Peculiar Versus Normal Phenomena in A-Type and Related Stars
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LINE VARIABILITY IN 33 GEM ?

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ABSTRACT The spectrum of 33 Gem exhibits a great similarity with that of a CP3 star, but in contrast to other members of this group, light variations and variability in helium lines were reported. Even an effective magnetic field strength up to 1.4 kG was measured in the lines of elements He I, Si II, P II, Mg II, Ti II, Mn II, Fe II (Glagolevskij et al., 1985). For these far-reaching differences high resolution (R$\simeq$ 40000), high signal-to-noise (> 100) CCD spectra of 33 Gem were observed with the Coudé spectrograph of 2.2 m telescope at Calar Alto. As well for the profiles of the He I lines as for those of the metallic lines no changes could be found. Our rough inspection of Zeeman spectograms taken with the 6 m telescope at Zelenschuk in which Glagolevskij et al. noticed a magnetic field revealed unexpected splitting of several lines into two components probably caused by a companion. The line components are separated approximately by 0.1 Å. For this splitting a confirmation of the presence of a magnetic field was difficult.

1. INTRODUCTION

33 Gem belongs to the group of CP3 stars for which the peculiarity refers mainly to unusual strong Mn II lines and to a remarkable absorption feature at λ 3984 Å identified as a Hg II line. The effective temperature and gravity of 33 Gem are typical for CP3 stars: K.C. Smith and M.M. Dworetsky (1990) found T_{eff}=14400 K and log g=3.85.

Exceptional interest to study this star comes from the observation of a strong effective magnetic field (1.4$\pm$ 0.2 kG) as reported by Glagolevskij et al. (1985). For other CP3 stars no effective magnetic field has been detected by Borra and Landstreet (1980) even though the errors are fairly small. Nevertheless, for the interpretation of the element anomalies in the HgMn star atmospheres the detection of a non-vanishing magnetic field should be of great importance (Michaud, 1981).

Even in contrast to other HgMn stars for 33 Gem variations in light in a system close to UBV with $\Delta m \geq 0^{m}.05$ with a period of $3^{d}.35$ have been reported by Panov (1985). After Glagolevskij et al. (1985) the equivalent width of He I lines λ 4026 Å and λ 4471 Å are variable too.

Since in Ap stars the frequently varying effective magnetic field is strongly linked to absorption line variations, we intended to use this fact to supplement the investigation of a magnetic field for 33 Gem.

2. OBSERVATIONS

To look for spectral line variations 33 Gem was observed during 3 nights in October 1991 with Coudé spectrograph of the 2.2 m telescope of the Calar Alto Observatory. The detector used was a TEK CCD with a 512 x 512 array of pixels of 27 μm size. The spectra were taken in the wavelength range 3975 - 5320 Å with a reciprocal linear dispersion of 2.2 Å mm^{-1} and a resolution of $\simeq 4\ 10^4$. Table I contains the journal of observations.

Table I.

Julian Date 2440000+	Exp. Time (minutes)	λ central (Å)	S/N
8547.595	60	4472	250
8547.639	24	4922	170
8548.551	60	4472	200
8548.604	60	4922	250
8548.661	60	5016	280
8550.556	45	4472	225
8550.594	37	3990	170
8550.620	25	4550	280
8550.654	22	4645	310
8550.685	40	5016	290
8550.712	34	4922	250
8550.730	16	5305	200

The reduction of these spectra, intensity and wavelength calibration were carried out according to CCD reduction software developed by J. Solf from MPIA. The line identification was performed using the tables of R.L. Kurucz and E. Peytremann (1975) and of Ch.E. Moore (1945). The equivalent width of the lines were computed by gaussian fit method.

In addition two sets of photographic spectrograms were used to complete the CCD data. One set of plates with 9 Å mm^{-1} was taken by Glagolevskij et al. with the 6 m telescope at Zelenschuk, the other one with 8 resp. 12 Å mm^{-1} by Vilhu et al. with the 2.6 m Shajn reflector of Crimean Observatory.

3. RESULTS

The CCD spectra were used to search for variations in equivalent width and line profiles of He I and other elements, especially Mn II, Fe II, Mg II and P II. No significant variation in these spectra could be detected; the uncertainty for equivalent width due to continuum placement is ± 5 mÅ (Fig. 1a, b, c). The accuracy of the line profiles is limited by S/N (see Table I) and resolution of $4\ 10^4$, i.e. $\Delta\lambda \approx 0.13$ Å. Variation in radial velocity could not be proved due to technical problems. Only for the last observing night a reliable value, namely $V=12.1 \pm 2.1$ km sec^{-1}, has been derived.

The inspection of the photographic spectra exhibits a surprising result. On most of the plates the lines profiles show the tendency to be "square" or rectangular suggesting incipient separation into two components. Even on some spectrograms the lines form well resolved pairs of nearly equal intensity. The largest separation between two components measured in Potsdam with the modified Abbe comparator is 0.3 Å, a value very near to the λ resolution.

For a determination of the radial velocity these spectra are not very well suited. The accuracy of the best one is not better than 3 km sec $^{-1}$.

By our trial to repeat the measurement of the magnetic field on the spectrograms from 6 m telescope, which were taken with Zeeman analyzer, we noticed that the line profiles are quite similar in left and rigth hand circular polarized light. A determination of B_{eff} is very difficult; on some plates a displacement is indicated, but with very large uncertainty in our measurements. It is to mention that recently by Bychkov (1990, 6 m telescope photoelectric magnetometer) obtained results could not confirm the magnetic field larger than observational error:

Julian Date	$B_{eff} \pm \sigma$ (Gauss)	Exp.Time (minutes)
2448172.563	134±134	63
2448222.523	109±177	33

4. DISCUSSION

The observational results, no variation in equivalent widths on CCD spectra, square shaped profiles for all lines in both circular polarizations, suggest that 33 Gem is a spectroscopic binary with components of nearly equal mass and peculiarity. Therefore we gathered all radial velocity values from the literature to prove whether there is an indication for a companion:

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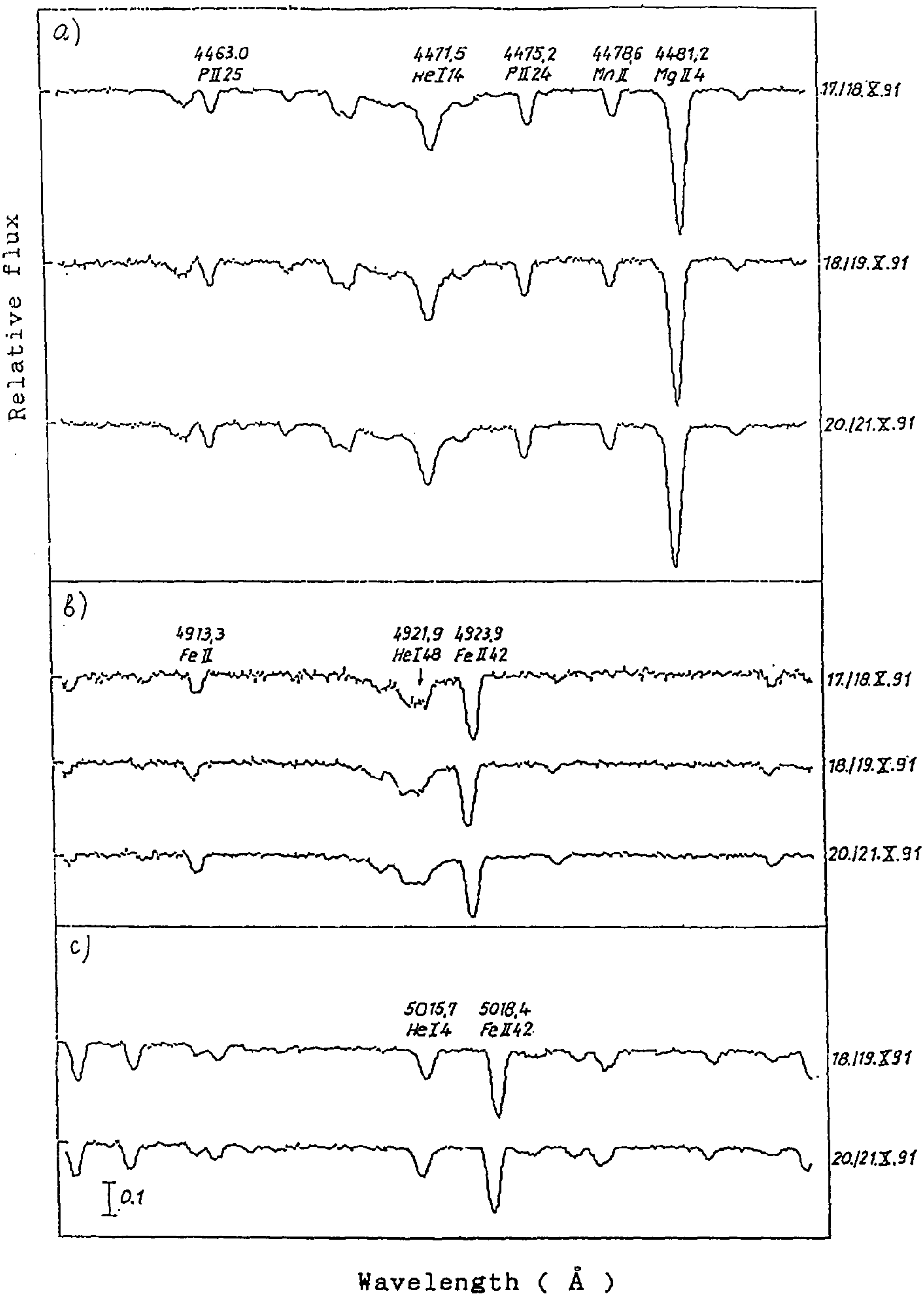

Fig. 1 a, b, c. Observations of the spectral regions around HeIλ4471 Å, HeIλ4922 Å and HeIλ5016 Å in 33 Gem.

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RV ($km\ s^{-1}$)	σ	reference
12.9	±0.7	Abt H.A., 1969, ApJS 19, 387
14.1	±0.5	
11.1	±2.4	
10.3	±0.6	Aikman G.C.L., 1976, Publ. DAO 14, 379
10.5	±0.8	Stickland D.J., Weatherby J. 1984, A&A Suppl. 57, 55
11.6	±1.1	
11.3	±1.2	
15.7	±0.7	
15.8	±3.1	Oetken L., 1990, private communication

The differences in the radial velocities are in the range of errors. That means in case of a binary its orbital plane must nearly coincide with the tangential plane. From the vanishing variations in the line profiles during gathered observations follows that its period must be larger than 10 days.

In the other case that 33 Gem resembles a magnetic Ap star, we would expect changes in line profiles caused by inhomogeneous distribution of chemical elements on the star surface: line splitting would be observed in the rotational phases, when regions of enhanced element concentration appear at opposite stellar limbs and the lines of different elements would not show the same phase dependence. The above mentioned observational results - especially that almost all metallic lines show similar "square" profiles at no time really asymmetric - do not support the model of a magnetic star for 33 Gem.

To decide definitely whether 33 Gem is really spectroscopic binary high resolution observations of line profiles, at least 100,000, are required. Nevertheless the search of a magnetic field further would be of large interest.

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DISCUSSION (Hubrig and Launhardt)

ADELMAN: What is the $v \sin i$ of 33 Gem? What shape do the strong lines of your comparison spectra have?
HUBRIG: I found literature values between 15 km s^{-1} and 30 km s^{-1}. For most spectra the arc lines are not really sharp. Maybe they have been taken out of focus.
ŽIŽŇOVSKÝ: I can confirm your conclusion that 33 Gem is probably a non-variable star. I have a few photometric measurements in Johnson's UBV system from last winter. Some of them were taken in phases corresponding to the extremal values of the light curve published by Glagolevskij et al. (1985). But I find the star is constant within 0.01 mag. If it is variable, then the value of the period is incorrect.
DWORETSKY: Have you examined the Zeeman plates for 33 Gem and if so, do you see the evidence for a magnetic field on those plates (the ones used by Glagolevskij et al.)?
HUBRIG: We tried to measure a magnetic field on the same plates Glagolevskij et al. used in their work. However, because of the line splitting probably caused by a companion, the confirmation of a magnetic field is difficult.