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SPECTROSCOPIC STUDY OF H_α—EMISSION OBJECTS IN IC 1396

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Spectral observations of 53 H_α–emission objects of the HII–region IC 1396 were carried out with a moderate resolution by 2.6–m telescope of the Byurakan Astrophysical Observatory. The factor analysis of these observational material indicates that two main factors are dominating. The most significant factor 1 (Fig. 1) resembles a spectrum of a star of spectral type F5 with a strong H_β–line in absorption. The factor 2 (Fig. 2), on the contrary, appears as a later type spectrum with H_α and H_β in emission. The obtained result can be explained by the transient nature of the H_α–emission.

1. *Introduction.* The existence of H_α–objects is an important indicator of star forming processes. The observations testify that they are always strongly concentrated in regions where stellar cosmogonic processes are clearly going on (stellar associations, molecular clouds). This fact stimulated many surveys of star forming regions carried out by mainly wide–field telescopes equipped with objective prisms of low resolution.

Taking into account that all HII–regions are members of stellar associations, centres of star formation in the Galaxy (see, for example, [1]) and the HII– region IC 1396 is a part of the Cepheus OB2–association and the open cluster Tr 37, one can conclude that at present it is a star forming region.

The HII–region is excited by the luminous OB stars of the Cepheus OB2–association and in particular by a multiple O6Vf star — HD 206267, of Trapezium type [2]. Spectroscopic study of luminous stars [3] indicated that this younger part of the Cepheus OB2–association has an age of about 3 million years.

A detailed study of the IRAS point sources in this region [4] revealed that the brightest sources are located at IC 1396.

The lower mass stellar population in IC 1396 is not so well studied as in other regions of star formation like the Orion and NGC 2264 associations.

Marshall and van Altena [5] estimated kinematic membership for Tr 37 and Marshall et al [6] measured photoelectric UBV colours for its 120 probable members. They concluded that Tr 37 contains several pre-main-sequence stars. Dolidze and Vyazovov [7] published 125 H_α-emission stars in the field of IC 1396. Wackerling [8], Dolidze [9] and Herbig and Bell [10] listed 45 objects. The most comprhensive study of this fieldwas carried out by one of authors [11,12] identifying 220 H_α-emission stars.

The comparison of the surveys concerning of this field published by different authors shows the lack of coincidence, which might be conditioned, at least partly, by the difficulty of recognizing the emission property on small scale spectrograms.

However, the main reason of it seems to be the fact that the H_α-emission of these objects is strongly variable in time. For example, already in 1948-52 Weston and Aller [13] has noted that in the spectrum of T Tau, the prototype of T Tau type stars, consisting a numerous group of H_α-emission objects (characteristic population of stellar associations) the rapid (durind some hours) variations of emission lines are observed. This conclusion was confirmed later on in a number of investigations (see, for example, [14]).

Therefore it is reasonable to repeat the observations of H_α-emission objects at different epochs with the same instrument using the same technic in order determine the time scale of these spectral variations.

For this purpose both in Byurakan and Konkoly Observatories a number of plates were taken with the Schmidt telescopes (Byurakan: 100/130/213cm, Konkoly: 60/90/180cm) to get the characteristic time scale of these variations.

First results of these investigations obtained by Balazs et al [15] indicated a time scale of a few days. One can not exclude, however, the possibility that in some cases the misinterpretation of small scale spectra and all of the subjective errors behind that are responsible for the lack of correlations between the different surveys.

Taking into account this possibility we have set up a program to investigate the objects found on small scale spectra with larger dispersion in order to get some insight into their real physical nature.

In the present paper we discuss the preliminary results of the spectral observations of some H_α-emission objects detected by Kun [11] in the HII-region IC 1396 with a slit spectrograph of a moderate resolution. More comprhensive study is in progress [16].

2. *Observational material.* We have a selected 53 objects of 12–16 magnitude from the catalogue of H_α–emission objects in IC 1396 by Kun [11]. For getting the spectra we used the 2.6–m telescope of the Byurakan Astrophysical Observatory equipped with an UAGS Cassegrain spectrograph and an YMK–91B image intensifier. The spectra were recorded on Kodak 103aO films. We utilized two diffracting gratings one of 651 line/mm and an other one with 1302 line/mm giving the dispersion of 100 A/mm and 50 A/mm, respectively.

Spectra were scanned by the PDS 1010 microdensitometer of the Byurakan Observatory using a 50x50 micron slit by the 25 micron step.

The density–intensity calibration were carried out by a spot sensitometer. The photometric calibration curves did not differ significantly from each other and we used a mean curve. For reduction of the spectra we used AIDA image processing system developed in Byurakan Observatory. We scanned the background and the calibrating spectra (He–Ne–Ar) on both side of the observed stellar spectra. The wavelength scale of the raw spectra was linearized utilizing the built in procedure of the AIDA system and all of the spectra taken with smaller dispersion were normalized to 5556A after a Gaussian filtering.

Together with the program stars we observed on each night comparison stars with known energy distribution. In most cases we used BD + 28°4211 and in some cases

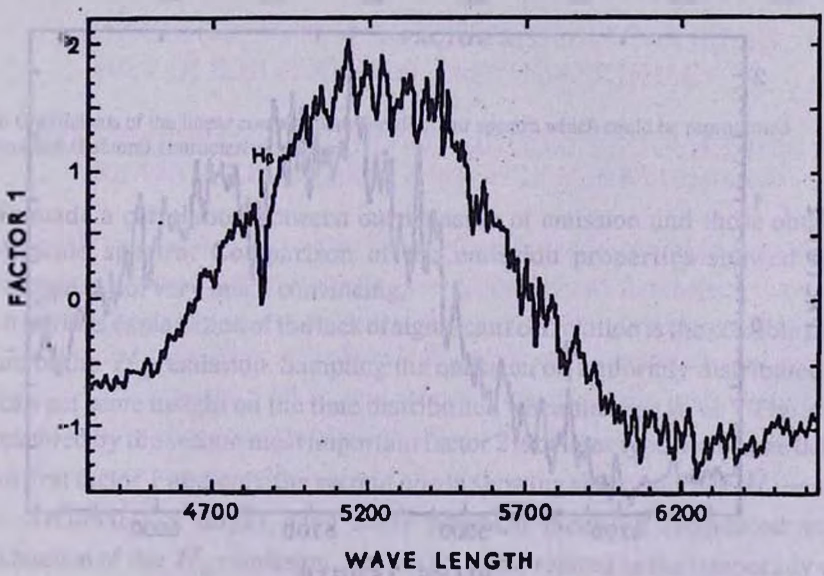

Fig.1. The dependence of scores of Factor 1 in function of the wavelenght. The most significant Factor 1 resembles a spectrum of a star of spectral type F5 with a strong H_β –line in absorption.

BD +40°4032 [17]. Based on the known energy distribution of the standard stars we determined the wavelength dependency of sensitivity of the system.

The sensitivity curve of the system was slightly varying from night to night but its nearly constant part between 4500 — 6400A did not changed significantly.

3. *Statistical analysis of the spectra.* For the 53 program stars we obtained and processed 73 spectra. Due to the moderate resolution it is not possible to make detailed quantitative analysis of the spectra and we can classify the individual stars into different categories, based on some characteristic spectral features.

To get an overview on the main physical characteristics of our program stars we may represent each spectrum by a point in a multidimensional parameter space. The intensities give the coordinates of the point. It is obvious that the number of elements of the array is much higher than the number of significant physical quantities (i.e. effective temperature, luminosity, chemical composition) behind the observed shape of the spectra. Thus, the reproduction of the basic properties of observed variables is carried out by the factor analysis (see, for example, [18]).

Applying factor analysis on our field we get two strong eigen values of the correlation matrix of our data using software package SPSS [19].

In order to get some idea on the physical meaning of these two main factors we plotted in Fig. 1 and Fig. 2 both factor scores in function of the wavelength. The most

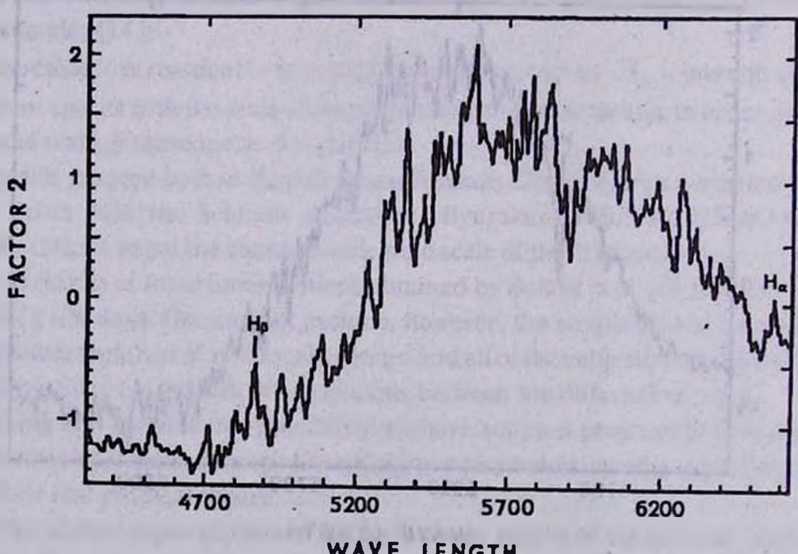

Fig.2. The dependence of Factor 2 of the wavelength. The Factor 2 appears as a later type spectrum with H_α and H_β in emission.

significant factor 1 (Fig. 1) resembles a spectrum of a star of spectral type F5 with a strong H_β line in absorption. The factor 2 (Fig. 2), on the contrary, appears as a later type spectrum with H_α and H_β in emission. All of the real spectra in our sample could be represented by a linear combination of these two main characteristic spectra. Fig. 3 displays coefficients of these linear combinations for all of our spectra.

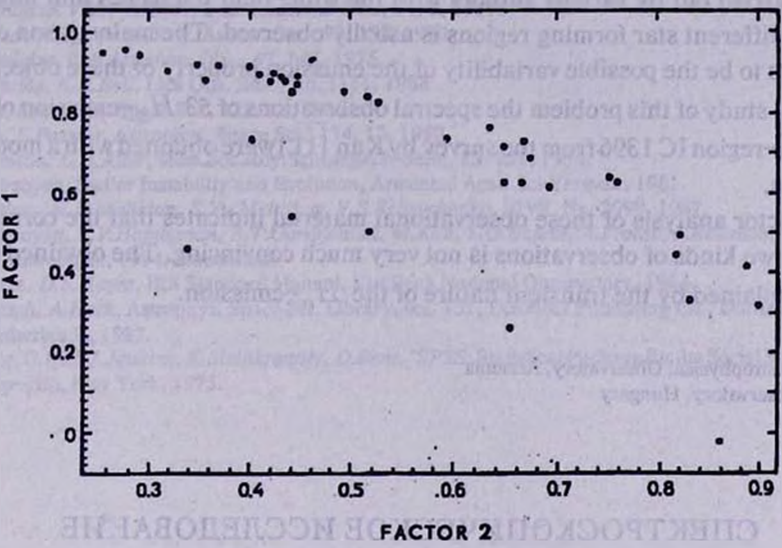

Fig.3. Coefficients of the linear combinations for all of our spectra which could be represented by two main (Factors) characteristic spectra.

We made a correlation between our measure of emission and those obtained on small scale spectra. Comparison of the emission properties showed that the correlation is not very much convincing.

An obvious explanation of the lack of significant correlation is the possible transient nature of the H_α–emission. Sampling the emission on uniformly distributed epochs one can get some insight on the time distribution when the star is 'on'. The spectrum represented by the second most important factor 2 is of later type than those belonging to the first factor 1 and only the second one is showing some traces of H_α–emission. This circumstance might have some physical meaning connected with the meachanism of the H_α–emission, i.e. the emission related to the temporally varying mass loss.

It seems reasonable to continue the systematic observation of our program stars in uniformly distributed epochs in order to see the real time scale of the suspected variation of H_α.

4. *Conclusion.* The lack of coincidence between the surveys of H_α–emission objects carried out by various authors with the wide–field telescopes and objective prism in different star forming regions is usually observed. The main reason of this fact seems to be the possible variability of the emission property of these objects.

For the study of this problem the spectral observations of 53 H_α–emission objects of the HII–region IC 1396 from the survey by Kun [11] were obtained with a moderate resolution.

The factor analysis of these observational material indicates that the correlation between two kinds of observations is not very much convincing. The obtained result can be explained by the transient nature of the H_α–emission.

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СПЕКТРОСКОПИЧЕСКОЕ ИССЛЕДОВАНИЕ H_α–ЭМИССИОННЫХ ОБЪЕКТОВ В IC 1396

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Выполнены спектральные наблюдения 53 звезд с H_α–эмиссией HII–области NGC 1396 с умеренной дисперсией 2.6–м телескопом Бюраканской астрофизической обсерватории. Фактор анализ этого наблюдательного материала указывает, что два фактора главенствуют. Наиболее важный фактор 1 (рис.1) напоминает спектр звезды спектрального класса F5 с сильной H_β — линией в поглощении. Фактор 2 (рис.2), наоборот, проявляется как спектр более позднего класса с H_α и H_β линиями в эмиссии. Полученный результат можно объяснить переменным характером H_α — эмиссии.

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