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# Orbits of Post-AGB Stars with Dusty Discs

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**Abstract.** Optical photometry and radial velocities have been obtained for stars whose near- and mid-infrared colours suggest that they have dusty circumstellar discs; many are RV Tauri variables. A subset of six stars have earlier spectral types and smaller light amplitudes than classical RV Tauri stars. All are spectroscopic binaries, with surprisingly short periods.

**Keywords.** Binaries: spectroscopic, circumstellar matter, variables: other

## 1. Introduction

The distinctive near-and mid-infrared colours of the RV Tauri stars (Gehrz 1972; Lloyd Evans 1985) have been recognised as the signature of a dusty circumstellar disc and fifty stars with similar infrared properties have been found to date (De Ruyter *et al.* 2006). The presence of the disc is best explained as the consequence of mass loss during the AGB phase of evolution, with some of the ejected material being trapped in the gravitational field of a binary system (Morris 1987). These stars are not all conspicuously variable in light and cover a greater range of spectral type than the classical RV Tauri stars, which are concentrated near G0 Ib (Lloyd Evans 1999). We discuss here six stars of spectral type F2 to F5.

## 2. Photometric properties

We have photometric data for each of the six stars from at least two of these three sources:

1. Geneva optical photometry, obtained with the 0.7-m Swiss Telescope at La Silla and with the 1.2-m Flemish Mercator Telescope at La Palma.

2. $UBVRI$ photometry from the 0.5-m telescope and the 0.75-m Automatic Photometric Telescope at the Sutherland Observatory of SAAO.

3. $V$ photometry obtained by the ASAS-3 project using small CCD cameras run by Warsaw University at Las Campanas, Chile (Pojmanski 2002).

The amplitudes of pulsation are small, and are variable in IRAS 08544-4431 and in EN TrA, which has been classified as an RV Tauri star in the past. These stars are on the hot side of the instability strip defined by the classical RV Tauri stars (Lloyd Evans 1999), yet the periods are quite long, so they are not likely to be pulsating in a higher radial overtone. Figure 1 shows the phase plot of the $V$ magnitudes for HD 108015 (IRAS 12222-4652).

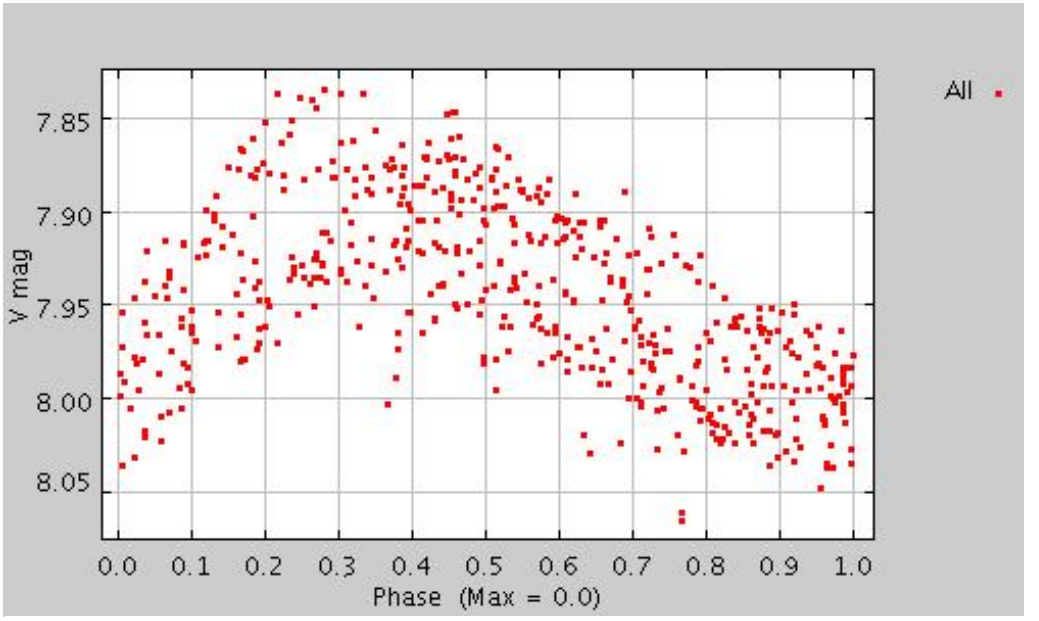


**Figure 1.** Phase plot, on P = 61.0 d, of $V$ photometry of HD 108015, from ASAS-3, SAAO and Geneva photometry.

## 3. Orbital determination

Long-term radial velocity monitoring has been performed as described in Maas *et al.* (2003). These stars are more suitable for orbital determination than an RV Tauri star, as the amplitude of pulsation is less, but attempts to allow for the pulsation velocity directly have not been successful, as the pulsations are not very regular. Figure 2 shows the radial velocity curve for HD 108015 (IRAS 12222-4652): the standard errors in the velocities do not account for all the scatter about the mean curve, as there is a contribution from the pulsation.

## 4. Discussion

Figure 3 shows the e-log(P) plot for the six F stars, together with other RV Tauri and related post-AGB stars for which we have preliminary data. The plot is well populated down to periods of a few hundred days, with some non-zero eccentricities over the whole range. Symbols are: diamonds, our six new orbits (except for the uncertain data for IRAS 19157-0247, denoted by a triangle); squares, other post-AGB stars with dusty discs. Van Winckel *et al.* (2006) have noted that these relatively short periods leave insufficient space to accommodate a full-sized AGB star, emphasising the degree of interaction which must have taken place. The eccentricities also pose a problem, as theoretical calculations predict an absence of eccentric orbits with periods much below 3000 days (Bonacic Marinovic & Pols 2004). The problem is common to several types of post-AGB binaries.

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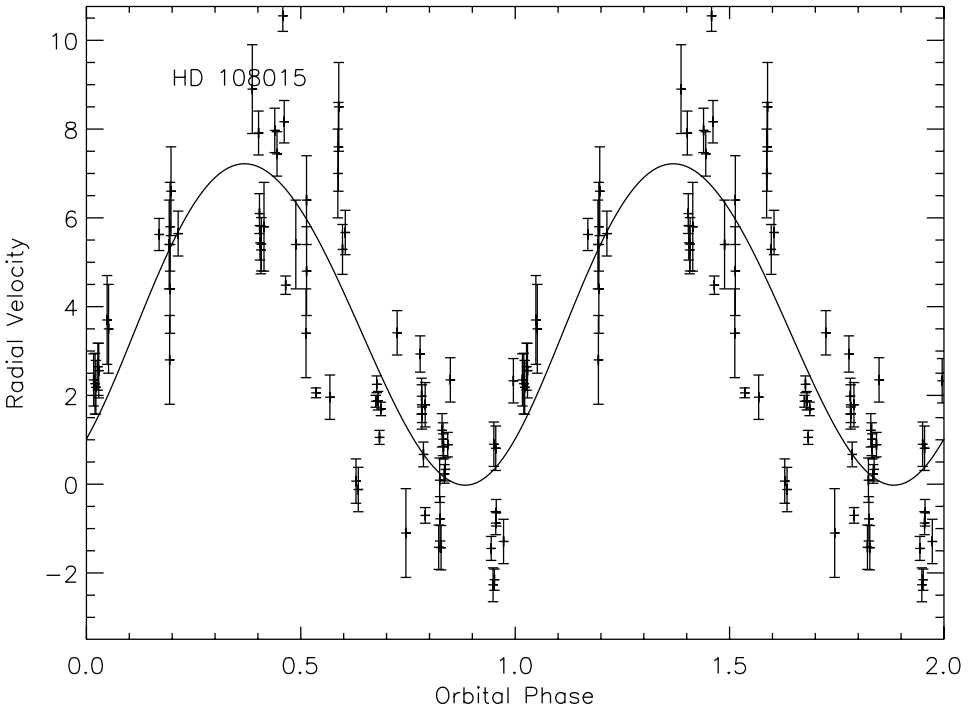


**Figure 2.** Observed radial velocities with error bars and fitted orbital solution with P = 915 d.

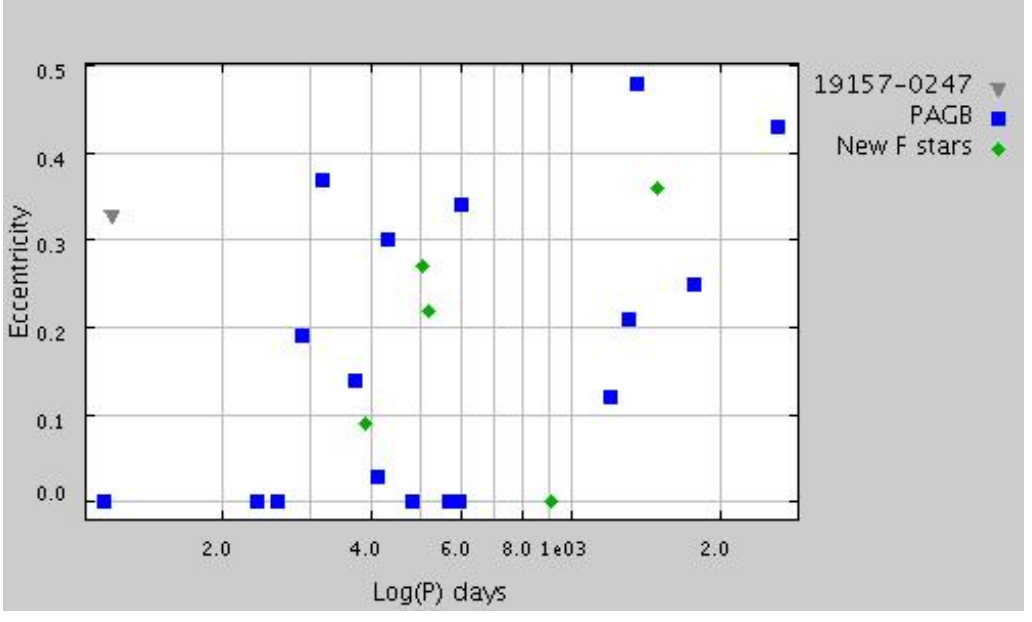


**Figure 3.** Orbital eccentricity as a function of log $P$ for the six stars of small amplitude and for a larger sample of post-AGB stars. The orbital periods are fairly uniformly distributed in log $P$ from 116 to 2600 d.

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## 5. Conclusions

Evolved stars whose spectral energy distributions indicate the presence of a dusty disc are probably all binaries. The e-log(P) diagram shows high eccentricities even at rather short periods, in contradiction to current theory.

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