Variability survey in NGC 6910, the open cluster rich in β Cephei-type stars

Dawid Moździerski[1], Andrzej Pigulski[1], Zbigniew Kołaczkowski[1·2], Gabriela Michalska[1], Grzegorz Kopacki[1], Artur Narwid[1], Marek Stęślicki[3], Ewa Zahajkiewicz[1], Jianning Fu[4], Xiaojun Jiang[5], Chao Zhang[4], Jason Jackiewicz[6], John Telting[7], Thierry Morel[8], Piotr Śródka[1], Przemysław Bruś[1] and Fabien Carrier[9]

1. Astronomical Institute, University of Wrocław, Kopernika 11, 51–622 Wrocław, Poland
2. Nicolaus Copernicus Astronomical Center Polish Academy of Sciences, Bartycka 18, 00–716 Warszawa, Poland
3. Space Research Centre, Polish Academy of Sciences, Kopernika 11, 51-622 Wrocław, Poland
4. Department of Astronomy, Beijing Normal University, Beijing, China
5. National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China
6. New Mexico State University, Las Cruces, NM, USA
7. Nordic Optical Telescope, La Palma, Spain
8. Institut d'Astrophysique et de Géophysique, Université de Liège, Liège, Belgium
9. Katholieke Universiteit Leuven, Instituut voor Sterrenkunde, Leuven, Belgium

NGC 6910 is the northern hemisphere open cluster known to be rich in β Cephei-type stars. Using four-season photometry obtained in Białków (Poland) and Xinglong (China) observatories, we performed variability survey of NGC 6910. As the result, we found over 100 variable stars in the field of the cluster, including many stars showing variability due to pulsations and binarity. Thanks to the spectroscopic observations, we also detected changes in the profiles of spectral lines of β Cep stars, caused by pulsations.

1 Introduction

NGC 6910 is the young open cluster containing many β Cep-type variables (Kołaczkowski et al., 2004). Preliminary results of the variability search based on photometric data obtained during the international observational campaign allowed to detect eight β Cep-type members (Pigulski, 2008; Saesen et al., 2010). Interestingly, it turned out that the frequency spectra of these β Cep stars, arranged according to the decreasing brightness (i.e. mass) showed a progression of frequencies of the excited modes (Pigulski, 2008). This result raised hope for a successful ensemble asteroseismology in this cluster (Saesen et al., 2010). In the present paper, we show preliminary results of the full variability survey of NGC 6910 based on the part of the data obtained during the international observational campaign in the years 2005 – 2007 and 2013. The full results will be published elsewhere.

2 Observations and Results

We used only Białków (Poland) and Xinglong (China) photometric data, the two most numerous data samples. Białków observations were carried out with a 60–cm reflecting telescope and the attached CCD camera covering $13' \times 12'$ field of view (FoV). Xinglong data were carried out with 50 and 100–cm reflecting telescopes, and CCD cameras covering, $10\farcm5 \times 10\farcm4$ and $11\farcm2 \times 11\farcm2$ FoV, respectively. In total, about 23 500 CCD frames were acquired through the B, V, R, $I_{\rm C}$ bands and narrow–band

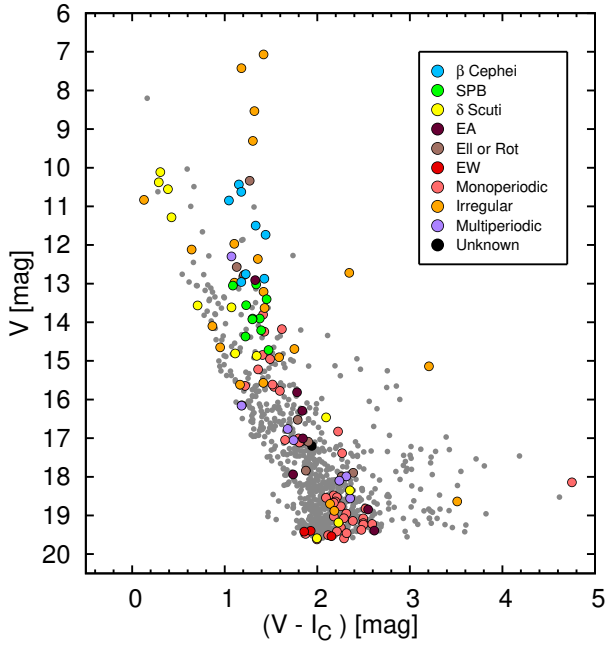

Fig. 1: Colour–magnitude diagram for NGC 6910 open cluster. Variable stars are marked by coloured circles.

Hα filters during 157 nights in these two sites. We also carried out spectroscopic echelle observations with the 2.56–m Nordic Optical Telescope, 1.93–m telescope of Haute–Provence Observatory and Apache Point Observatory 3.5–m Astrophysical Research Consortium telescope in 2007 and 2013.

Photometric observations allowed us to detect 125 variable stars in the field of NGC 6910 open cluster, of which 117 are new (Fig. 1, Tab. 1). Thanks to the large difference in longitude between both observatories, we were able to reduce significantly the daily aliases in the frequency spectra. One of the most interesting results is the mentioned earlier progression of the frequencies for β Cep stars, up to almost $13\,\mathrm{d}^{-1}$ in NGC6910-38. We also detected changes of amplitudes of some modes in two β Cep stars, NGC6910-16 and NGC6910-27 between 2005 – 2007 and 2013.

Thanks to the spectroscopic observations we have found well pronounced variability of spectral line profiles caused by pulsations for two β Cep stars: NGC6910-14 and NGC6910-18. We will use this information to identify the degrees l and azimuthal orders m of the strongest modes using methods of Zima (2006), Daszyńska-Daszkiewicz et al. (2005) and Daszyńska-Daszkiewicz & Walczak (2009).

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Table 1: Variable stars in the observed FoV and probable NGC 6910 membership.

Variability type	**Likely members**	**Non–members**
β Cep	8	0
SPB	10	0
δ Sct	0	12
EA	3	4
Ell or Rot	2	6
EW	0	3
Monoperiodic	34	12
Irregular	16	6
Multiperiodic	0	7
Unknown	0	2
Total	**73**	**52**

the Department of Theoretical Physics and Astrophysics of the Masaryk University.

References

Daszyńska-Daszkiewicz, J., Dziembowski, W. A., Pamyatnykh, A. A., *A&A* **441**, 641 (2005)

Daszyńska-Daszkiewicz, J., Walczak, P., *MNRAS* **398**, 1961 (2009)

Kołaczkowski, Z., Pigulski, A., Kopacki, G., Michalska, G., *Acta Astron.* **54**, 33 (2004)

Pigulski, A., *Journal of Physics Conference Series* **118**, 1, 012011 (2008)

Saesen, S., et al., *Astronomische Nachrichten* **331**, 1080 (2010)

Zima, W., *A&A* **455**, 227 (2006)