeing into a denser region then. The lowest recorded fluxes occur at $\phi = 0.89$, which is a sign that the inclination of the system is high and the secondary is partially eclipsed. There is also evidence, based on the multiple observations near $\phi = 0.3$, of a secular variation of the UV flux.

In the LW region, we find that the flux at 3100 Å shows no cyclical variation because of the dominance of the flux from the red giant photosphere in this region. The Mg II lines and flux at λ2600 show similar variations as seen in the SWP, but of smaller amplitude. The minimum Mg II flux is consistent with that of an M giant of similar V−K color as HR 1105. Thus the Mg II lines have contributions from both the S-star chromosphere and the UV source.

In high dispersion, the Mg II profiles show changes in the ratio of the violet to red emission peaks around the centrally reversed absorption core. At $\phi = 0.68$, the line is blue-shifted with respect to the central absorption, indicating it arises close to the red giant since the S star is at maximum velocity of approach at that phase. At $\phi = 0.3$, when the hot component is in front, the Mg II line is much stronger than at other phases, and an absorption trough appears at -78 km s^{-1}. Compared to the systemic velocity, this represents an flow of about 55 km s^{-1} towards the observer. It is unclear whether this feature is seen in all data (i.e., it arises from a wind from the S star), or if it it strongest at this conjunction (i.e., it is formed in a stream).

3. Discussion

Of the possible scenarios for the orbital modulation of the UV flux in HR 1105, the Shcherbakov & Tuominen gas-streaming model is the most consistent with the *IUE* observations. Because the UV source nearly disappears far from conjunction, it cannot be due to atmospheric heating or an accretion disk. The secondary maximum also rules against atmospheric heating. Although detailed observations near the conjunctions are not available, there is evidence that the peak emissions occur at $\Delta\phi \sim 0.1$ before conjunctions, i.e., when looking down a stream of material from the S star towards the secondary. This is also consistent with the appearance of the blue-shifted absorption feature in Mg II. The stream is optically thin since it is only seen at certain orientations. The absence of N V and low fluxes near inferior conjunction of the S star indicate parts of the UV source are eclipsed.

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