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Pulsation of the late-type star in symbiotic systems

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Abstract. Pulsation has been detected spectroscopically in the late-type star in both D- and S-type symbiotic binaries. Time-series radial velocities reveal Mira stellar pulsation in the late-type star in D-type symbiotics. Orbital motion has too long a period to be detected with current time series. For the S-type systems time series of radial velocities are typically dominated by orbital motion but in some systems "long-secondary period" stellar pulsation is present.

Key words. Stars: pulsation – Stars: atmospheres

1. Introduction

Symbiotics are mass-exchange binary systems typically containing a stellar remnant and an evolved late-type star. We report on time-series infrared spectra obtained to survey the velocities of the late-type star in a sample of both D- and S-type symbiotics. Observations were obtained either with the NOAO near-infrared Phoenix spectrograph on variously the Kitt Peak 2.1 m or 4 m telescopes or the 8 m Gemini South telescope (Hinkle et al. 1998) or with a near-infrared detector blocked with a very narrow-band filter on the 1.88 m telescope and coudé spectrograph at the Mt. Stromlo Observatory (Joyce et al. 1998).

Near-infrared observations are one important technique for probing complex symbiotic mass-exchange systems. In the near-infrared the late-type star dominates the observed signal. From the near-infrared spectrum of the interacting stellar system a single-line spectroscopic orbit and/or information on the cool star component of the system can be derived.

2. D-type Symbiotics

D-type (=Dusty) symbiotics are binary systems containing a Mira variable and a hot degenerate or dwarf star. Near-infrared photometry of D-type systems confirms the presence of a Mira variable. Little additional work has been carried out on these systems.

The D-type symbiotics have long orbital periods for readily understood reasons. A Mira has a photospheric radius of order 1 AU, so has merged with close companions. Miras have

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masses ∼1 $M_{\odot}$. If, as seems typical, the companion is a white dwarf, it has a similar mass, yielding a Roche-lobe filling system with period of at least 20 years. Most D-type symbiotics appear to have periods of many times 20 years and probably none are contact binaries. Kenyon et al. (1988) found H II data consistent with binary separations in excess of 100 AU, corresponding to periods on the order of 10^3 years. Recently Raman spectroscopy by Schmid & Schmid (2002) suggests some orbital periods as short as ∼100 years. Periods close to 100 years seem likely since symbiotic spectral properties, i.e. an optical spectrum combining high excitation emission lines and cool star absorption lines, requires considerable interaction between the binary components.

Over a time scale of a few years, the D-type symbiotics have near-infrared velocity behavior typical for Mira variables observed in the near-infrared (Lebzelter et al. 2005). Mira radial velocity curves are discontinuous near phase 0 due to the passage of a shock through the photosphere. We see this behavior in D-type systems with periods ranging from 388 days for UV Aur to 787 days for V407 Cyg. No orbital motion can be detected over the five year interval these stars were observed. Of our sample of seven D-type symbiotics six have normal Mira velocity curves, confirming that Mira variables are one of the components of D-type symbiotics. The seventh D-type symbiotic surveyed, HM Sge, had a heavily dust-obscured spectrum which interfered with velocity measurements.

3. S-type Symbiotics

Unlike the D-type symbiotics, the S-type systems are not associated with intrinsic stellar pulsation. Variations in the optical photometry are dominated by mass transfer between the late-type star and the degenerate companion. Extensive time-series of high-resolution infrared spectra reveals that, as expected, the velocities of most S-type symbiotics are dominated by orbital motion. However, in a few cases pulsation of the late-type primary makes a significant contribution to the observed velocities. For two systems, XX Oph and CH Cyg, the stellar pulsation plays a dominant role. Surprisingly, in both systems the observed pulsation period is far longer than the star's fundamental pulsation period. Both XX Oph and CH Cyg have period and velocity curves that are very similar to those of long secondary period pulsation in M giants with multiple periods (Hinkle et al. 2002). Multiple period M giants were found to be pulsating with the long period significantly exceeding the fundamental radial pulsation period. The velocity curves for the M-giants and the two symbiotic stars are nearly identical. Wood et al. (2004) found that approximately 25 percent of pulsating AGB stars have long secondary periods and concluded that long secondary periods result from a low degree g^+ mode confined to the outer radiative layers of the red giant.

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