ON THE SPECTRAL AND PHOTOMETRIC ACTIVITY IN YOUNG STARS

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ABSTRACT. Results of long time homogenous medium resolution spectral observations of classic T Tauri type stars DI Cep, T Tau and GW Ori obtained during 1972-1990 are analyzed. Weak correlation with on metallic absorption lines of optical spectrum spectral types and equivalent widths of hydrogen lines is discovered. It is showed that spectral types of these stars are varying during observation seasons in different ranges. More wide range of variations of spectral types, is observed in DI Cep - F4-K5V, are of all 21 subtypes, in GW Ori - F3-G5V, are of all 13 subtypes and T Tau - G1-K5V, are in all 9.5 subtypes. Observational photometric and spectral properties of these stars may be explained by formation of hot (in case of DI Cep) and cool (in case of GW Ori and T Tau) spots on these stars. We are suggesting that simultaneously a presence of variable circumstellar dust may also be a cause of variability of following two stars.

Key words: stars: pre-main-sequence - stars: spectral types - photometry- variability.

1. Introduction

Studies of photosphere absorption spectrum of T Tauri type stars (TTS) are much confused. Observations by modern detectors shows that the optical absorption spectrums of TTS, consist of a star absorption line spectrum, stellar continuum, superimposed nonphotosphere continuum and linear emission spectrum (e.g. Appenzeller 1986; Finkenzeller and Basri 1987; Hartigan et al. 1989; Franchini et al. 1989). Because of superimposed nonphotospheric emission continuum, all the photosphere absorption lines look generally wide than in the standard stars with comparable effective temperature. In some strong-emission TTS this veiling absorption spectrum is so strong that the photosphere absorption lines are not detectable on low-resolution spectrograms. Spectral classification on the visual blue range of absorption spectrum gives more high effective temperature in TTS than on spectral lines in red range (Herbig 1977; Walker 1980; Appenzeller 1986). Nonphotospheric continuum is free on spectral lines and superimposed to star continuum especially in blue side of spectrum (see, e.g., Hartigan et al. 1989).

More early spectral observations of TTS evidence on short time (see, e.g. Mundt 1979, 1984; Aiad et al. 1984; Hartigan et al. 1986; Ismailov 1987, 1988) and long time (see, e.g. Krasnobabtsev 1982; Grinin et al. 1985; Guliev 1994) variations of Balmer lines of hydrogen, H, K CaII, FeII, etc. Investigators more often studied weak absorption components of shell spectrum (see, e.g. Holtsman et al. 1986, Hartigan et al. 1986, Petrov et al. 1996). However photosphere absorption spectrum investigations in visual range were provided poorly.

The aim of our work is to study a time variability of absorption spectrum of some T Tauri type stars and to search its possible connection with emission lines and in whole with star activity for these objects.

2. Observations and results

All the observations of program stars were carried out in Cassegrain focus of 2 m Karl Zeyss telescope of ShAO AS of Azerbaijan with 2X2 prism "Kanberra" spectrograph. Spectral range is $\lambda\lambda$3600-5100 ÅÅ, dispersion 93 Å/mm at H_γ and 60 Å/mm at H, K CaII. All spectrograms were processed in standard conditions, identical methods and homogenous equipment. In our previous works a method of processing this spectrograms was described in detail (Ismailov, 1992, Rustamov, 1987).

For this work we were chosen of all 46 spectrograms for DI Cep, obtained in 1978-1988(Ismailov, 1987, 1988), 13 spectrograms for GW Ori - 1972-1988 (Ismailov, 1993), 88 spectrograms for T Tau, obtained in 1972-1985 (Guliev, 1991, 1994, Rustamov, 1999).

For investigation of relation with emission and absorption spectrum in this TTS we used definition equivalent widths of emission lines H_β, H_γ, H_δ, H, K CaII (Ismailov, 1987, 1988, 1993; Guliyev , 1991, 1994; Rustamov, 1999).

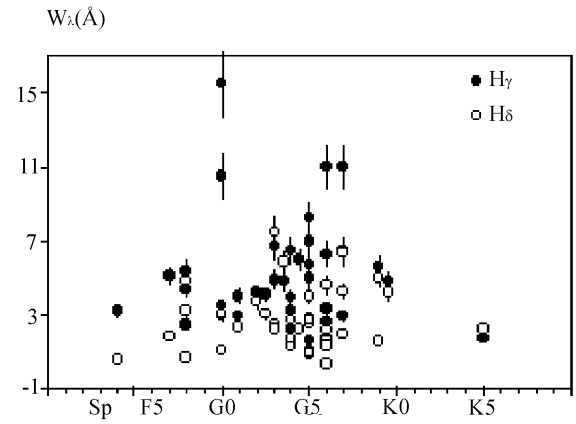


Figure 1: Relation of equivalent width W_λ of emission lines H_γ (black circles) and H_δ (light circles) with spectral types.

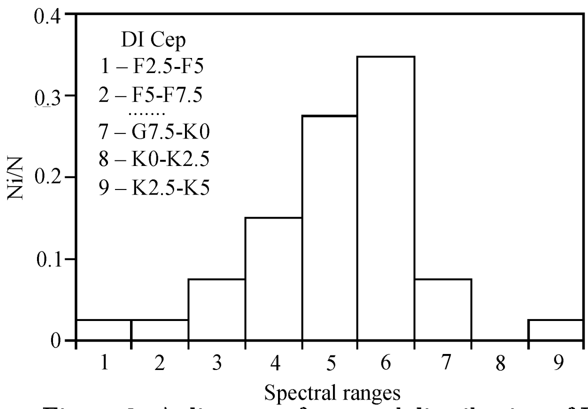


Figure 2: A diagram of spectral distribution of DI Cep. Of all 8 subranges, include 2.5 subtypes of each. A maximum is corresponding G5-7V. In ordinate relative number of spectra in subrange was given.

DI Cep. In fig. 1 was showed equivalent width of emission lines of H_γ and H_δ and spectral types for DI Cep. As demonstrated in this figure, weak correlation between W_λ and spectral type till spectral range of spectral types G5-G7 was observed. For all range of observed spectral types variability quantity of coefficient of correlation R for this lines is equal to 10.6% and 13%, correspondingly.

In fig. 2 was given histograms on frequency distribution of spectral types of star DI Cep in all observation time. In ordinate were given the relation of spectral types in given observed subrange Ni to all observed spectral types N. Every subranges include 2.5 spectral subtypes. On the abscissa spectral subranges are presented. For DI Cep were observed of all 9 subranges where including number of spectral types varied from 1 to 14. Limits of spectral types of each subrange were given in fig. 2.

Thus, a range of variability of spectral types for DI Cep is corresponding 21 subtypes, from F4V to K5V. A maximum in diagram is G5-7.5V. As shown in this diagram spectral condition after maximum was observed rarely (of all 4 spectrum from 40), while till maximum 11 subtypes were observed (of all 22 spectra ~55%) in the range F4-G5V, where a number of spectral types is increasing monotonic till maximum.

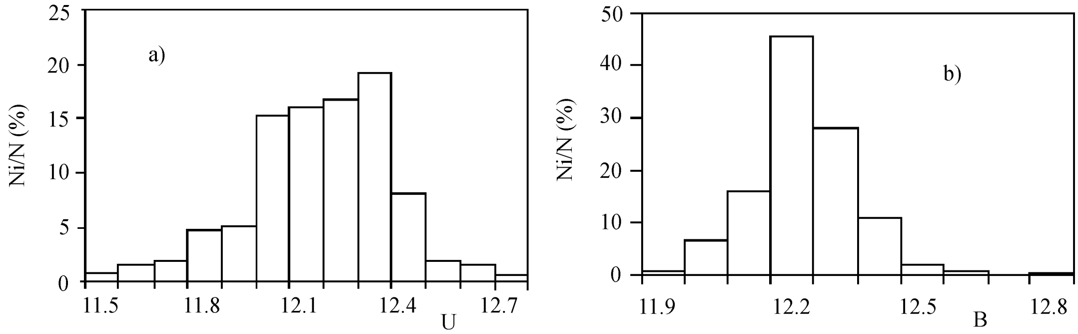
As shown in fig. 2 after maximum (G5-7V) of spectral types frequency distribution we observed highly rare condition, while till maximum of diagram spectral types shows smooth distribution. From side of later spectral types is destroyed normal distribution of random values, which we conditionally will call as "cool break".

In a fig. 3 (a, b, c) were displayed diagrams of light distribution of DI Cep in UBV photometric bands. For analysis UBV photometric characteristics of this star we used literature data from Kardopolov and Filipyev (1985), Grinin et al. (1980), Keleman (1985) and proper observations of Ismailov (1988, 1999) (of all ~500 measure in each bands). In these diagrams each column from left to right decreased with step $0.^m1$. Light variations of star occur in range $11.^m5$ (1 band) -$12.^m8$ (13 band) in U, $11.^m9$ (1 band) -$12.^m9$ (10 band) in B, $11.^m1$ (1 band) - $11.^m8$ (7 band) in V with amplitudes $\Delta U=1.^m3$, $\Delta B=1.^m0$, $\Delta V=0.^m7$. It is shown that distributions of lights in U and V bands have similar kind with spectral distribution diagram. Thus, in U and V bands we see, more frequently a star being in more wide light range, i.e. "cool break" are observed in light distribution diagram. Consequently, small quantity of equivalent width of absorption lines (t.i. more early spectral type) of photosphere absorption more frequently correspond more bright condition of star.

GW Ori. In fig. 4 dependence of equivalent width of emission line of H_β (filled circles) and H_γ (open circles) and spectral types for GW Ori . As demonstrated here, till range G2.5-G5V, with increasing W_λ emission lines, spectral type becomes more lately. In whole coefficient of correlation R for W lines of H_β and H_γ is equally to 25% and 19%, correspondingly.

In fig. 5 was demonstrated diagram of spectral distribution for spectral conditions of GW Ori. We obtained variation of spectral types in ranges F3-G5, of all 13 subtypes. Maximal number of spectral types was placed in ranges G2.5-G5, of all 5 (38.5%) were observed. A diagram maximum unlike of DI Cep placed nearly in lately condition of spectral types. In this diagram as in case of DI Cep we also observed "cool break" effect.

A diagram of light distribution on the UBV photometry data for GW Ori was presented in Ismailov's work (1993). In this work it was shown that for GW Ori in all photometry bands light distribution diagram without exception had a maximum corresponding to more bright condition of star. We also observed break in



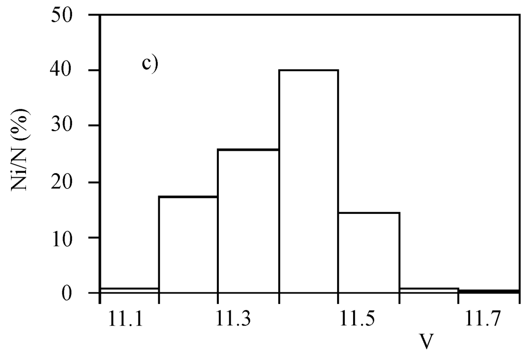


Figure 3: The diagram of light distribution in U(a), B(b) and V(c) bands of DI Cep. In abscissa were given ranges with step $0.^m1$, in ordinate relative number of subrange to all number of observation. A stellar magnitude limits for each column were presented in text of paper.

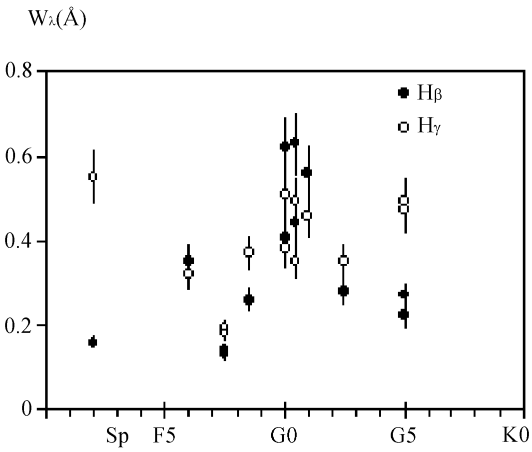


Figure 4: Dependence of equivalent width of emission lines of H_β (filled circles) and H_γ (open circles) for spectral types of GW Ori.

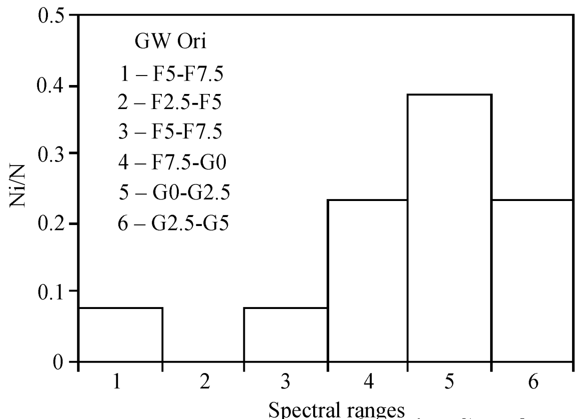


Figure 5: The same as in fig.2 for GW Ori. A maximum of diagram corresponds G2.5-G5V.

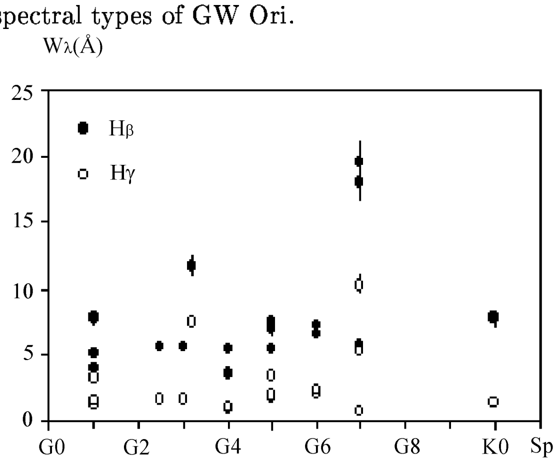


Figure 6: Dependence of equivalent width of emission lines of H_β (filled circles) and H_γ (open circles) for spectral types of T Tau.

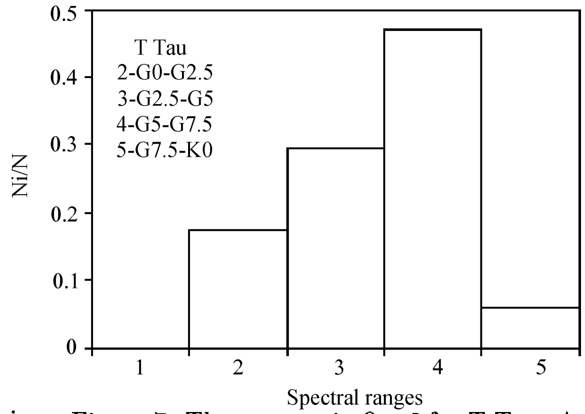


Figure 7: The same as in fig. 2 for T Tau. A maximum of diagram corresponds G5-G7.5V.

distributions of light in direction of increase of magnitudes. Thus, if suppose that maximums in spectra and light diagrams are more stable conditions of the star, then we must accept that more early spectral types are observed in more weak brightness. Consequently decrease of equivalent widths of absorption photosphere lines must be observed in case of decrease of brightness of star.

T Tau. Of all 87 spectrograms of T Tau during 17 separate nights were obtained. In fig. 6, was demonstrated relation of mean for each night equivalent widths of emission spectral lines H_β and H_γ W_λ and obtained mean for night spectral types for T Tau. A number of spectrogram differs in different nights from 1 to 12, often 5-6. Therefore, statistical weight of each point in fig. 6 considerable larger than in case of DI Cep and GW Ori. As showed in this figure, there is a weak correlation between W_λ of this emission lines and spectral types. For lines H_β and H_γ correlation coefficient is 40% and 18%, correspondingly. We must note that unlike analogy diagrams for previous stars in T Tau some maximum W_λ of emission lines do not distinguish here.

In diagram of spectral type distribution demonstrated in fig. 7 for T Tau we obtained similarity with previous stars. So, spectral types varied in range G1-K0.5V, of all 9.5 subtypes. A maximum of spectral types distribution was obtained at G5-G7.5V, in lately spectral types. At maximum of diagram we observed 47% of all observations, and in latter column 6%(of all 1 case). From this diagram we may confirm that, a) later than G5-G7.5V spectral types was not observed or observed rarely, b) more possible condition of spectral types of star is G5-7.5V and with a time spectrum crosses to more early spectral types fluently.

3. Conclusions

Thus, spectral and photometry results obtained in long time period for some TTS allowed doing following conclusions: 1. More stable condition of spectral types of DI Cep is determined as G5-G7.5V, and maximal variable ranges of spectral types is 21 subtypes. Spectral types more often vary to more early types, *cool break effect* is observed. Taking into account photometric characteristics, variability of star can be explained with formation of hot spots on the star surface.

2. More stable spectral type condition of GW Ori determined as G2.5-G5V, maximal observable range of spectrum variability -13 subtypes. A spectral type more often varied to more early types, which have cool break. With take account photometry characteristics a variability of star may be explained dust obscuration of star with circumstellar matter. Moreover one cannot accept cool spot origin effect.

3. More stable spectral condition of spectral types of T Tau is determined as G5-G7.7V, maximal range of variation is -9.5 subtypes. Is observed cool break at more probable condition of spectrum. Taking into account photometric observations variability of star may be explained with cool spots on star surface. One mustn't except dust obscuration by circumstellar matter.

4. More often observed spectral types on our data are more stable and near to real mean spectral types of stars. Simultaneously, cause of variation of real physical conditions is observed in different spectral types for a time in TTS, which were obtained, perhaps, by same authors.

5. Emission line equivalent widths variability, which weakly correlated with spectral types in all three stars, only in part may be described by variable total luminosity of central star. It shows that main causes of variability of emission lines in TTS are other unclear processes.

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