RAPID OSCILLATIONS IN THE SPECTRUM OF roAp STARS χ PSC AND γ EQU

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ABSTRACT. Results of high time and spectral resolution spectral observations with CCD in 1998-1999 for Ap stars χ Psc and γ Equ were presented. Spectroscopic parameters (Vr, W_λ) of spectral lines SiII, CrI, CrII, FeI, FeII, Hα, Hβ shows that despite of different value of rotation velocity of χ Psc (180 km/s) and γ Equ (~74 years), both stars shows short-time oscillations of spectral parameters, and concern to a subgroup of roAp stars. It is showed that spectroscopic parameters and magnetic field strength variations may be described with short-time pulsation periods ~17 min and ~12 min for χ Psc and γ Equ correspondingly.

Key words: spectroscopy of stars-roAp stars-stellar magnetism.

On the basis of echelle-spectrums, received with the high time and spectral resolution in spectrometer with application CCD in Cude-focus of 2 telescope of ShAO NAN of Azerbaijan (dispersion 3-5 Å/mm), variations of spectrum Ap stars χ Psc and γ Equ were investigated. The spectral resolution R = 30000. For 1998-1999 was received only 84 spectrums for χ Psc and 56 for γ Equ with a signal to noise relation in area Hα ~ 80-120. In detail about an observational material and technique of observation was described in works Aliev and Ismailov (2000, 2001).

χ **Psc.** The changes of equivalent widths and radial velocities of lines H_α and H_β within the first and second night of observations have shown, that the wavy type changes both equivalent widths, and radial velocities of these lines was obtained. In a fig. 1 the time dependence of parameters (radial velocities Vr, equivalent width W_λ) of spectral lines H_α and H_β is given. Pulsation type short time variations of parameters of spectral lines were discovered. On the Fourier analysis of parameters of spectral lines in an interval of frequencies 0-120 d^{-1}, the period of oscillation P2 = 0.0119±0.0008 day was obtained. Besides it, probably, there is a period P3 = 0.0093±0.0005 day, and also the period of axial rotation P1 = 0.5583±0.025 day was found. The different spectral lines show different amplitudes with a short time pulsation, and the largest amplitudes of changes of radial velocities shows lines of peculiar of elements.

In a fig. 2 the phase diagram of relative equivalent widths of a star χ Psc determined for the period P2≈17 minute is given for different spectral lines.

As shown here, within one year the received results give satisfactory stability on the given period.

In a fig. 3 the phase curve of a magnetic field of a star for the period of a pulsation χ Psc is given. It is shown, that the strength of a magnetic field is satisfactorily described by this period. The measurements of a magnetic field strength were taken from Borra and Landstreet (1980). Though quantity of magnetic field measurements is small, confidently it is possible to tell about periodic changes its with the period of pulsation P2. This observational fact shows, that, apparently, main reason of processes of a pulsation also is the magnetic field, though complete understanding of this process encounters difficulty.

The magnetic field of a star varies with a phase also with both period's P1 and P2, though the forms of curves are various. Average curves of radial velocities of lines of peculiar elements show's synchronism of changes with a magnetic field strength. On the rotation velocity of the star are determined an inclination of rotation axis with beam of sight i = 9°±1° and corner of inclination of a magnetic axis of a star to a beam of sight equal β = 63°±1°. The maximal strength of a magnetic field of a star equal about 1468±200 G is appreciated.

For the first time is shown, that the magnetic field of a star synchronously varies with radial velocity of lines CrII and SiII, and to a lesser degree by other lines. We suggested that this is a result of direct connection of a magnetic field of the star and it peculiar properties.

γ **Equ.** In the fig.4a for example the change of radial velocities of spectral lines FeIλ 5171Å, MgIλ 5172Å, CrIIλ 4836Å is given for the first night of observation. In the fig. 4b is given change of Vr for the second series of observation, for lines FeIλ 5162Å, FeIIλ 5169Å, CrIIλ 4836Å and Hα. From a fig. 4 it would be visible, that two type of changes Vr are observed simul-

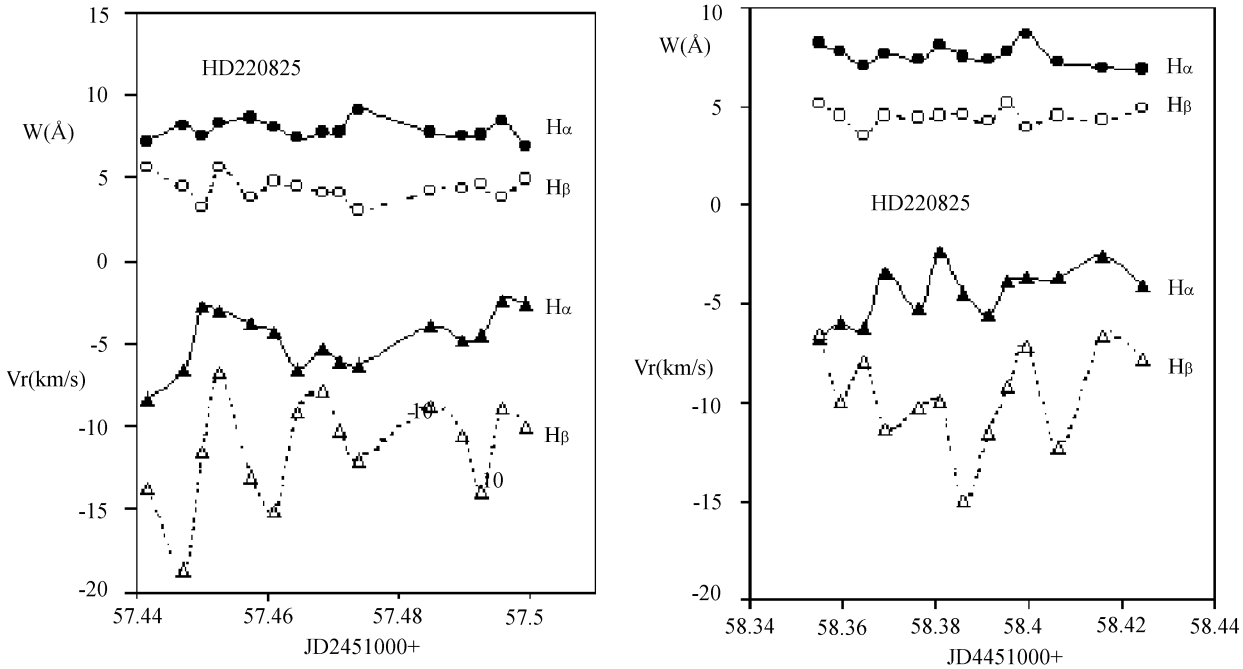

Figure 1: Time variations of spectral parameters W_λ and Vr for hydrogen lines Hα and Hβ during two different nights of observations for χ Psc.

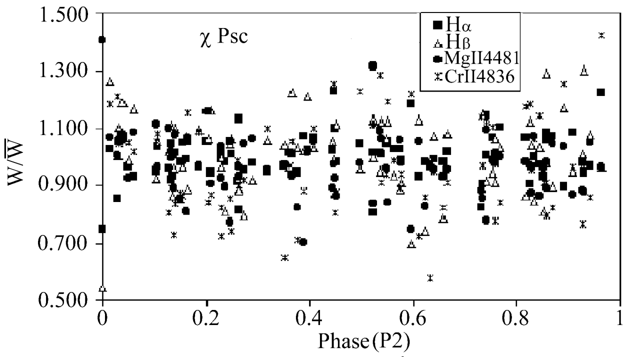

Figure 2: The phase diagram of relative equivalent width of spectral lines of a star χ Psc in phases of pulsation period P2. In ordinate is given of separate relation of equivalent widths meaning to average for the given line.

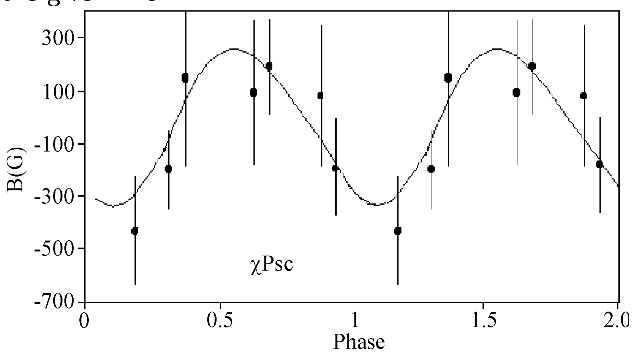

Figure 3: A phase curve of magnetic field strength for χ Psc. Results of a magnetic field measurements are taken from Borra and Landstreet (1980).

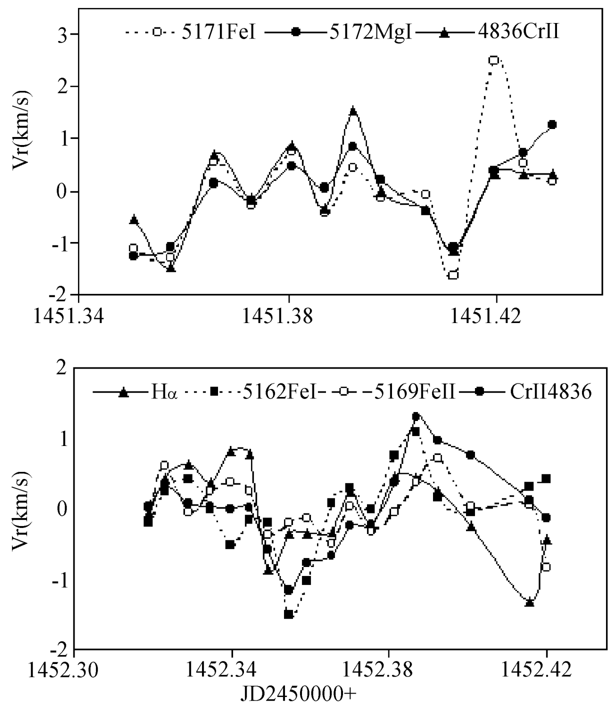

Figure 4: Time variation of radial velocities for separate nights on different spectral lines of γ Equ.

taneously: a) a short-time pulsation type variability, b) rather slow wavy type variation during characteristic time about 1.5 hours. Both types of variations are well appreciable till a fig. 4 both in first, and in the second series of observation: in the first series two minima and one maximum, and in the second series two minima and two maximum are observed. The similar fluctuations of Vr are observed the in other series of observations too.

As a result of frequency Fourier analysis of spectral parameters, from our observation two most probable frequencies ν_2 and ν_4 are revealed which correspond 1324±80 mHs and 1440±70 mHs. These meanings pulsation of modes are very close to meanings of the period given in work Martinez et al. (1996) and on spectral observation, found in Kanaan and Hatzes (1998), and also Malanushenko et al. (1998). As a result of our analysis of a spectrum γ Equ the following basic results are received:

a) The analysis of the data on Vr measurements on different lines showed to existence the pulsation period on a surface of a star γ Equ about $P = 0.^d0080 \pm 0.^d0002$ ($\sim$12 minutes) and period, contiguous to this meaning. On the radial velocities the separate groups of lines are observed which make pulsation in an antiphase.

b) All spectral parameters (W_λ, Vr, $\Delta\lambda_{1/2}$(FWHM), R_λ) have shown synchronous change with pulsation period, that confirms a reality of existence oscillations processes as the physical phenomenon on a surface of a star. Two extreme during one pulsation period on all spectral parameters of a star was observed.

c) It is shown, that the magnetic field of a star makes pulsation type fluctuation in an interval ±350 G. The variations of a magnetic field of the star, on the data of the different authors, will not bad be coordinated with pulsations by the period of the star, and testifies to genetic connection between a magnetic field and processes of oscillations in the atmosphere of the star.

In the conclusion we shall note, that despite of different value of rotation velocity of χ Psc (180 km/s) and γ Equ ($\sim$74 years), both stars show short-term oscillations of spectral parameters, and concern to a subgroup of roAp stars. It testifies that the origin pulsations processes in atmospheres of roAp stars, apparently, is not a consequence of their axial rotation.

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