Stellar Rotation
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Rotational Velocities of S-Type Symbiotic Stars

Francis C. Fekel

Tennessee State University, Center of Excellence in Information Systems, Nashville, Tennessee 37203, USA

Kenneth H. Hinkle and Richard R. Joyce

National Optical Astronomy Observatory, Tucson, Arizona 85726, USA

Abstract. We obtained high-resolution spectroscopic observations at 2.226 μm of 13 S-type symbiotic binaries using the Phoenix infrared spectrograph on Kitt Peak telescopes. From an empirical calibration we determined $v \sin i$ values for the giant components. Combined with information from a program to determine orbits, the rotational velocities have been used to estimate the sizes of these stars and the fraction of their Roche lobes that they fill.

1. Observations

High-resolution spectroscopic observations of 13 symbiotic systems plus several standard stars having a range of $v \sin i$ values were obtained at 2.226 μm with the Phoenix infrared spectrograph (Hinkle et al. 1998) on the 2.1 and 4 m Kitt Peak National Observatory telescopes. The wavelength region covers about 100 Å and was chosen to contain several isolated atomic lines.

2. Measurements and Inferences About Mass Exchange

In each spectrum the full-width at half-maximum was measured for 3 or 4 isolated atomic features. The instrumental broadening was adopted from the width of several water vapor lines in the wavelength region. For the late-type giants with known $v \sin i$ values, we determined an empirical broadening relationship with a procedure similar to that of Fekel (1997). Using that empirical infrared calibration and an adopted macroturbulence of 3 km s^{-1}, we obtained projected rotational velocities for the late-type giants in our observed symbiotic systems. Velocity uncertainties are estimated to be 1 km s^{-1} except for BF Cyg and V1329 Cyg, where the uncertainty is 2 km s^{-1}.

Nearly all symbiotics with well-determined orbital elements have circular orbits. From the work of Zahn (1977) and following Schmutz et al. (1994), we assume that if the orbit of the symbiotic binary is circular or nearly so, the late-type giant in such a system is synchronously rotating and its rotational and orbital axes are aligned. With an estimate of the inclination taken from the literature the projected rotational velocity is converted to an equatorial rotational velocity. Then the radius R of the late-type star can be determined

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from

$$R = (vP)/50.6$$

where R is in solar radii, v is the rotational velocity in km s^{-1}, and P is the orbital period in days. With orbital elements from our published (Fekel et al. 2000a,b; Fekel et al. 2001) and unpublished results plus masses taken from the literature or in some cases canonical values of 1.5 and 0.5 $M_\odot$ for the cool and hot components, respectively, the separation of the two stars follows from Kepler's third law. This leads to the computation of an effective Roche lobe radius from Eq. (2) of Eggleton (1983).

Table 1. Cool giant radius and Roche lobe radius comparison

Star	P_{orb} (days)	v sin i (km/s)	i (°)	R ($R_\odot$)	M_c ($M_\odot$)	M_h ($M_\odot$)	R_L ($R_\odot$)	R/R_L
TX CVn	199	8.9	60	40	1.5	0.5	85	0.47
T CrB	228	5.4	60	28	0.7	1.2	53	0.53
BF Cyg	757	4.5	75	70	2.2	0.6	243	0.29
CH Cyg	756	8.2	70	130	1.5:	0.3:	221:	0.59:
CI Cyg	854	10.4	80	180	1.5	0.5	227	0.79
V1329 Cyg	956	7.0	86	132	2.2	0.75	277	0.48
AG Dra	549	3.6	40	61	1.0	0.5	141	0.43
V443 Her	599	4.5	60	62	1.5	0.5	179	0.35
RW Hya	370	5.0	80	37	1.6	0.5	134	0.28
BX Mon	1259	6.8	85	...	...	...	...	...
AG Peg	818	4.5	60	84	2.6	0.65	273	0.31
FG Ser	634	7.0	80	89	1.7	0.6	193	0.46
V343 Ser	451	5.7	18	144:	1.5	0.5	148	0.97:

Table 1 provides the results for the late-type giants in 13 S-type symbiotic systems. The last column of the table gives the ratio of the giant's radius to its effective Roche lobe radius, indicating how much of the Roche lobe it fills. In agreement with the results of Mürset & Schmid (1999), we find that most of the giants do not come close to filling their Roche lobes.

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