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New variable and multiple stars in the lower part of the Cepheid instability strip

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Abstract

We obtained high-resolution spectra for 33 A-type stars during 4 consecutive nights. All our targets are HIPPARCOS program stars located in the lower part of the Cepheid instability strip which show hints for variability in radial velocity of a yet unidentified nature.

CCD photometry was acquired for some of the most promising candidates and used to further interpret the variability of several targets. A first result is the discovery of two new pulsating variable stars.

In addition, five new binary or multiple systems were identified (one SB1, three SB2 and one SB2 triple system).

1. Introduction

A very interesting region of the Hertzsprung-Russel diagram lies at the intersection of the main sequence and the classical Cepheid instability strip, where a variety of phenomena are at play in the stellar atmospheres.

These phenomena include magnetism, diffusion, rotation and convection, which are active in δ Scuti, SX Phe, γ Dor and roAp variable stars. The latter processes may boost or, on the contrary, inhibit the presence of chemical peculiarities (occurring in Ap, Am, ρ Puppis and λ Boo stars). The competition between these processes and mechanisms thus leads to a large mix of stellar groups of different atmospheric composition which also behave in different ways with respect to pulsation and binarity. To address the issue of the interactions between chemical composition, pulsation and multiplicity, we aim to perform a

systematic study of the chemical composition of a sample of poorly known main-sequence A- and F-type stars in this region. For this purpose, high-resolution spectroscopic observations were carried out at the *Observatoire de Haute-Provence* (OHP, France) in December 2004. We here give a brief account of the present variability status in the observed sample.

2. Description of the sample

We selected 38 targets from the HIPPARCOS catalogue. The following criteria have been adopted : 1) brightness larger than magnitude 8; 2) spectral type ranging from A0 to F2; 3) showing some indication of radial velocity variability in the catalogue of Grenier et al. (1999) and 4) having less than 10 references in the bibliography recorded in the SIMBAD data base (CDS). Except for the HIPPARCOS epoch photometry and because of the use selection criteria, very little is known about the targets. The distribution in spectral type of the sample of 33 observed stars is plotted in Fig. 1 (based on Grenier et al. 1999).

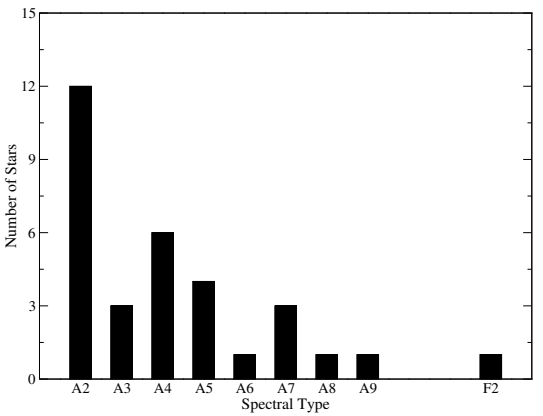

Figure 1: Distribution in spectral type of the observed sample.

3. Observations

The spectroscopic observations were carried out at the 1.93 m telescope equipped with the ELODIE spectrograph of the OHP (Baranne et al. 1996). High-resolution spectra were collected during 4 nights in 2004 (December 3–7). Each target was observed 2 to 5 times in order to be able to detect rapid (periods of order of a few hours) or slow (periods of order of a few days) line profile

variations (LPVs) and/or changes in radial velocity. However, due to circumstances (bad weather conditions) some of our targets were only observed 2–3 times successively, without the ability to reobserve at a later date. We adapted the time exposures to ensure a S/N ratio per pixel (at 5000 Å) generally varying from 80 to 100. The data were automatically reduced order by order at the end of the night using the INTERTACOS pipeline. INTERTACOS was also used to perform a cross-correlation with the F0 mask after each exposure.

For 4 promising candidates, we also acquired complementary CCD photometry in the period between December 2004 and February 2005. These observations were carried out using a 40cm Newton equipped with a SBIG ST10XME camera (2 targets) at BHO, a 30cm telescope with SBIG ST8i camera (1 target) at SETEC Observatory (Kansas, USA) and a 25 cm telescope with a SBIG ST10XME camera (1 target) at BHO on one more occasion. Depending on the target's magnitude, a B or V filter according to Bessell's specifications (Bessell 1995) was used.

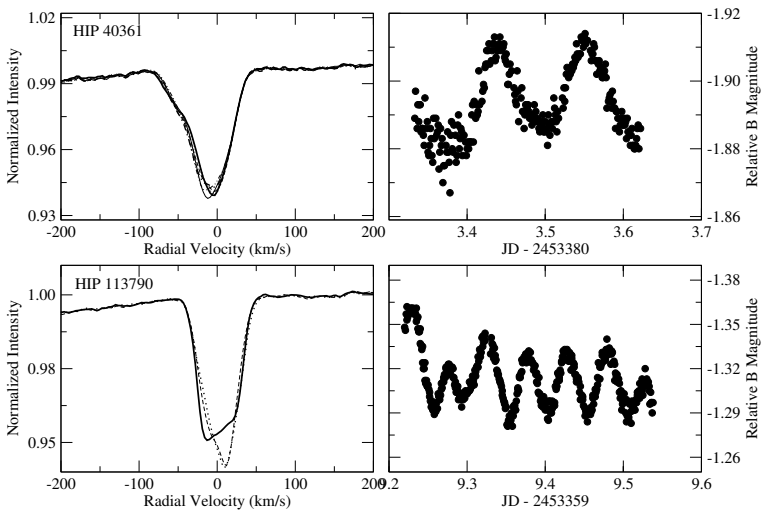

Figure 2: The left panels show some cross-correlation functions obtained during consecutive exposures while the right panels illustrate the corresponding light curves.

4. Detection of pulsation and/or multiplicity

The detection of the occurrence of pulsation and/or multiplicity is done by a visual inspection of the shape and the variations of the cross-correlation functions (CCFs) for each target. The identification of several peaks in the CCFs

and/or the existence of day-to-day changes in radial velocity are interpreted as the signature of binarity or multiplicity, while the appearance and disappearance of bumps in the peaks of the CCFs collected during two consecutive exposures are interpreted as the signature of intrinsic variability.

We classified the observed targets according to their likelihood to be effectively intrinsically variable. To this purpose four classes were defined (VAR1, VAR2, VAR3, VAR4) among which the class VAR1 indicates a large probability. All VAR1 candidates were subsequently submitted to at least two (short) photometric runs in order to verify whether they also show short-period light variations (see new variable stars in Table 1). Fig. 1 illustrates the procedure as applied to HIP 40361 and HIP 113790. Note that a simple frequency analysis of the Hipparcos epoch photometric data confirms the listed main periodicity for HIP 113790.

Table 1: Newly detected photometric-spectroscopic variable stars as well as multiple systems.

HIP	HD	Mag V	Sp. Type	Notes
New variable stars confirmed by CCD photometry				
9501	12389	7.99	A4V	already known δ Scuti star
40361	68725	6.94	F2	P $\sim$ 0.12 d
113790	217860	7.30	A8III	P $\sim$ 0.05 d, multiperiodic unresolved Hipparcos variable
Newly detected multiple systems				
3227	3777	7.44	A2III	SB2
8581	11190	7.88	A2III	SB2
46642	81995	7.35	A5	SB1
115200	219989	7.35	A2IV	SB2
116321	221774	7.38	A4IV	SB2

5. Conclusion

Among the 33 observed stars of our sample, 9 were found to be spectroscopically variable on a timescale of several hours and are thus promising candidates for the detection of pulsation(s). We classified these 9 candidates into two classes VAR1 and VAR2. For 4 of these targets CCD light curves in the B or V passband

were obtained. The new photometric data confirm the variable nature of 3 stars, one of which is the already known δ Scuti star HIP 9501 (Schutt 1991) and another one is an unresolved Hipparcos variable star (ESA 1997). Five new binary or multiple systems were further identified (one SB1, three SB2 and one triple system). We are presently analyzing and exploiting the ELODIE spectra in order to determine fundamental parameters for each observed target. These results will be published in more details in the near future. We further plan to organize a large photometric campaign next season in order to monitor the light variations of the new intrinsic variable stars HIP 40361 and HIP 113790.

Acknowledgments. This work is based on spectroscopic observations made at the *Observatoire de Haute-Provence* (France) and on CCD photometric observations collected at Beersel Hills and SETEC observatories. Part of the photometric data were acquired with equipment purchased thanks to a research fund financed by the Belgian National Lottery (1999). Ample use was made of the SIMBAD data base (*Centre de Données Stellaires*, Strasbourg).

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