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The Effects of Eccentric Accretion Structures on the Light Curves of Interacting Algol-type Binary Stars

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Abstract. The light curves of many Algol-type binary stars are complicated with strange variations. Secular variations are due to the transient nature of the accretion structure, while the phase-dependent features, such as outside-of-eclipse dips, are likely geometrical effects of the accretion structure eclipsing the primary star. Presented here is a model of the ultraviolet light curve of R Arae that explains these variations through the combination of an eccentric accretion structure and the system's orbital inclination.

The orbital period of R Ara is 4.4 days, which is too long to allow for direct impact of the mass transfer stream onto the primary star, but not long enough for a stable accretion disk to form. Such intermediate-period Algols are good candidates in which to find transient and eccentric accretion structures. Other examples of interacting Algols that exhibit outside-of-eclipse dips in their light curves include RV Oph ($P_{orb.} = 3.7$ days) and Y Psc ($P_{orb.} = 3.9$ days).

In order to more accurately model eccentric accretion structures with synthetic light curves, especially at visible (and longer) wavelengths, more work must be done to account for emission by the parts of the accretion structure that are not in the line of sight to the primary star. The model presented here accounts only for the eclipsing regions of the accretion structure.

Keywords. accretion, accretion disks, techniques: photometric, (stars:) binaries: eclipsing

R Ara's peculiar variations are perhaps a cause for its neglectedness. Badly blended absorption lines were reported by Sahade (1952) and photometric variations were detected by Nield (1991) and Banks (1990). It was not until recently that the first ephemeris curve was constructed and analysed by Reed (2011), which provides strong evidence for a continuous period change due to rapid mass transfer within the system.

The detailed analysis of *IUE* data by Reed *et al.* (2010) relies on mass transfer to explain R Ara's photometric and spectroscopic variations. Since the *IUE* data consist of consecutive images spanning one complete orbital cycle, they eliminate the confusion of secular variability and provide insight into phase-dependent variations.

The *IUE* light curves reveal outside-of-eclipse dips that grow deeper at shorter wavelengths, which indicates they are caused by the primary star being eclipsed by something cooler. Spectroscopic evidence strongly supports the model of an eccentric accretion structure surrounding the primary star. Figure 1 illustrates the accretion structure. The light curve is shown in Figure 2.

The geometry of the eccentric accretion, coupled with the system's orbital inclination of 78°, is quite possibly the cause of the phase-dependent variations in the light curve. The method of Doppler tomography, which requires a large set of high resolution spectra with good phase coverage, could reveal the actual shape of the accretion structure and provide further evidence that we are seeing the effects of an eccentric accretion structure on the light curve of this interacting Algol-type binary star.

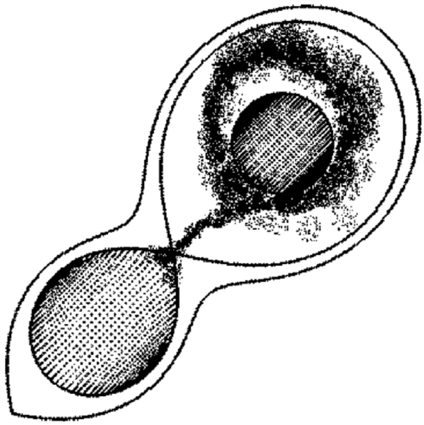

Figure 1: An illustration representing the eccentric accretion structure detected in R Ara. Taken from Reed *et al.* (2010).

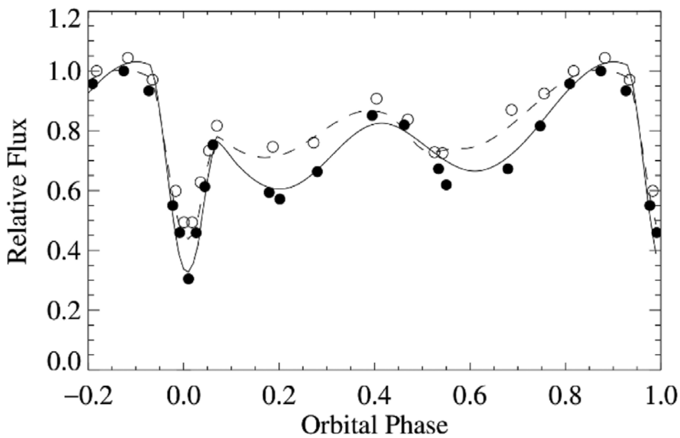

Figure 2: The *IUE* light curve for R Ara. Solid circles are at 1320 Å and open circles are 2915 Å. The solid and dashed lines are the theoretical models. Taken from Reed *et al.* (2010).

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