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Radial Velocity Variable sdO/Bs from SPY – Preliminary Orbits of Three New Short Period Binaries

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Abstract. We present new results from follow-up time-resolved spectroscopy of radial velocity variable hot subdwarfs from the SPY project. Medium resolution spectra were taken at the ESO NTT. Preliminary orbital solutions are presented for three single-lined sdO/B binaries. The orbital periods of all binaries are short and the companions are most likely white dwarfs or late main-sequence stars. Follow-up time-resolved spectroscopy is necessary to measure the orbital parameters with higher accuracy. Light curves should be taken in order to search for reflection effects and or eclipses.

1. Introduction

The ESO Supernovae Ia Progenitor Survey (SPY) aimed to find double-degenerate binaries in close orbits (Napiwotzki et al. 2003). The merger of two white dwarfs is considered to be one of the processes, which could lead to a supernovae Type Ia (SN Ia) explosion. A large spectroscopic survey of 1 000 white dwarf (WD) candidates was undertaken using the UVES spectrograph at the 8-m ESO VLT UT2 (Kueyen) to search for radial velocity (RV) variable WDs. About 140 hot subdwarfs of various types were included. Hot subdwarf B stars (sdBs) are considered to be core helium-burning stars with very thin hydrogen envelopes which are situated on the Extreme Horizontal Branch (EHB). The formation of sdBs is still unclear. Different formation channels have been discussed (Han et al. 2003). As it turned out, a large fraction of the sdB stars are members of short-period binaries (Maxted et al. 2001; Napiwotzki et al. 2004b). For these systems common-envelope ejection is the most probable formation channel. Hot subdwarf binaries therefore provide a suitable population to study this very important, but still poorly understood phase of stellar evolution. Most companions of sdBs in such systems are white dwarfs (WDs) or late type main-sequence (MS) stars (Morales-Rueda et al. 2003; Edelmann et al. 2005). Close binary sdB+WD systems, which exceed the Chandrasekhar mass, turned out to be good candidates for double-degenerate progenitors of SN Ia (Maxted et al. 2000; Geier et al. 2007). Measuring the orbits of close binary sdBs is therefore necessary to study common-envelope evolution and a prerequisite for more detailed studies to constrain the system parameters.

Table 1. Orbital periods, radial velocity semi-amplitudes, mass functions and minimum masses of the companions (assuming $M_{\rm sdB} = 0.47\,M_\odot$). The orbital parameters are similar to known close binary sdBs with short periods (Morales-Rueda et al. 2003).

	P [d]	K [km s^{-1}]	$f(M)$ [$M_\odot$]	$M_{2\rm min}$ [$M_\odot$]	
WD 0107−342	0.375 ± 0.05	127 ± 2	0.08	0.39	sdB+MS/WD
HE 1415−0309	0.163 ± 0.03	228 ± 8	0.20	0.62	sdB+WD
HE 1423−0119	0.197 ± 0.01	44 ± 11	0.001	0.08	sdO+MS/WD

2. Observations and Data Analysis

The programme stars were observed at least twice in the course of the SPY project with the high-resolution echelle spectrograph UVES at the ESO VLT (2000–2002). Follow-up observations were undertaken with the medium resolution spectrograph EMMI at the ESO NTT in June 2007. Reduction was done with the ESO–MIDAS package. The radial velocities (RV) were measured by fitting a set of mathematical functions (Gaussians, Lorentzians and polynomials) to the hydrogen Balmer lines using the FITSB2 routine (Napiwotzki et al. 2004a). Sine curves were fitted to the RV data using single-value decomposition, a χ^2 minimising method, and the power spectrum was generated.

3. Orbital Parameters, Minimum Companion Masses and Nature of the Unseen Companions

All three binaries presented here are single-lined systems. This yields an upper limit for the mass of a late main sequence companion of $0.45\,M_\odot$, which should otherwise be visible in the spectrum. HE 1415−0309 has a very short period and high radial velocity amplitude. The minimum mass of the secondary exceeds $0.45\,M_\odot$ and therefore excludes a main sequence companion. It is very near the average mass of DA white dwarfs ($0.59\,M_\odot$; Koester et al. 2001). A high inclination is therefore probable and the system could be eclipsing. HE 1415−0309 is likely to be an sdB+WD binary, but a heavy compact companion cannot be ruled out. HE 1423−0119 is a hydrogen rich sdO star in a close orbit. Due to its low minimum mass the companion may be a late-type MS star. In this case, a reflection effect may be detectable in the lightcurve. The minimum companion mass of WD 0107−342 is compatible with a WD as well as a late MS star.

Assuming orbital synchronization of the binary and measuring the subdwarfs projected rotational velocity $v_{\rm rot} \sin i$ from high resolution spectra, it is possible to derive the inclination of the system as well as the companion mass. In this case the companion is most likely a heavy white dwarf and WD 0107−342 becomes a viable candidate for a SN Ia explosion (see Geier et al. these proceedings).

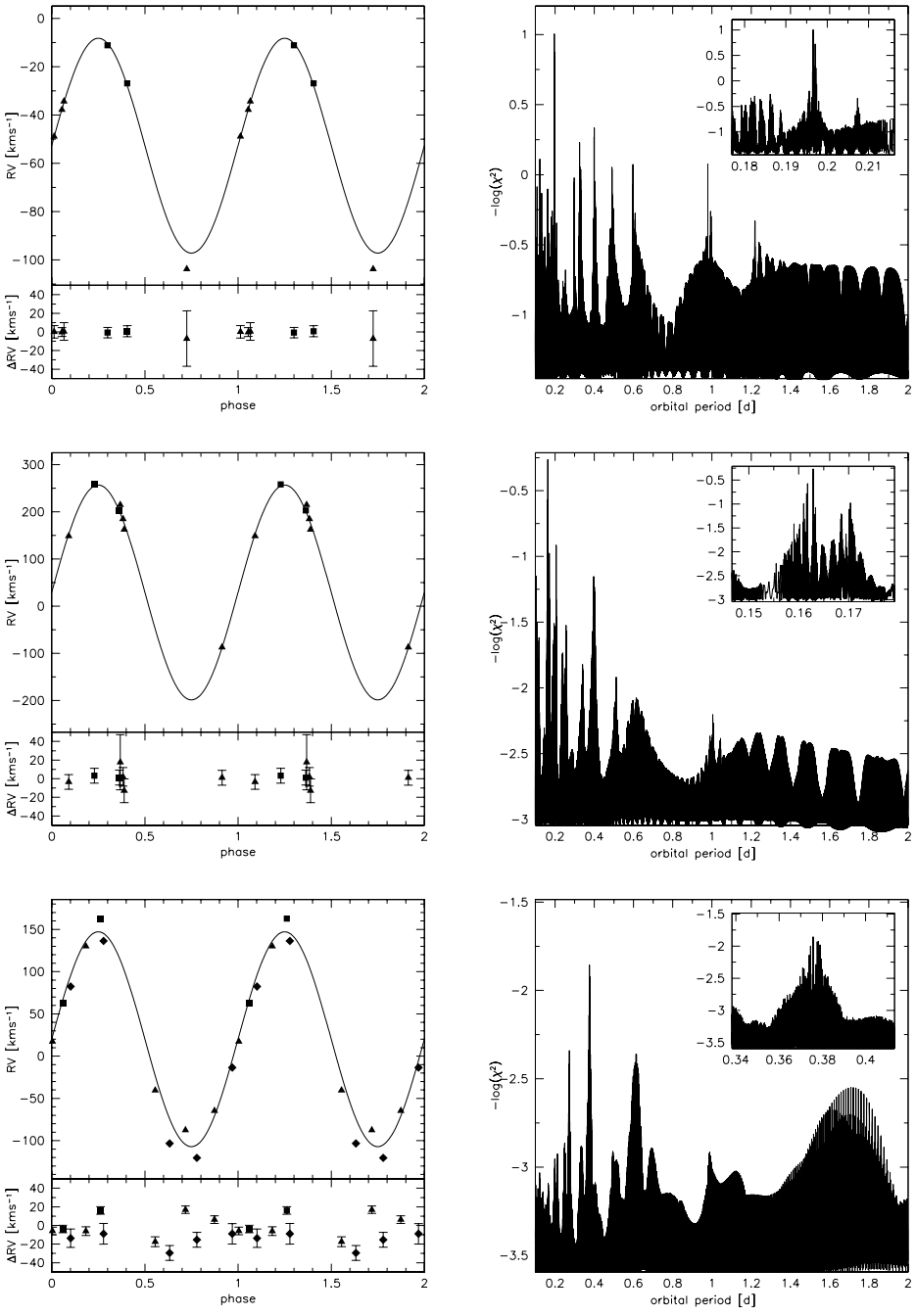

Figure 1. *Left panel:* Subdwarf radial velocities against orbital phase for HE 1423–0119 (top), HE 1415–0309 (middle), and WD 0107–342 (bottom). The residuals and errors are plotted below for VLT (squares), NTT run 2004 (diamonds) and NTT run 2007 (triangles) velocities. *Right panel:* Power spectra $-\log\chi^2$ of the best sine fits are plotted against orbital period. Best solutions are expanded in the inset boxes.

4. Discussion

The results presented here should be considered to be preliminary. As can be seen from the RV curves, more data points are needed to get better phase coverage, in particular for HE 1415−0309 and HE 1423−0119. In the course of the SPY survey 18 radial velocity variable subdwarfs were discovered. The orbital parameters of 12 close binary subdwarfs have already been determined (Napiwotzki et al. 2001, 2004b). The goal of our project is to measure the orbital parameters of all RV variable subdwarfs from the SPY survey. Additional NTT time was granted for Period 80 in January 2008.

To constrain the nature of the companions further, light curves have to be taken. If the companions are main-sequence stars, they should be detectable from light variation due to the reflection effect. As an example we mention HE 0230−4323, an sdB binary with a period of 0.45 d (Edelmann et al. 2005). Koen (2007) demonstrated that the companion is a main-sequence star by measuring the reflection effect. This star is of particular interest because other, yet unexplained light variations have been discovered as well.

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