

New observations of CP stars in the spectral regions of Li I $\lambda 6708$ and $\lambda 6104$ with the 6-m BTA telescope

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Abstract. We present the first results of the CP star observations in the spectral regions of the Li I lines at $\lambda 6708$ and $\lambda 6104$ obtained with the 6-m BTA telescope of the Special Astrophysical Observatory of the Russian Academy of Sciences.

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1. Introduction

The International Cooperation Program “Lithium in Magnetic CP Stars” (Polosukhina *et al.* 2005) has the purpose of studying the behaviour of the Li I $\lambda 6708$ resonance doublet and its subordinate $\lambda 6104$ line in the spectra of CP stars. For a long time, the results of Li line observations in the CP stars have been controversial due to the lack of high quality observational data. The increase of the number of high resolution ($R \sim 100000$, $S/N \sim 100$) spectral observations and also modern methods of spectra processing have provided the opportunity for the detailed study of CP star spectra in the vicinity of the Li I $\lambda 6708$ and $\lambda 6104$ lines and, therefore, to obtain a better comprehension of the Li problem in CP stars.

2. Main objectives of the Program

The program of Li observations in CP stars which uses the 6-m BTA telescope has the following objectives:

- Test observations - to search for Li I $\lambda 6708$ in the spectra of selected CP stars;
- Monitoring of slowly rotating roAp stars (with sharp lines);
- Monitoring of rapidly rotating roAp stars to study the behavior of Li I $\lambda 6708$ with the rotation phase and search for CP stars with “Li spots”;
- Identification of some faint spectral lines of Rare Earth Elements (REE) near Li I $\lambda 6708$ in the spectra of slowly rotating C^{mp} stars;

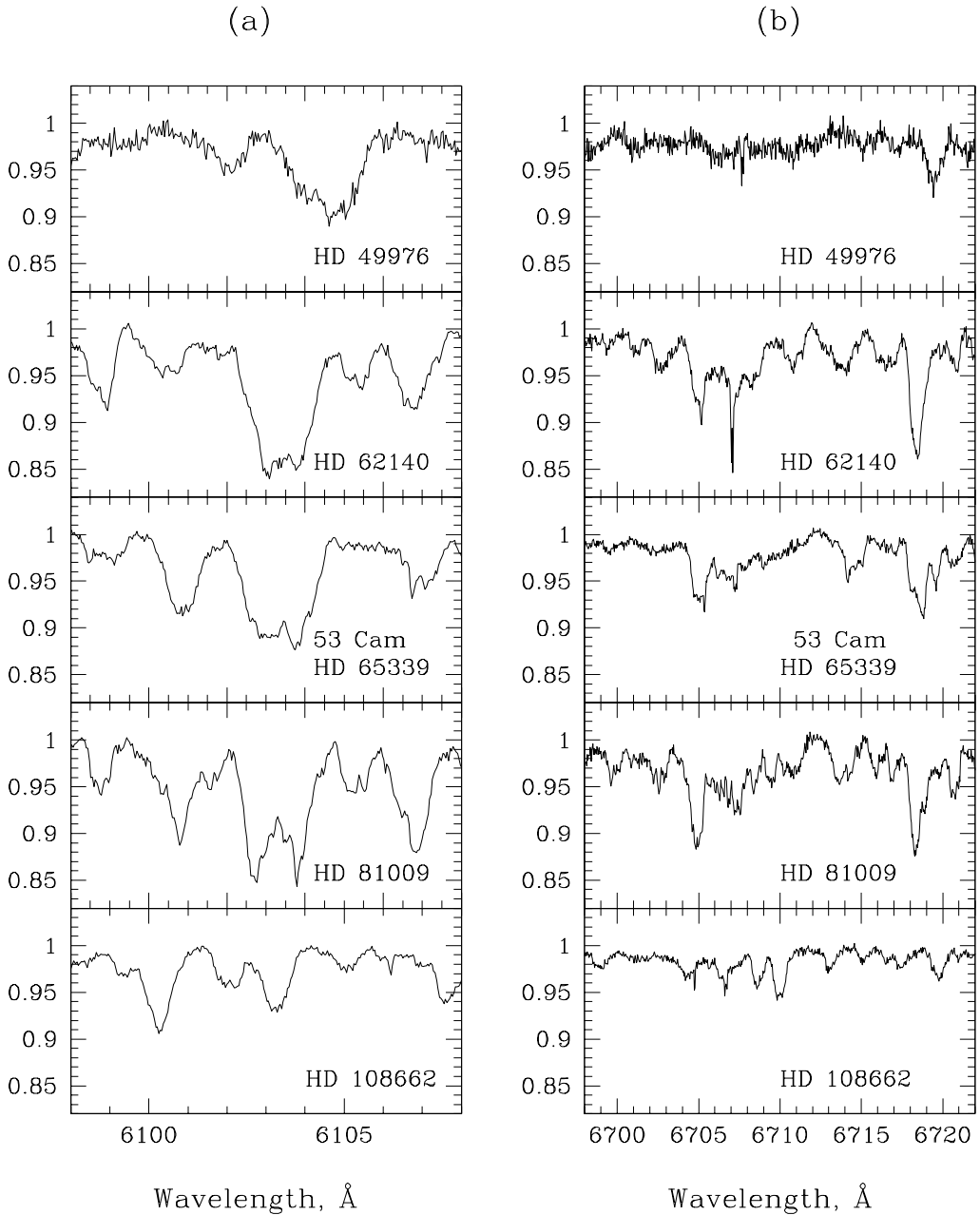


Figure 1. Test observations. Spectra of the rapidly rotating CP stars close to Li I $\lambda 6104$ (a) and $\lambda 6708$ (b).

- Determination of the Li abundance using Li I $\lambda 6708$ and $\lambda 6104$ taking into account magnetic field effects;
- Determination of the Li isotopic ratio ${}^6\text{Li}/{}^7\text{Li}$ using Li I $\lambda 6708$.

This long term program will substantially increase the number of CP star spectra in the regions of Li I $\lambda 6708$ and $\lambda 6104$ and will build a reliable database of them. This may lead to a better understanding of the anomalous behaviour of these lines in CP stars.

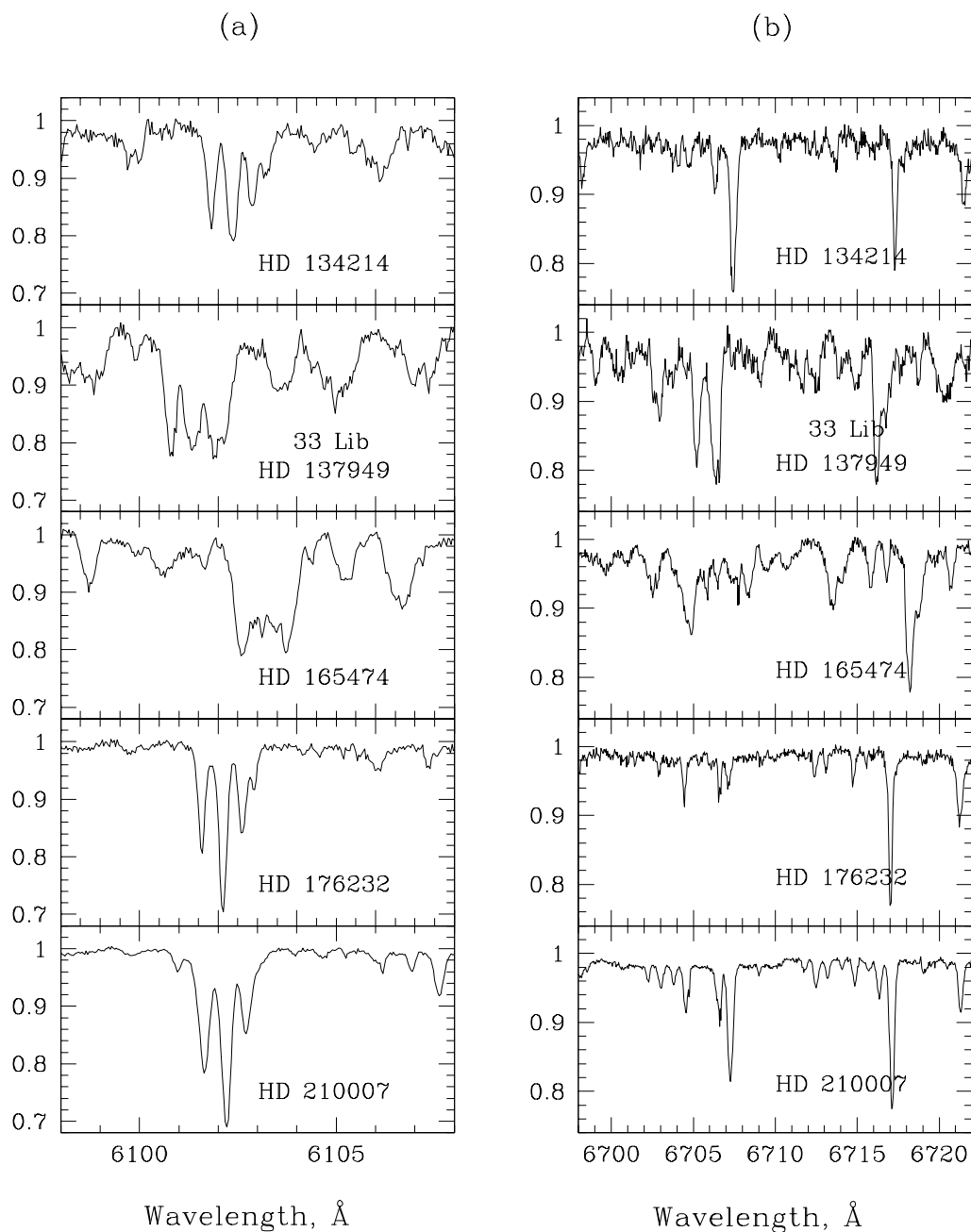


Figure 2. Sharp-lined CP stars. Spectra of the slowly rotating CP stars near Li I $\lambda 6104$ (a) and $\lambda 6708$ (b) .

Additional monitoring of γ Equ (with exposure times of 1.5 – 2.0 min) was carried out to search for oscillations in the spectral region of Li I $\lambda 6708$ and Pr III $\lambda 6706.7$ and to compare them with the oscillations in other REE lines (Kochukhov *et al.* 2004).

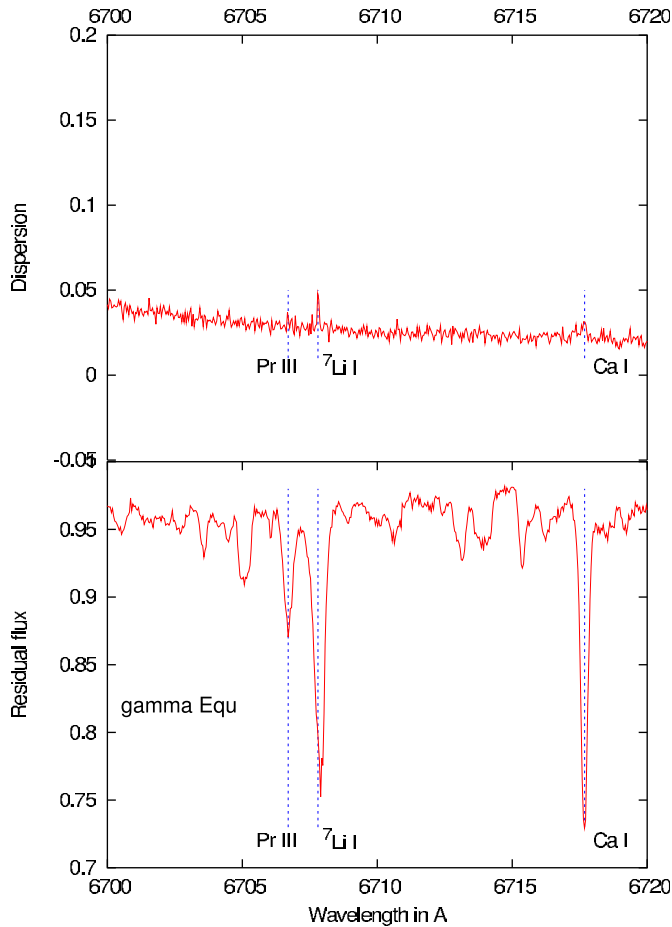


Figure 3. The dispersogram for γ Equ in Li I λ 6708 spectral region. A noticeable variability of the Li I line is evident

3. First preliminary results of the observations with the 6-m BTA telescope on April 8 - 9, 2004

Observations have been carried out at the NASMYTH focus of the 6-m BTA telescope with the echelle spectrometer NES (Panchuk & Klochkova 1999) in the spectral region $\lambda\lambda$ 6000-6800 with a signal-to-noise ratio $S/N \sim 60 - 100$. For spectra reduction the software package REDUCE (Piskunov & Valenti 2002) was used.

a) Test observations of HD 49976, HD 62140, 53 Cam, HD 81009, HD 108662, and HD 176232 permitted us to find two new Ap-CP stars with Li I lines, HD 62140 and HD 176232, to add to the list of “Lithium Ap-CP stars”.

Figure 1 shows the spectra of these stars near Li I λ 6104 and λ 6708. The spectra of HD 62140 and HD 176232 contain Li I λ 6708. In our next set of observations, we plan to monitor these stars to study the behaviour of the Li I line as a function of the rotational phase.

b) Sharp-lined CP stars have been included in the program for the BTA (this program is similar to Wade’s (2005)). These stars are slowly rotating, very rich in REE lines and have strong magnetic fields ($\sim 1500 - 5000$ G). As a first approximation, modelling calculations have been carried out with the atmospheric parameters $T_{\text{eff}} = 7700 - 8100$ K

and $\log g = 4.2 - 4.4$, taking into account Zeeman splitting of the resonance Li I $\lambda 6708$ doublet and the contributions of both ${}^6\text{Li}$ and ${}^7\text{Li}$ isotopes (Zverko *et al.* 2000). More recent analyses of slowly rotating stars have accounted for the magnetic splitting of Li I $\lambda 6708$ and $\lambda 6104$ and all blending lines (Shavrina *et al.* 2005).

For detailed analyses of the Li I line profiles and synthetic spectra calculations, precise measurements of the magnetic field for each rotation phase, as well as corrected data for REE lines in the vicinity of Li I $\lambda 6708$ and $\lambda 6104$ are needed. We plan to carry out the observations of the sharp-lined stars accompanied by the magnetic field observations of the same stars in Wade's program.

Fig. 2 shows the first observations of these stars on the BTA telescope. Strong Li I $\lambda 6708$ and Pr III $\lambda 6706.7$ lines are clearly seen in the spectra. Further detailed study and surface modelling of the slowly rotating roAp stars with the strong non-variable Li I $\lambda 6708$ line (taking into account the blending by the REE lines, magnetic field structure and Li stratification in the stellar atmosphere) will be done in the future.

c) We present here the first high-time resolution observations of γ Equ in the Li I $\lambda 6708$ spectral region, obtained during two nights, on April 8-9, 2004. About 60 spectra with a time resolution of 1.5 – 2 min were obtained. Our preliminary results of time variations of the spectra of γ Equ are shown in Fig. 3. The dispersograms for some CP stars obtained by Polosukhina *et al.* (1999) clearly show that the largest amplitudes of the short time variations are to be found in the intensities of the Li I $\lambda 6708$ and Pr III $\lambda 6706.7$ lines.

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