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Multi-periodic oscillations of HD 32887 and HD 81797

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Abstract. In this paper we present two evolved stars, HD 32887 and HD 81797, which show multi-periodic oscillations. We observed the oscillations by means of the precise radial velocity technique with the simultaneous calibration method. The high-resolution spectra of each star have been obtained with FEROS at the 2.2 m-MPG/ESO telescope in La Silla Observatory, Chile. We found variation in the stellar radial velocities and spectral line profiles. The periods of the oscillations are from several hours up to few days. The sources of the short-term oscillations of HD 32887 and HD 81797 are obviously due to stellar pulsations, which are similar to solar-like oscillations. In particular, in HD 81797 we found a clear correlation between the variation in the asymmetry of the spectral line profile, measured in the bisector velocity spans, and the radial velocity. Both stars have bisector velocity spans which also show oscillations. The periods of the bisector oscillations are similar to those of the radial velocity variation. The detection of the multi-periodic oscillations in HD 32887 and HD 81797 makes these star to be amenable targets for asteroseismology, in particular, of stars in the red giant branch.

Key words. stars: individual: HD 32887 – stars: individual: HD 81797 – stars: oscillations – technique: radial velocity –

1. Introduction

Precise radial velocity (RV) technique has been very successful in the detection of extrasolar planets and low-amplitude stellar pulsations, which are similar to the solar-like oscillations. Ground-based detections of solar-like oscillations in stars other than the Sun have reported e.g. by Bedding & Kjeldsen Bedding (2003) and references herein.

In the 1980s G and K giant stars have been found to be variable stars by measuring the radial velocity as reported by Walker et al. Walker (1989) and Smith et al. Smith (1987). The amplitude of the variation in RV is between 30 – 300 m s^{-1}. Further RV surveys showed that G and K giants exhibit RV variations on time scales from several hours up

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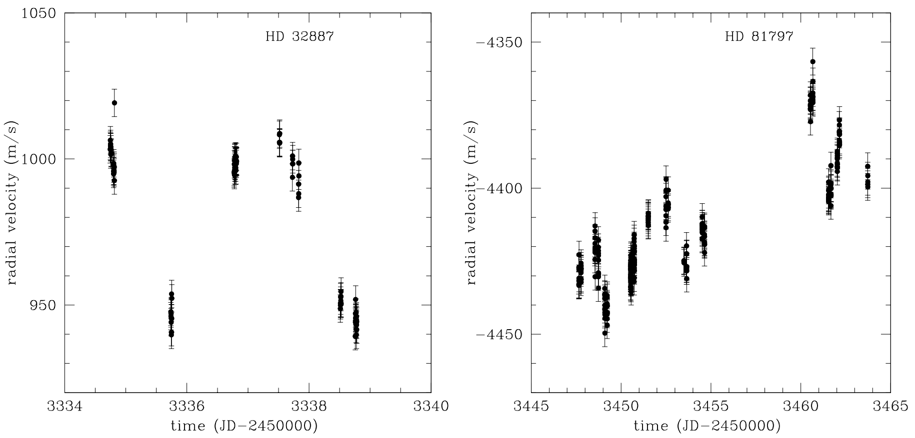

Fig. 1. Radial velocity measurements of HD 32887 in November 2004 and HD 81797 in March/April 2005.

to hundreds of days. A possible source of the long-period low-amplitude RV variation is the presence of planetary companions, as reported by Setiawan et al. Setiawan (2005), Hatzes et al.Hatzes (2005) and references herein.

The long-period RV variation can be also caused by rotational modulation due to surface inhomogeneities. This feature can be analysed by investigating the Ca II H and K emission lines or the variation in spectral line bisector. For example, Setiawan et al.Setiawan (2004) detected rotational modulation in the giant HD 78647 by examining the spectral line bisector.

G and K giants are also subject to stellar oscillations. Evidences for non-radial stellar oscillations in G and K giants have been detected, e.g., in Arcturus by Smith et al.Smith (1987) and Hatzes & Cochran Hatzes (1994a), β Oph by Hatzes & Cochran Hatzes (1994b), α UMa by Buzasi et al.Buzasi (2000) and ξ Hya by Frandsen et al.Frandsen (2002).

In this workshop we report the detection of multi-periodic oscillations in HD 32887 and HD 81797. We observed short-term RV oscillations with periods of several hours up to few days. For HD 81797 we also present the analysis of the spectral line profile asymmetry (bisector). We found a correlation between the variation in the bisectors and radial velocity. This finding leads to the source of the observed low-amplitude RV oscillations. The bisector analysis seems to be an excellent method and an alternative to the RV measurements to detect stellar oscillations.

2. Radial velocity and bisector measurements

We observed HD 32887 and HD 81797 with FEROS at the 2.2 m MPG/ESO telescope in La Silla observatory, Chile. The spectra have been obtained in the "simultaneous calibration" mode, in which the instrumental velocity drift is corrected by using the Thorium-Argon reference emission lines. The short-term (few weeks) velocity precision of FEROS is 5 m s^{-1}.

For HD 32887 we took 105 spectra during five consecutive nights from 24–28 November 2004 and 165 spectra during eight consecutive nights from 17–24 March 2005. The observations of HD 81797 have been taken during eight nights from 17 – 24 March 2005 and other four consecutive nights from 30 March 2005 – 2 April 2005.

For both stars we have taken several time-series of exposures. Each series contains 5-40 spectra. The total exposure time of each series ranged between 5–40 minutes. In order to resolve the oscillations with time scale of minutes and hours, we recorded several blocks of time series exposures per night with an interval between 1 – 6 hours.

The detailed data reduction procedures and the radial velocity computation have been presented in Setiawan et al. (2003).

Surface inhomogeneities such as starspots or/and granulation will introduce an asymmetry in the spectral line profile, as described in Gray Gray (1982). This feature can be measured from the shape of the line bisector or bisector velocity span (BVS) as demonstrated in Hatzes Hatzes (1996).

The measurement of the BVS can be done as well with the cross-correlation method, as done by Queloz et al. Queloz (2001). A correlation between BVS and RV indicates that the observed RV variation is most likely due to stellar pulsations, if the rotational modulation can be excluded.

3. Results and discussion

The RV measurements of HD 32887 and HD 81797 are presented in Fig. 1. HD 32887 shows RV variation with an amplitude of $\approx 40\,\mathrm{m\,s^{-1}}$ and a period of few days. In HD 81797 we observed a linear trend which corresponds to a long-term RV variation and also oscillations with periods of several days.

We computed a Lomb-Scargle (LS) periodogram (Lomb Lomb (1976) and Scargle Scargle (1982)). of each star to find the oscillation frequencies. Fig. 2 shows the respective LS periodograms of the RV measurements. In HD 32887 we found several peaks in the low-frequency region at $\nu \approx 2-5\,\mu$Hz, which correspond to oscillation periods of few days. This is in good agreement with the RV variation shown in Fig. 1. Other peaks observed in the LS periodogram can be aliases, the daily window frequency or other real oscillations. More detailed analysis of the oscillation frequencies will be presented in forthcoming papers.

In HD 81797 we identified oscillation frequencies in two regions, i.e., $\nu = 2 - 30\,\mu$Hz and $\nu = 50 - 120\,\mu$Hz. The corresponding periods are between few hours and several days. We cannot exclude that there might be still aliases resulted from the daily observational window. However, the few days oscillation seems to be real as can be seen clearly in the RV measurement data. The oscillations of hours can be seen in the bisector velocity variations better than in the RV data (Setiawan et al., in preparation).

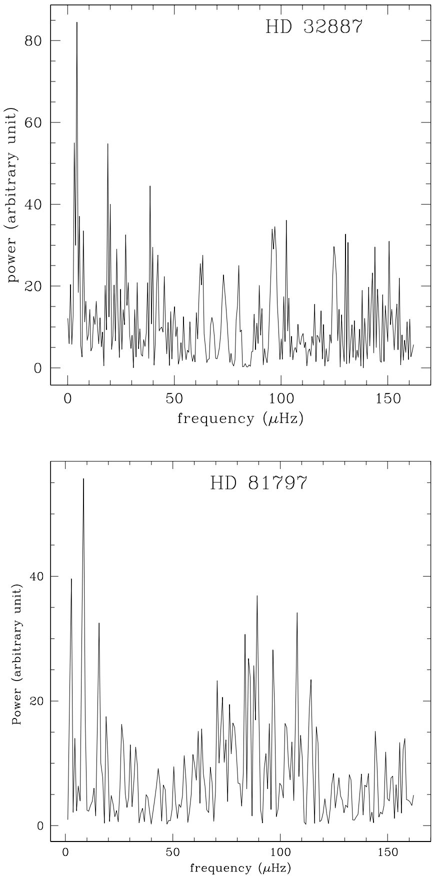

Fig. 2. Lomb-Scargle periodogram of RV variation of HD 32887 and HD 81797.

The source of the low-amplitude RV variation is obviously due to stellar pulsations. Other possibilities, like planetary companion and rotational modulation due to starspots can be excluded. A planetary companion with orbital period of few days would have an orbit which is smaller than the stellar radius of HD 32887 or HD 81797. A rotational modulation of the period of several days would

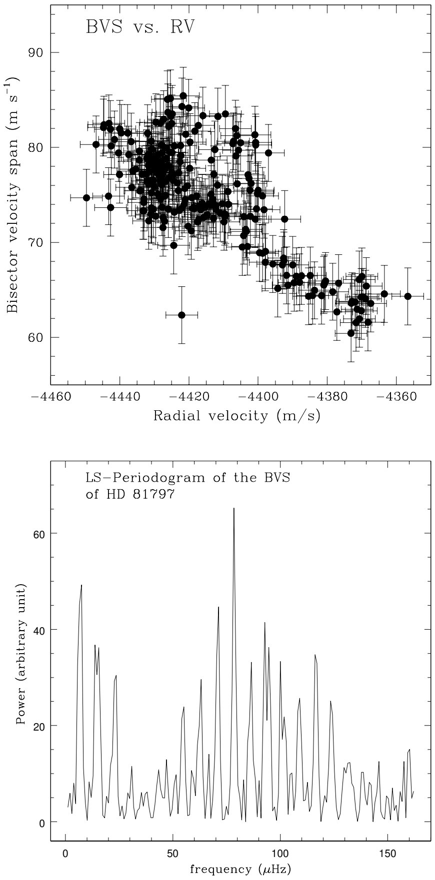

Fig. 3. Bisector velocity spans of HD 81797 and its periodogram.

imply, that the star should rotate very fast ($v \sin i > 100$ km s^{-1}). Such a fast rotating K giant would have a strong X-ray emission and thus, it should have been detected by the ROSAT survey.

In HD 81797 we observed oscillations in the time series of the BVS. The oscillations in the spectral line asymmetry, and in particular the correlation between BVS and RV (Fig. 3) indicates, that the observed variations are due to non-radial oscillations. This result is an observational approval of the method proposed by Hatzes Hatzes (1996). The LS periodogram of the BVS time series shows peaks in the frequencies between $5-30\,\mu$Hz and $50-120\,\mu$Hz, which is in good agreement with the periodogram of the RV time series.

The shape of the power distribution in the periodograms of the RV and BVS measurements with high amplitudes at high frequencies indicates that there exists the possibility of solar-like oscillations in the frequency range between 50 – 120 μHz. The modes around 10 μHz in the RV and the BVS periodograms seem to exhibit a decrease in amplitude with higher frequencies, which would support a Mira-like interpretation for these pulsations.

Our findings in HD 32887 and HD 81797 are in good concordance with earlier detections of solar-like and mira-like oscillations in red giant stars.

4. Conclusions

Until now, non-radial pulsations in red giants have been detected only in a few numbers of stars. Therefore, each detection will give a valuable contribution to asteroseismology, which is a powerful tool for performing direct tests of stellar structure and evolution theory.

We report our prelimiary results of HD 32887 and HD 81797, as we detected multi-periodic oscillations in these cool evolved stars. The detection of these oscillations is twofold. On the one hand we found them in RV measurements and on the other hand in measurements of the BVS. Especially in HD 81797 both measurements correlate well. This correlation, in particular, hints to the detection of non-radial oscillation modes. Our observations are a direct approvement of the mapping of the oscillation velocities onto the line profile bisector as suggested by Hatzes Hatzes (1996).

The bisector method turns out to be a good alternative to the radial velocity measurements in searching for stellar oscillations. Our findings in HD 32887 and HD 81797 are in good concordance with earlier detections of solar-like and Mira-like oscillations in red giant stars.

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