Magnetic stars, 2004, 85-87

Photometric variability of CP stars

(Review)

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Abstract. Rotational photometric variability of CP stars as one of the oblique rotator demonstrations is reviewed. Some new observational results are presented.

Key words: stars: chemically peculiar – techniques: photometric – photometric variability – oblique rotator

1 Introduction

The last review on the photometric variability of CP stars was given ten years ago (Žižňovský 1994). Since then a lot of new photometrically variable CP stars has been discovered, new values of their rotational periods have been derived and a few surprising discoveries have been published. As the introduction to the topic given in the above mentioned paper, I will concentrate in this paper on the progress made during the last ten years only. A detailed review was published on photometry of rapidly oscillating (roAp) stars (Kurtz & Martinez 2000), so the present review deals with the rotational variability of magnetic CP (CP2) stars.

2 Photometric observational programs

The Catalogue of observed periods of Ap stars and its three supplements (Catalano et al. 1984, 1988, 1991, 1993) contained more than 300 stars 10 years ago. Now, with two new supplements (Catalano & Renson 1997 and Renson & Catalano 2001) it contains $\sim$ 500 CP stars, thanks to a few successful coordinated observational programs.

2.1 The Hipparcos photometry

The majority of the newly discovered variable CP stars was found by Paunzen & Maitzen (1998). Their searching the Hipparcos Variability Annex (ESA 1997) for peculiar stars is included in Renson's (1991) catalogue of Ap and Am stars. Rotational periods for 130 stars of Renson's catalogue were found. Their periods range from 25.4 d (HD 92106) to 0.135 d (HD 79781). The second star seems to be the fastest rotator among CP2 stars. Some previously published periods were corrected. The newly found rotational periods for 34 stars with known values of $v \sin i$ were tested by means of the P vs. $v \sin i$ diagram. All but three (HD 88158, HD 104810, HD 151363) fit the conditions of the Oblique Rotator Model. All the CP1 (Am) photometrically variable stars of the sample are eclipsing binaries.

Adelman (1998) turned his attention to the nonmagnetic (HgMn and Am) CP stars observed by Hipparcos and concluded that the Am stars were slightly better candidates for photometric constancy as the HgMn stars. He found four possible Am variables (HD 27628, HD 30453, HD 124915, and HD 223991). As the Am stars are members of binary systems, this could be an explanation of their possible light variability. Seven of the sample of HgMn stars deserve additional study, HR 7911, 13 And, HR 149, HR 8512, HD 2019, HD 65949, and HD 65950.

A bright eclipsing binary was discovered by Torres (2003) in the Pleiades cluster. This star (HD 23642) was known as a double-lined spectroscopic binary (Pearce 1957 and Abt 1958). Abt predicted eclipses as possible, but only a careful study of the Hipparcos photometry by Torres confirmed the secondary eclipse. Hipparcos missed the times of primary minima during the mission. What is very important is that both components of HD 23642 are CP stars: A0p(Si)+Am (Abt & Levato 1978). HD 23642 and HD 121276 (North 1995) are the only two newly discovered eclipsing CP2 stars during the last ten years.

2.2 FCAPT

A great body of *UBV* and *uvby* photometric data of different groups of CP stars has been collected by Pyper and Adelman using the 0.75 m Four College Automated Photometric Telescope in Arizona over the past 12 years. Some of the most interesting results obtained with this telescope are mentioned in Section 3. In context with this automated photometric telescope, I would like to point out the importance of the ASTRA spectrophotometer project (Adelman et al. 2003). This automated istrument is designed for spectrophotometry of stars brighter than 10.5 mag.

2.3 CP stars in open clusters

Maitzen, Paunzen and collaborators have run a program of detecting CP stars in open star clusters for more then 20 years. Both classical photoelectric photometers, as well as CCDs, were used for this survey. A detailed review of the history of development of Δa photometry and of some results were given by Maitzen (1998). One of the recent discoveries is interesting, the first extragalactic classical CP stars have been found in NGC 1866, a star cluster in the Large Magellanic Cloud (Maitzen et al. 2001).

2.4 Infrared photometry

Long-term monitoring of CP2 stars in the near infrared region (J, H, K bands) was performed at the ESO 1 m photometric telescope at La Silla, Chile in the years 1986–1993. Interesting results were published by Catalano et al. (1998a, 1998b). The amplitudes in the near infrared range are lower than in the visible. At least 4 of 12 observed SiSrCrEu CP2 stars show IR variability in phase with their light curves from the visual region. The mechanism of the variability is probably the same. In the sample of 20 SrCrEu CP2 stars the same periods of variability as in the visual region were definitely found for 14 objects.

3 Stability of light curves

Photometrically variable CP2 stars as rigid rotators have constant periods and light curve shapes. There are, however, some exceptions. Three less understood CP2 stars are suspected to vary the shape of their light curves. Mantegazza et al. (1990) compared their V light curve of 41 Tau with those published earlier by Wolff (1973), Rakosh (1974) and concluded that the light curve has changed its shape. As 41 Tau is a member of a binary system, forced precession can be a mechanism of the observed changes. Adelman & Boyce (1995), Adelman (2000), Adelman & Knox (1994), and Adelman (1997, 1999) studied *uvby* light curves of 20 Eri and 108 Aqr and concluded that the light curves were somewhat different from those published earlier. These stars deserve further attention of observers.

The well-studied, short period variable ($P \sim 0.728$ d) CP2 star 56 Ari definitely changes the light curve shapes. It was first mentioned by Adelman & Fried (1993), who compared their *UBV* and *uvby* light curves with those published earlier. Žižňovský et al. (2000) obtained *UBV* light curves of 56 Ari in three consecutive observational seasons (1996/1997, 1997/1998, and 1998/1999) using the same telescope and photometer in order to exclude possible instrumental effects. They proved the variability of the light curves in all three filters, most prominent is in the U. Finally, Adelman et al. (2001) collected more than 4 600 photometric (*UBV* and *uvby*), including FCAPT data, and 127 spectroscopic (Si II 6347 line equivalent widths) data covering a time interval of 17 641 days. Their detailed analysis resulted in a discovery of a linearly increasing period with a rate of 2 seconds per 100 years. Another period of approximately 5 years was found, which was attributed to the precession of the axis of rotation of the star. Earlier, Musielok (1988) had found a period change of 56 Ari by 4 seconds per 100 years. His U filter observations covered 17 660 rotational cycles of the star.

Pyper et al. (1998) presented the results of a period study of another well-studied CP2 star, CU Vir. Photometric (most of them are FCAPT data), spectroscopic, and magnetic field data (1 860 points) covering more than 40 years were used in their analysis. They came to a surprising conclusion: while the rotational period was constant till the end of the year 1984, an abrupt change of the period occurred near epoch JD = 2446000. More precise photometric observations of CU Vir are necessary in future, as there is an indication in the O–C diagram on continuing change of the rotational period. CU Vir is also a fast rotator with a period of ~ 0.52 days. As none of the known mechanisms is able to change the rotation af the star by the observed amount ($\Delta P/P \sim 4.9 \times 10^{-5}$), possible explanation was given by Stępień (1998). *The star may be in a state of torsional oscillations resulting from an interaction of meridional circulations and internal magnetic field.*

Acknowledgements. This contribution was supported by the Vega Grant No. 3014 and the Science and the Technology Assistance Agency (APVT) Grant No. 51-000802.

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