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RAPID RADIAL VELOCITY VARIATIONS IN ROAP STAR γ Equ FROM LINES OF NdIII AND PrIII

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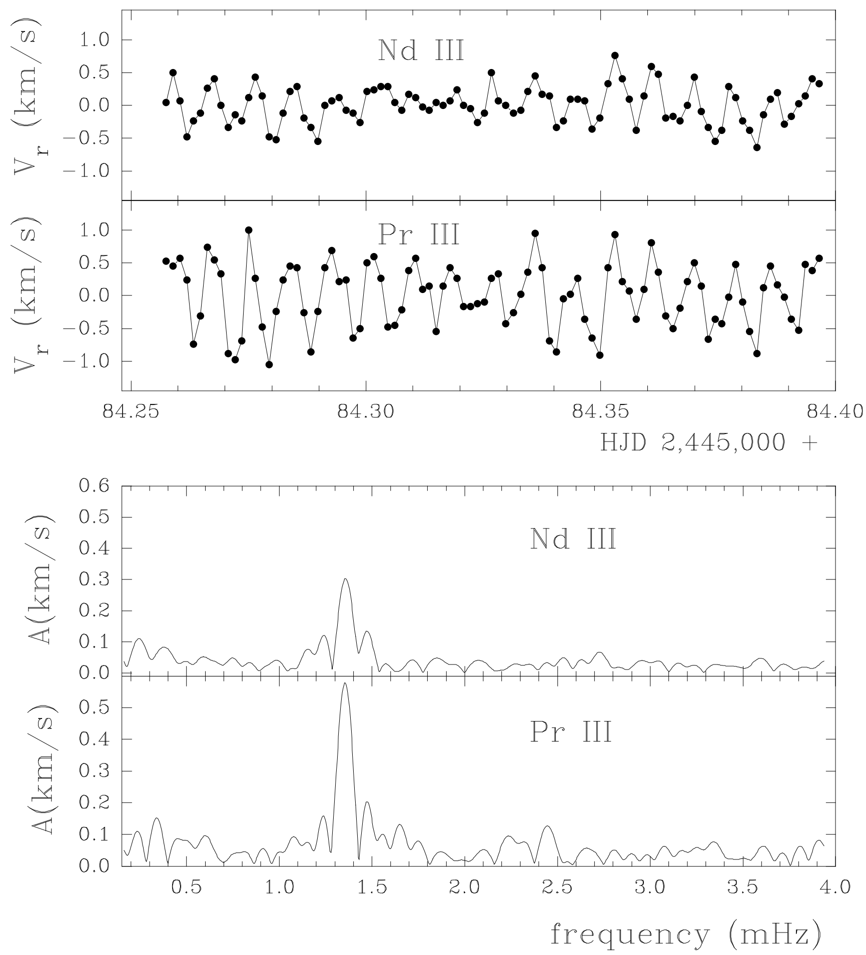

Figure 1.

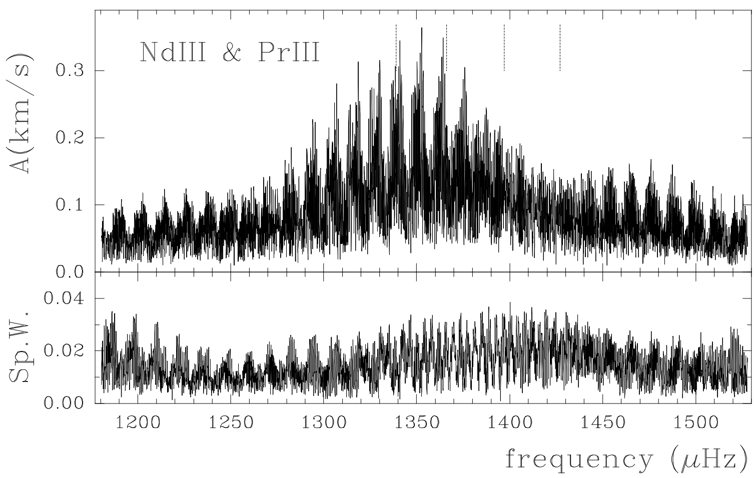

Figure 2.

Cool, magnetic, chemically peculiar stars which exhibit low-amplitude ($\Delta B \leq 16$ mmag) photometric variations with the typical periods of 6 to 16 minutes form the group of rapidly oscillating Ap (roAp) stars. Detailed description of the observed properties of roAp stars is given in a review by Martinez and Kurtz (1995).

SrCrEu star γ Equ (HD 201601) is one of the best-studied among roAp stars. The analysis of its photometric oscillations revealed the existence of at least four high-overtone pulsational modes (Martinez et al. 1996). Practically zero rotational velocity of this star (Ryabchikova et al. 1997) makes it the best candidate for the measurements of radial velocity (RV) variations due to pulsations. The first RV monitoring was made by Libbrecht (1988) who found a peak-to-peak amplitude of 42 m/s. Recently, Kanaan and Hatzes (1998) performed new observations of γ Equ with the iodine absorption cell and found peak-to-peak amplitudes of RV variations ranging from less than 100 m/s to about 1000 m/s. Kanaan and Hatzes showed that the weaker chromium and titanium lines have the largest amplitudes in comparison with the stronger lines of the same elements as well as with the iron lines.

We performed new observations of γ Equ in the red spectral region looking for high amplitude radial velocity variations with the classical technique of RV measurements.

All observations have been performed with the Photometrics CCD camera installed in the coudé spectrograph of the 2.6–meter Shajn reflector of the Crimean Astrophysical Observatory during 14 nights in August–October of 1998. The exposure time was 90 seconds. This value is a reasonable compromise that allows to obtain sufficient signal-to-noise ratio, and is still short enough to minimize phase smearing for the 12 minutes pulsation period (Martinez et al. 1996). The interval between the two consecutive exposures (including readout and data acquisition time) was equal to 128–130 seconds. Typical signal-to-noise ratios per pixel are in the range 60–120 (depending on the weather conditions and seeing). Spectral resolution is about 35000 for the observations in the second order of grating (regions $\lambda\lambda$ 6690, 6340, 6140 Å). For the region centered at λ 6530 Å (the first order of the grating) it is equal to 18000. A calibration spectrum (ThAr lamp) was obtained for each stellar spectrum. Typical set of observations consists of 20 to 90 exposures. The estimated error of the RV measurements for a single line is within 160–240 m/s.

Data reduction was done with the SPE package written by S.G. Sergeev. Continuum fitting was made with the help of synthetic spectrum calculated for each spectral region with SYNTH code (Piskunov 1992) using abundances from Ryabchikova et al. (1997).

During our preliminary analysis we try to identify the lines with the largest RV amplitudes. The Vienna Atomic Line Database (VALD, Piskunov et al. 1995) was extensively used for line identification. A few rather strong features at $\lambda\lambda$ 6145, 6160, 6327, 6690 Å, which show the largest RV variations, were identified with the lines of Nd III and Pr III. Data for the identification of the second ions of rare-earth elements were taken from Mathys and Cowley (1992), and from Cowley and Bord (1998). Fig. 1 shows the curve of the RV variations (upper panel) and its amplitude spectrum (lower panel) for Nd III λ 6145.07 Å, and for Pr III λ 6160.24 Å lines for one night – August 27, 1998 (94 spectra). The oscillations clearly seen in the RV curve, also appear in the Fourier power spectrum. The amplitude spectrum has a strong peak at a frequency of 1.35 $\pm$ 0.05 mHz, which corresponds to the pulsation period of 12.35 minutes. The RV data were analysed using the period-finding package ISDA by Pelt (1992) and the program PERDET (Breger, 1990). Combining RV measurements obtained in different nights (the data were rectified by subtracting a mean value for each night) we get the resulting periodogram in the frequency range of interest $1180 \leq \nu \leq 1530$ μHz which is shown in Fig. 2 together with the spectrum of the window function of observations. The largest amplitude is found at the frequency of 1352.6 μHz. The pulsation frequencies detected in the photometric data (Martinez et al. 1996) are indicated by dotted lines.

The analysis of the RV variations indicates a presence of the amplitude modulation, which may be caused by beating among several frequencies. Kanaan and Hatzes (1998) obtained the highest RV variations in $\lambda\lambda$ 5828–5852 Å spectral region. This region contains Nd III λ 5845.07 line. Perhaps this line rather than Cr I λ 5844.30 is responsible for high RV amplitude.

The preliminary analysis of the radial velocity data for γ Equ shows that:

- the highest amplitudes of RV pulsations are associated with the lines of Pr III and Nd III.
- the spectral lines of other species in the observed spectral regions do not show regular RV variations.
- Two out of four photometric frequencies (Martinez et al. 1996) appear in the RV periodograms.

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