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Binarity and multiperiodicity in high-amplitude delta Scuti stars

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Abstract.
We present our first results for a sample of southern high-amplitude δ Scuti stars (HADS), based on a spectrophotometric survey started in 2003. For CY Aqr and AD CMi, we found very stable light and radial velocity (RV) curves; we confirmed the double-mode nature of ZZ Mic, BQ Ind and RY Lep. Finally, we detected γ-velocity changes in RS Gru and RY Lep.

Key words. Stars: variables: δ Sct – Stars: oscillations – Stars: binaries: general

1. Introduction

Both binarity and multiple periodicity offer independent methods to determine fundamental physical parameters of oscillating stars. Our aim in this project is to detect binarity or multiperiodicity (or both) in selected bright southern HADS variables in order to combine binary star astrophysics with asteroseismology. Currently, only a few HADS are known in binary systems (e.g. Rodríguez & Breger 2001 listed six such stars), but there are more with suspected binarity.

Here we present our first results for six southern stars. Previous analyses of northern variables can be found in Kiss et al. (2002) and Derekas et al. (2003).

2. Observations

We carried out photoelectric, CCD photometric and medium-resolution spectroscopic observations with four instruments at Siding Spring Observatory (Australia) on approximately 50 nights between 2003 October and 2005 May. The 24″ telescope was used for BVI photometry; CCD photometric data were obtained with the UNSW Automated Patrol Telescope (APT) and with the 1m telescope; for spectroscopy, we used the 2.3m telescope, equipped with the Double Beam Spectrograph.

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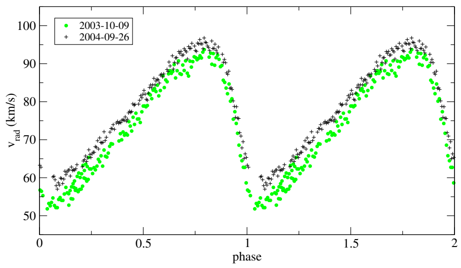

Fig. 1. RV curve of RS Gru phased with P=0.147d.

All radial velocities were determined via cross-correlation, using IAU radial velocity standards.

3. Results

3.1. CY Aqr

5 nights of photometry in 2004 and 2 nights of spectroscopy in 2003 and 2004 revealed: (1) the lack of a secondary period, indicating a light curve that has remained stable over many decades. (2) a stable radial velocity curve, which agrees very well with that of Fernley et al. (1987), but has better accuracy. The absence of a change in mean velocity is consistent with the predicted low-mass companion from the O–C diagram (Fu & Sterken 2003).

3.2. ZZ Mic, AD CMi, RS Gru, BQ Ind

We obtained the first RV curve of ZZ Mic with simultaneous BV light curves. Three nights of photometry confirmed the double-mode nature of ZZ Mic: P_0=0.0671 d and P_1=0.0522 d. We note, however, that the second mode has much lower amplitude (A_1=0.015 mag compared to A_0=0.189 mag). The γ-velocity of ZZ Mic was determined as -7.8 ± 1 km/s.

For AD CMi we measured an accurate RV curve to search for changes in the systematic velocity. Our γ-velocity (35km/s) is in good agreement with Abhyankar (1959) (34.5 km/s), which is the only other measurement published. Our result does not contradict binarity because the O–C analysis suggested a low-mass companion that would cause only tiny velocity shift.

We have been monitoring RS Gru since 2003 October. Two sample RV curves are shown in Fig. 1, where the shift in the systemic velocity is evident. Our data do not have enough coverage of the orbital phase to determine orbital period, but we continue collecting further RV measurements.

We observed BQ Ind on six consecutive nights in 2004, confirming the presence of double-mode pulsations. Our data yielded the same frequencies (f_1=12.192 c/d, f_2=15.768 c/d) as those in Sterken et al. (2003), with no further frequencies in the residuals.

3.3. RY Lep

CCD images were taken on 20 nights in 2004. We identify two main frequencies as f_1=4.4416 c/d and f_2=6.5987 c/d (same as identified in Rodríguez et al. 2004) and their various linear combinations (up to 10 frequencies).

We also obtained radial velocity measurements on four nights in 2004. The data revealed that there was a ~25 km/s γ-velocity shift over the 8 months of observations. This is the first hard evidence for binarity in RY Lep, and the large γ-velocity change suggests a relatively massive companion (comparable to RY Lep).

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