PHOTOELECTRIC OBSERVATIONS OF THE MAGNETIC STAR HD 215 441

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ABSTRACT. Photoelectric UBV and intermediate-band observations of the magnetic Ap star HD 215 441 obtained in 1981 and 1982 are analysed from the point of view of rapid variability. No intrinsic rapid vyriability was disclosed in a set of the observations analysed.

ФОТОЭЛЕКТРИЧЕСКИЕ НАБЛЮДЕНИЯ МАГНИТНОЙ ЗВЕЗДЫ HD 215 441. Фотоэлектрические UBV и среднеполосные наблюдения магнитной Ap звезды HD 215 441 которые мы получили в 1981 и 1982 гг, анализируются с точки зрения быстрой переменности. В этой серии наблюдений мы непоказали наличие фотометрических быстрых изменений.

FOTOELEKTRICKÉ POZOROVANIA MAGNETICKEJ HVIEZDY HD 215 441. Fotoelektrické UBV a strednopásmové pozorovania magnetickej Ap hviezdy HD 215 441 získané v období 1981 - 1982 sú analyzované z hľadiska rýchlej premennosti. V uvedenej sérii pozorovaní sa rýchle fotometrické zmeny ktoré by patrili skúmanému objektu, nenašli.

1. INTRODUCTION

Babcock's star, HD 215 441 (GL Lac), with the largest known magnetic field has frequently been observed in the past. The photoelectric observations by Jarzebowski (1960), Cameron and Perry (1966), Rakosch (1968a), Stepien (1968), Stift (1973), Blanco et al. (1973), Panov (1974) and Schöneich et al. (1976) disclosed the photometric variations of this star with amplitudes of 0.12 mag in V, 0.14 mag in B and 0.18 mag in U colour, which are synchronous with the variations of the magnetic field and display a period of about 9.49 d. These variations are now generally considered to be due to the spots on the surface of the star which rotates with the same period. Osawa (1965) determined this star to be of peculiarity type Si λ4200.

Polosukhina (1963) observed rapid changes of the degree of polarization and Wood (1967) rapid changes of the intensity of the Hβ-line. It is evident that the origin of the rapid changes (spectral and photometric), provided they are real, should be in short-term physical processes.

2. OBSERVATIONS

We included the star HD 215 441 in our observational program with the purpose of determining the rapid photometric variations. The observations were carried out with a single-channel UBV photoelectric photometer of the 0.6 m reflector at the National Astronomical Observatory (NAO) in Rozhen and with a single-channel photoelectric photometer of the identical reflector at the Skalnaté Pleso Observatory (SPO) using a filter with λ = 526 nm and a halfwidth of 19 nm. The NAO photometer was described in detail by Panov et al. (1982), the SPO photometer by Horák et al. (1976).

At the NAO the observations were made either quasi-simultaneously in UBV with an integration time of 1 s, or only in B colour with an integration time of 10 s. Each observation consists of a sequence of "comparison - variable - comparison ..." measurements, one measurement being the average of ten readings of the counter in the case of the 1 s integration, and of five readings in the case of the 10 s integration. The SPO observation method is described in detail in Zverko's paper (1982). In each case the comparison star was HD 215 501. The observational data are summarized in Tab. I.

3. DISCUSSION

The observational series was obtained on nine nights at the NAO and six nights at the SPO. Four series obtained at the NAO were selected for studying the rapid variability, the other series displayed inferior observation conditions. As regard the SPO observations, rapid variability was studied using series with durations in excess of 2 hours.

3.1. RAPID VARIABILITY

Since our observations did not disclose distinctly amplitudes of possible rapid photometric changes larger than the scatter, we also devoted our attention to analysing the observations of the comparison star. Figures 1 - 3 show the observation series for each of the three types of observations. The values Δu, Δb, Δv and Δm are instrumental in the sense of HD 215 441 - HD 215 501. Figure 1 shows the UBV-type of observations. Apart from the light curves for HD 215 441, observations of the comparison star HD 215 501 are also shown: The plotted value is the difference of two consecutive measurements expressed in terms of magnitude. In the V colour standard deviations also are shown. The decreasing tendency from the beginning of the observations is due to the fall in brightness on the rotational light curve at phase 0.21. To determine possible variations on the seconds time scale, we also analysed the directly obtained observations. This is illustrated in the bottom part of Fig. 1. The individual symbols indicate the separate readings of the counter as they followed in sequence for the comparison and variable star expressed in terms of magnitude relative to the average of the measurement. Figure 2 shows observations in B colour with 10 s integration. The separate readings of the counter, their averages (crosses) and differences of two consecutive averages for the comparison star expressed in terms of magnitudes are plotted. In the bottom part, the observation sequence as a whole together with standard deviations is plotted on a diminished scale. Figure 3 shows observations with the $\lambda = 526$ nm filter. All the observations indicate that the character and amplitudes of the changes on the light curves are the same for the variable HD 215 441 and the comparison HD 215 501. These changes were discussed in detail by Zverko (1982), and the conclusion that they may be explained as the results of the instability of observation conditions even on the seconds time scale (Fig. 1, bottom part) is also applied to the case of the present observations of star HD 215 441. This conclusion is substantiated also by the fact, documented in Fig. 4, that the values plotted on the light curves have been calculated for the comparison and the variable star using the same method. These are the differences of two consecutive measurements expressed in terms of magnitudes. In this representation, the light curve of the variable should display an excess of positive or negative values in case of variations lasting longer than the resolution of the measurement in certain intervals, whereas the character of the comparison light curve should remain random. However, the behaviour of the curves is random in both cases.

3.2. ROTATIONAL LIGHT CURVE

We compiled a rotational light curve from all the UBV observations. The phases were calculated using the ephemeris

$$JD(\text{Max. light}) = 2\,436\,865.0 \text{ d} + 9.4875 \text{ E}.$$

TABLE I.

Date and JD 2 440 000 +	Colour	ΔU or	ΔB instrumental	ΔV	Duration n	Rotational phase	
1981, sep. 4/5 4 852.411	526		.433 ± 10		4.6 59	.89	+
22/23 4 870.426	UBV	-.388 12	.216 10	.434 9	3.5 58	.79	
23/24 4 871.434	UBV	-.431 13	.179 10	.402 10	3.2 69	.89	
24/25 4 872.387	UBV	-.436 20	.174 15	.397 10	1.5 25	.99	
26/27 4 874.436	UBV	-.372 6	.226 6	.457 6	2.3 57	.21	+
27/28 4 875.376	UBV	-.307 5	.276 3	.489 5	1.1 3.0[a] 21 52	.31	+
28/29 4 876.269	UBV	-.271 1	.303 4	.513 4	0.2 4	.40	
29/30 4 877.281	UBV	-.265 9	.303 2	.507 4	0.2 6	.51	
oct. 6/7 4 884.385	526		.521 14		3.5 53	.26	+
25/26 4 903.393	526		.497 14		4.0 59	.26	+
29/30 4 907.342	UBV	-.340 3	.251 3	.465 6	0.2 2.0[a] 4 29	.68	+
30/31 4 908.246	UBV	-.393 4	.214 3	.439 9	0.2 2.0[a] 5 29	.77	+
1982, jan. 13/14 4 983.330	526		.506 17		2.4 102	.69	+
20/21 4 990.298	526		.571 15		4.3 123	.42	+
feb. 16/17 5 017.288	526		.532 12		1.0 46	.27	

Notes: The errors are the standard deviations.

a) duration and a number of measurements in only B colour of the UBV observations.

+) runs analysed with regards to rapid variability.

Duration is given in hours.

"n" - number of observations.

The initial epoch T_0 = 2 436 865.0 was adopted from the paper of Jarzebowski (1960). The rotational light curves in the standard UBV system are shown in Fig. 5. The arrows indicate the positions of the UBV observations analysed with regard to rapid variability. Rakosch (1968b), Stift (1973) and Panov (1974) presented proof of variations of the period of HD 215 441. However, our present observations are not sufficient enough to allow a deeper insight into the problem of possible changes of the period than the earlier photometric papers.

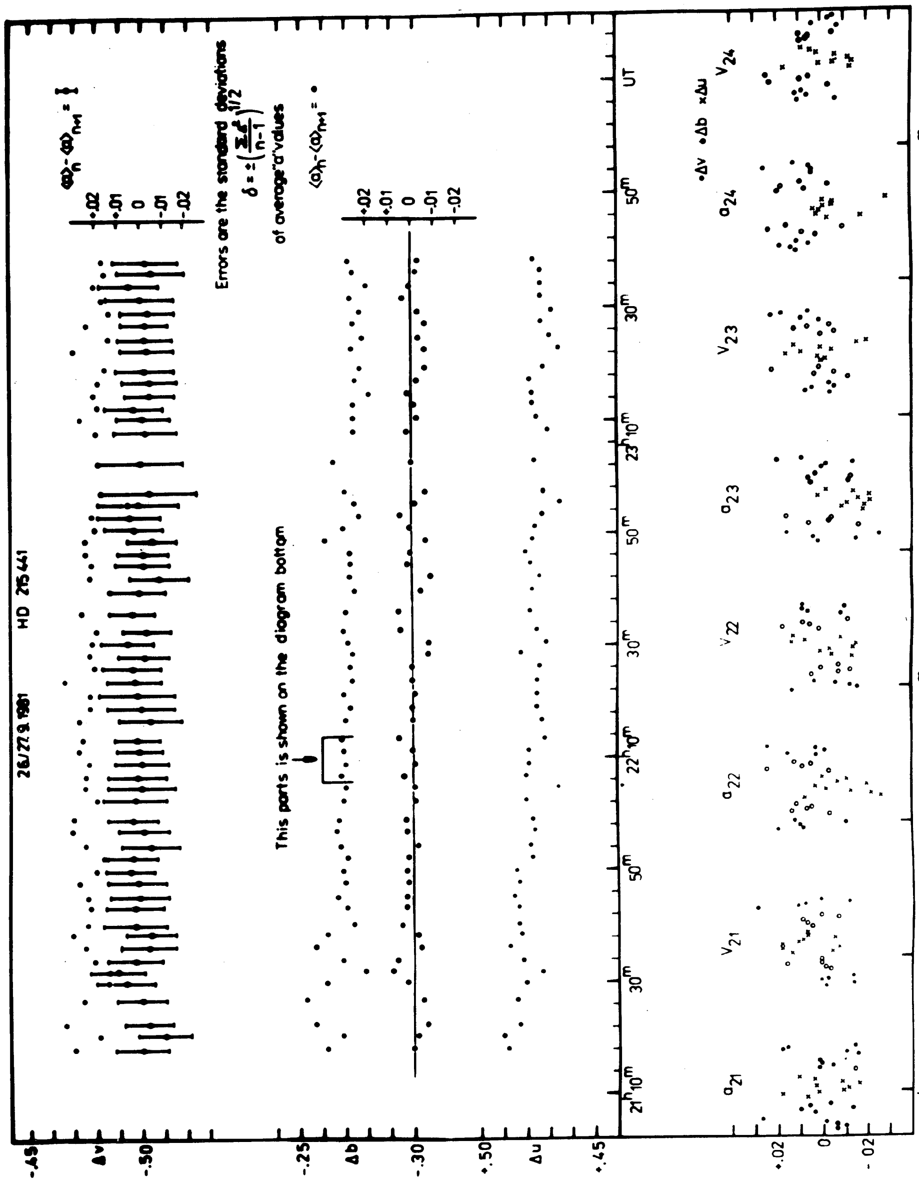

Fig. 1. UBV observations, integration period 1 s. The values of Δv, Δb, Δu are plotted in the instrumental system. As regards the comparison star, differences of two consecutive measurements, expressed in terms of magnitudes, are plotted, $\langle a \rangle_n - \langle a \rangle_{n+1}$. In the bottom part, the individual readings are plotted, expressed in terms of magnitudes relative to the average value. "a" indicates the comparison, "V" the variable star, the indices represent ordinal numbers of the measurements.

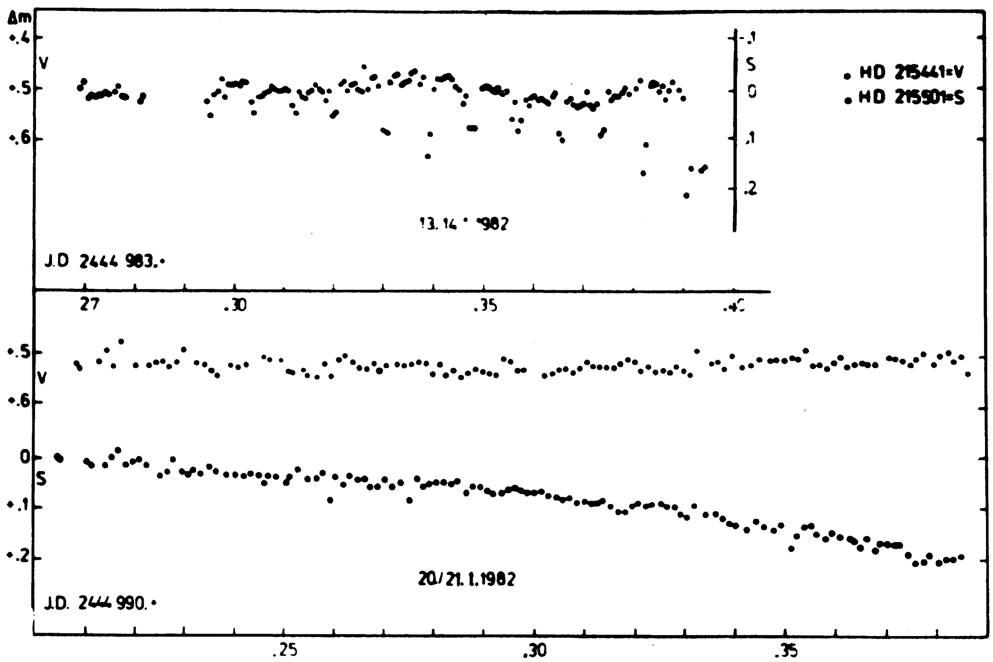

Fig. 3. Observations with the filter of λ = 526 nm, halfwidth 19 nm. The variable values are instrumental quantities in terms of magnitudes, the comparison values are differences relative to the first measurement in terms of magnitudes.

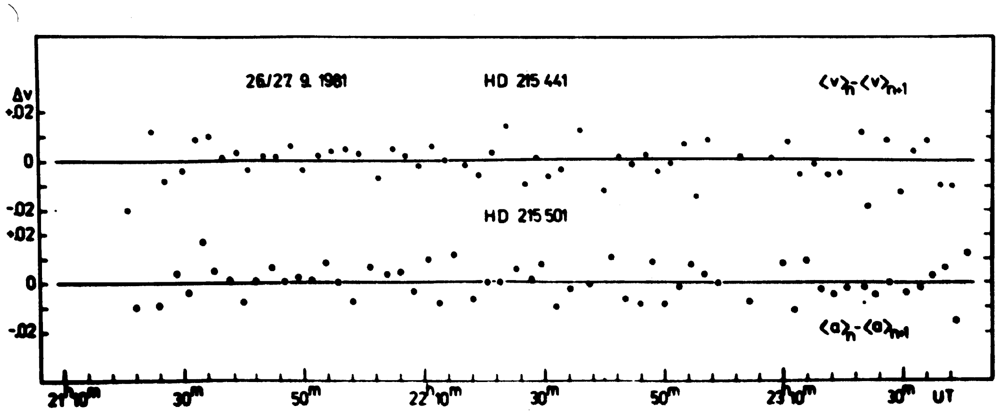

Fig. 4. "Differentiated" light curves. For details refer to text.

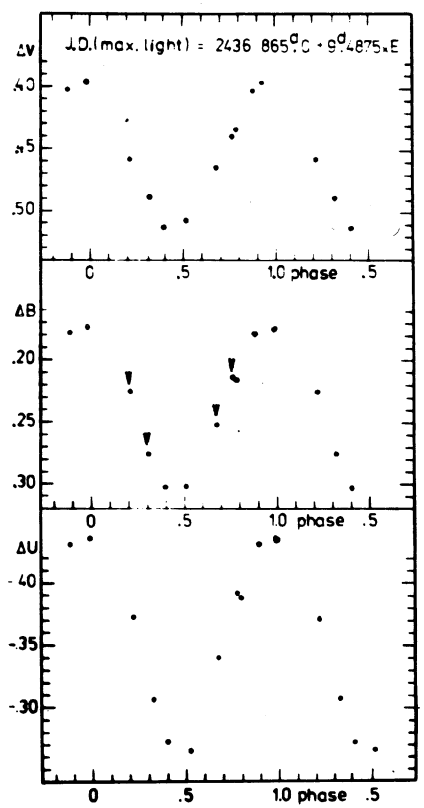

Fig. 5. Rotational light curve in the standard UBV system.

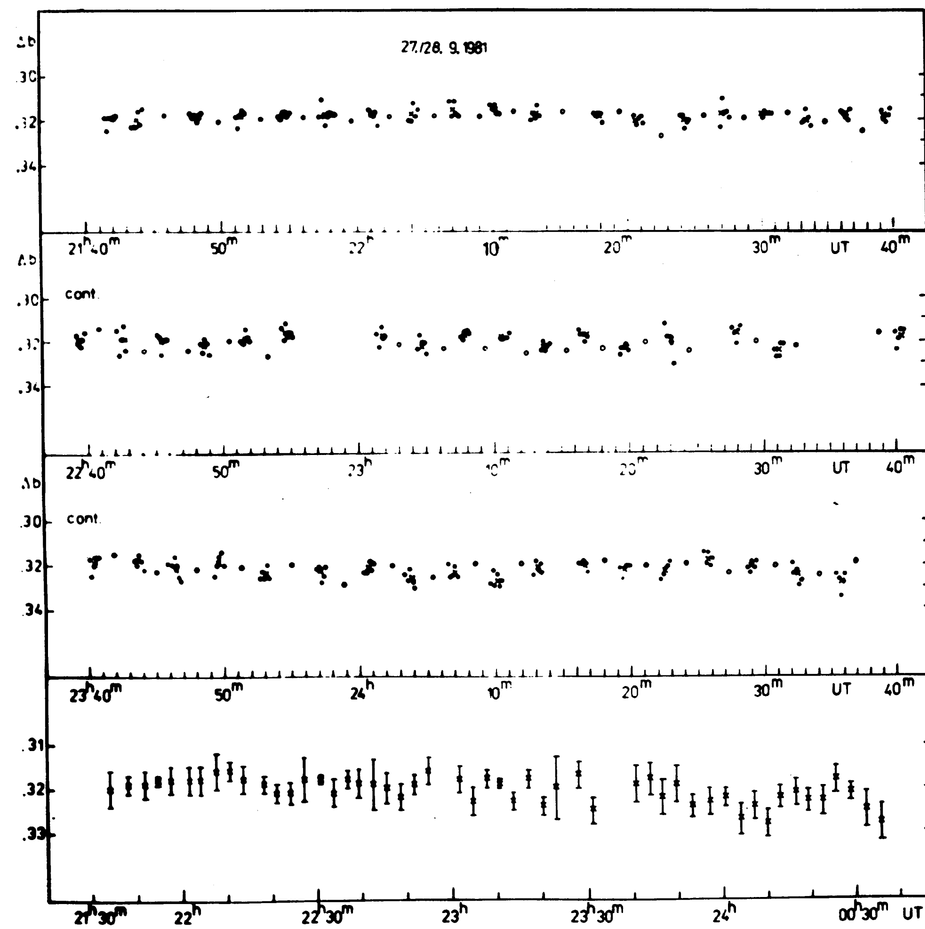

Fig. 2. B observations, integration time 10 s. The crosses indicate the average values of five readings; the other symbols are the same as in Fig. 1.

4. CONCLUSIONS

The analysis of photoelectric UBV and intermediate-band observations, obtained simultaneously at two observatories, has shown the absence of rapid photometric changes of the star HD 215 441. Classical photometry, as well as photon counting have yielded the same results. The observed variations have the nature of random scatter caused by variations of observational conditions.

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