A BRIEF HISTORY OF RESEARCHES OF YOUNG STARS IN THE SHAMAKHY ASTROPHYSICAL OBSERVATORY

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The study of stars at the stage of evolution to the Main Sequence (MS) in the seventies of the last century was of particular importance. At that time, studies were conducted all over the world of of the young solar type emission stars, genetically related to the gas and dust regions of star formation of the Galaxy. These objects in the years 1947-1949 were identified by Joy [1] as a separate group of variable stars, hereinafter called T Tauri stars (TTS). It was later shown that these stars are observed in the form of groups in the regions of gas-dust complexes in the stellar associations of the Galaxy. Judging by the spectral and photometric characteristics, by their position in the Hertzsprung-Russell (HR) diagram, this group of stars is at an early stage of evolution [2]. Studies have shown that these stars are the forerunners of our Sun, and reflect its state at a very early stage of evolution.

In the 60-70 years of the last century throughout the world, for example, in the USA, Mexico, Italy, Germany, including in the former USSR – astronomers of CrAO (Ukraine), in the SAI of Moscow State University (Moscow), in Abastumani (Georgia), in BAO (Armenia) and in the AI of the Academy of Sciences of Uzbekistan - spectral, photometric and polarimetric observations of these stars were carried out, and their new properties were studied. Note that the vast majority of T Tauri stars are weaker than 10^m, and their spectral observations require medium and large telescopes.

At this stage, when the 2 m ShAO telescope came into operation, due to the high quality of the telescope optics and spectrographs in the Cassegrain focus, it was possible to obtain spectrograms of relatively bright T Tauri stars on a «Canberra» prism spectrograph with a dispersion of 93 Å/mm for Hβ for 10-15 minutes, or on a diffraction spectrograph with a dispersion of 75 Å/mm in 20-30 minutes exposition. It was a record for those times in the USSR, despite the fact that both telescopes of a larger aperture of domestic production — 2.6 m telescopes — worked in both the CrAO and BAO. Therefore, the study of T Tauri stars and related objects in ShAO was considered very relevant and timely.

In the early seventies of the last century, most of the research of young stars was aimed at studying the spectral and photometric characteristics of these objects in the optical range. The spectra of T Tauri stars themselves seemed unusual at that time: the fuzzy (veiled) absorption photosphere spectrum corresponds to the late spectral classes G-M, luminosity class IV-V, and there is wide emission in the hydrogen lines of the Balmer and H and K CaII lines. Stars of earlier spectral classes B-A were later called Ae/Be Herbig type (HAeBe). The first most important criteria's in the spectra of stars indicating their belonging to TTS were put firstly by Herbig in 1962 [2]. Then it was already known about a small group of young stars discovered by Joy in 1947-1949 [1]. At that time, researchers of young stars faced the following important tasks:

1. To study the features of the spectrum of the T Tauri type stars and related objects.
2. Investigate the photometric characteristics, variations in gloss and colour over time.
3. To study a location an individual groups of young stars on the MS diagram.
4. To distinguish individual varieties among the young stars - groups of stars with common properties.
5. In theoretical studies, it was necessary to explain the cause of the activity of young stars and the anomalies in their spectra.

As you can see, during the formation of ShAO, the researchers of young stars was challenged an important new task - to study the nature of young stars to understand the processes of star formation and the initial stage of evolution of stars of small and moderate masses.

Undoubtedly, Z.A. Ismayilov can be considered a pioneer in the research of young stars in ShAO. Even before the installation of a 2 m ShAO telescope, he performed spectral observations of several T Tauri stars on the 70 cm meniscus telescope with an objective prism of the Abastumani Astrophysical Observatory in Georgia. Soon, on the 2 m telescope of ShAO, he made a large number of spectral observations of the following classical stars of the T Tauri type: T Tau, RW Aur, GW Ori, RY Tau, etc. In addition, he managed to obtain spectrograms of a large number of eruptive stars, including, symbiotic stars AG Dra, AG Peg, flashing BY Dra and others. He wrote more than 20 scientific papers on T Tauri stars included in the NASA ADS archive [3-16, 19, 60, 61].

According to Z.A. Ismayilov's the works (see, for example, [14]) for the first time, the variability of the contours of emission lines and their splitting in the T Tauri type star — RW Aur for a record-breaking short observation time of -10 minutes was firstly established. In 1974, under the supervision of academician V. Krat, he defended his thesis on the topic "Spectrophotometric studies of T Tauri type stars". For many years he was the head of the variable stars department and supervised the work of the 2 m ShAO telescope. Later, he held the post of deputy director for science, organized the installation of the 60 cm telescope, and did a lot to organize observational work in ShAO.

Under the leadership of Ismayilov Z.A. for the first time in observations of 1986-1988 an «Alcor» - high-power electron-optical converter was used. In combination with the UAGS spectrograph, this image intensifier was used to obtain the spectra of stars with very short - second exposures. Spectra of young stars were obtained with exposures of 10-30 seconds in the region of the Hα line.

The next researcher in ShAO in the field of young stars was Salmanov I.R. He managed to conduct synchronous photometric and spectral observations of T Tauri stars and related objects such as SU Aur, V380 Ori, RY Tau, FU Ori. Photometric observations Salmanov I.R. performed synchronously, on a cassette device installed in the focus of 30 cm of the refractor guide, 2 m of ShAO telescope. The results of his scientific research have been published in more than 20 works [17-36].

In 1975, Salmanov I.R. the Ph.D. thesis was defended on topic: "Spectrophotometric and photometric studies of T Tauri type stars". He showed that during a significant increase in the brightness of the star RW Aur, the signs of the envelope spectrum of the star intensify. For the first time, a variation in the radial velocity of the RW Aur emission spectrum from -80 to +80 km/s over a month was detected, which indicates the presence of an ejection and fall of matter in this star. Based on the analysis, he concluded that rapid variations can be the result of active processes in the atmospheres of young stars.

With the replenishment of the observatory with young personnel, under the direction of Z. Ismayilov, the research of T Tauri stars and related objects began to be carried out by Timoshenko L.V., Rustamov B.N., Guliev N.Kh., Ismayilov N.Z., Bayazitov U.Sh. In particular, in the works of L.V. Timoshenko, spectral observations of Herbig Ae/Be stars were performed. He managed to obtain the spectra of the WW Vul star, both in the normal state and in the weakening of the brightness. He showed that the spectral class of a star variations with a decrease in brightness towards a later type. According to spectral observations of the stars SV Cep, UX Ori, and DD Ser, Timoshenko L.V. determined the spectral classes and luminosity classes of these stars, showed the boundaries of the variations in the spectral class from night to night. Under the direction of Dr. R.E. Gershberg, he defended his thesis on the topic: "Spectral and photometric research of fast variables with non-periodic light attenuation." He has published more than 25 scientific articles [38-58].

In order to further determine the spectral and luminosity classes of young stars, L. Timoshenko developed a two-dimensional spectral classification scheme for the spectra of 42 standard stars for the spectrum interval B9-F8I-V [45]. To perform a two-dimensional spectral

classification of stars according to spectrograms obtained on a Canberra 2x2 prism spectrograph, equivalent widths and their ratios for selected spectral lines were used as criteria.

At the beginning of the 80s of the last century, Ismayilov N.Z. joined in the research of young stars. In the works of Ismayilov N.Z. attention was paid to such varieties of young stars as orion variables — Herbig Ae/Be stars — and research on T Tauri stars was continued. His objects of research at that time were the binary system in the trapezoid θ^1 Ori - BM Ori, V1016 Ori, as well as Ae/Be Herbig type stars - θ^1Ori D, EY Ori, T Ori, AB Aur, HD200775, HD216623, and stars T Tauri type - SU Aur, T Tau, DI Cep, GW Ori, RY Tau, DR Tau, BP Tau, etc. In recent years, a spectral study of intermediate-mass stars, such as Herbig Ae/Be type [59-111], was performed by N.Z. Ismayilov.

In addition to long-term spectral observations made with a 2 m telescope, for the first time in ShAO, Ismayilov N.Z. applied the photoelectric UBVR and Hα method of TTS photometry and carried out synchronous photoelectric and spectral observations of the T Tauri type star DI Cep. He performed photoelectric UBVR observations as well as observations with a narrow-band Hα interference filter using a single-channel photometer mounted in the Cassegrain focus of the Zeiss-600 telescope. N.Z. Ismayilov also made part of the photometric observations of a group of T Tauri stars in the Crimean Station of the ShAI of MSU using the Zeiss 600 telescope [75]. Part of the results of photometric observations of Ismayilov N.Z. included in the US Wesleyan University database (www.astro.wesleyan.edu).

Furthemore, Ismayilov N.Z. received more than 500 spectrograms of the studied objects, and also actively participated in the study of observational techniques and radiation detectors, took part in tests to launch an echelle spectrometer and a CCD detector, installed in the Coude focus of ShAO 2 m telescope, and then applied the system in observations of specific objects.

The most important results were obtained by Ismayilov N.Z on the structure, dynamics, and physics of the disk-shaped shells of a large group of T Tauri stars and related objects. Under the guidance of academician A.M. Cherepashchuk (ShAI MSU), in 1990 he defended a dissertation on the topic “Search and research of binaries, among young stars,” and in 2004, his doctoral dissertation on the topic “Spectral and photometric studies of young and magnetic stars. " Based on the results of scientific work, N.Z. Ismayilov wrote a monograph and more than 250 scientific articles and reports, more than half of which were published in referred publications. Some of these articles were published in journals with a high impact factor. A list of only part of these publications is given under the numbers [59-106] in the list of references.

The following researchers later connected to the topic of research of young stars under the supervisors of N.Z. Ismayilov - Shustarev PN, Alieva A.A., Guliev N.Kh., Alimardanova F.N., Khalilov O.V., Bakhaddinova G.R., Adygezalzade A.N., Bashirova U.Z., Alyshov S.A., Vidadi Z. and others.

P.N.Shustarev, together with co-authors, developed a methodology for analyzing combined long-term observational data of T Tauri and Ae/Be Herbig stars. Using the spectral Fourier analysis, synthetic light curves of a number of young stars were constructed under the assumption that there are additional bodies around the central star in Keplerian orbits with different periods of rotation (see, for example, [62]).

Alieva A.A. defended her thesis on the topic “Study of T Tauri and Ae/Be Herbig stars with a strong emission spectrum”. Here are the most important results obtained by A. Alieva.

It was shown that for the star DI Cep, the equivalent widths of the hydrogen emission lines have a direct correlation with the brightness of the star, and the emission spectrum intensifies with increasing brightness [64].

For the first time, such a unique fact was observed that in this star simultaneously on the same spectrograms, weak emission components were found on the emission wings Hα and Hβ shifted to the red and blue parts of the spectrum by ±400 km/s, respectively. The active variability of the H_α and H_β emission lines was detected for the star DI Cep.

A variation in the radial velocity of the mass centre of the system was detected, which made it possible to suspect the DI Cep star in duality. It was shown that the previously detected period

of variation in the spectrum and brightness, P = 9.24 days, most likely refers not to the surface of this star itself, but to the upper, more slowly rotating parts of the stellar disc [72, 73].

For the first time on the basis of the theory of magnetospheric accretion (MA), the magnetic field intensity on the surface of the DI Cep star was estimated to be in the range of 600-1000 Gs.

Within 1-2.5 hours of continuous observations over individual nights in 2004, no significant rapid variations were revealed in the profiles and spectral parameters of individual components of the H_α line for the star MWC 361 [69].

A smooth shift to the short-wavelength part of the spectrum of individual components of the H_α line was detected for the star MWC 361 for about 10 days. A significant variations in the spectral parameters of individual components of the H_α line for different nights was revealed.

Spectrograms with high spectral resolution revealed a fragmentation structure in the shells of Herbig Ae/Be stars — AB Aur and MWC 361.

For WTTS stars, a significant correlation was found for the first time between radiation in the near UV and IR spectral regions. Classical T Tauri stars have practically no dependence between the excess radiation in the near UV and IR spectral regions.

Guliev N.Kh. studied the spectrum of the star T Tau based on spectral material obtained over a long observation period. He, in 2008, defended his thesis on the subject "Study of different phases of T Tauri activity based on long-term spectral observations". Here are some of the scientific results obtained in the work of Guliev N.Kh. together with Ismayilov N.Z. et al. [67].

1. For the first time, a rapid variations in the H_α line profile with a characteristic time scale of 6–8 minutes was obtained, as well as a variations in the parameters of the emission spectral lines of hydrogen and H and K CaII with a characteristic time scale of 90–120 minutes.
2. Was shown that the state of the emission spectrum can be "active" and "quite". In a quite state, the intensities of the emission lines are decreased, the absorption spectrum is clearly expressed. In the active state, emission lines are to be stronger; the absorption spectrum seems to be "veiled".
3. A long transition from a quiet to an active stage of emission activity of the emission spectrum has been found. A quasicyclic period is traced in different phases of the radiation in the emission spectrum of the star with a characteristic time scale of 28-30 days.
4. A variation in the equivalent widths of emission from 2 to 5 times is observed, respectively, with a weak and bright state of the total brightness of the star. The spectral activity of the system in different years of observation is different, and, possibly, has a long-term cyclic character.
5. Despite the fact that within each 6-year cycle the star's brightness variations with a constant amplitude of $0^m.2$ in the V band, the activity of the emission spectrum of the star in this case shows an independent variability from brightness variations within such a cycle.
6. It was established that the level of variation in the total brightness does not coincide with the level of variations in the emission lines equivalent widths. This indicates the existence of an additional source of radiation in the spectral lines in a bright state. Such source may be hot spots which are formed due to disk accretion.
7. In a quiet state of emission of the emission spectrum, the equivalent widths of the absorption lines of metals did not show a rapid variation during the night of observation. In this state, a variation in absorption lines is observed only at different nights or seasons.
8. With the active state of the emission spectrum, a rapid variation in the absorption spectrum of the star is observed with a characteristic time from 1 to several hours.
9. A synchronous variation was observed in the equivalent widths of the emission and absorption spectra, as well as in the V values of the star's brightness, at least within one 6-year cycle. With increasing brightness, an increase in the equivalent widths of absorption and emission lines is observed simultaneously.

Further, the scientific results obtained in the work of F.N. Alimardanov together with a group of researchers are presented [106]:

1. Based on synchronous photometric and spectral observations, it was shown that the degree of activity of the emission spectrum of a classical T Tauri type star DI Cep, depends on the brightness. With an increase in optical brightness, an increase in the equivalent widths of emission lines is observed.
2. Observations of the DI Cep star over the past 30 years have shown that since 1990, the average brightness level has been monotonously decreasing, and currently the brightness of the star is at an absolute minimum; at the same time, average values of equivalent widths of emission lines also showed a monotonic decrease.
3. An analysis of the UBV photometric observations of DI Cep revealed 2020 ± 200 day-time quasiperiodic brightness variations. This variability is explained by an additional component which is placed at the central star environment.
4. A new method was applied for to interpretation of the complex light curves of young T Tauri stars. To do this, we used the 2-3 most probable periods of variability in the brightness of the star, obtained on the basis of statistical spectral analysis, and it was shown that a combination of these periods in young stars DI Cep, T Tau, and SU Aur can explain the observed average annual light curves. This result confirms the assumption that protoplanets and/or protostars exist in the environment of young stars.
5. In the UV - spectrum of a classical T Tauri star - BP Tau, a periodic variability of the emission line intensities with a period of 8.275 days was found. During 10 - year observations, two groups of emission lines were detected in the BP Tau spectrum. The first group of lines for 10 years showed a monotonic decrease, and the second group of lines showed a chaotic variation in intensities.
6. Using ground-based broadband photometric data, as well as IRAS archive data in the range 0.36-100 μm, the spectral energy distribution curves (SED) for 87 young stars were built. It was shown that according to the types of curves, SED can be divided not into 3, as previously assumed, but into 5 types. Two more additional subclasses were added to the classification scheme of SED curves of young stars. An updated classification scheme explains the different stages of the evolutionary path of young stars.
7. It was shown that in the X-ray diffraction curves of young stars, in addition to the main maximum, 2-3 regions of excess radiation are often observed, which are in the infrared part of the spectrum. The temperatures of such maxima very often correspond to 2500-3000 K and 90-100 K.
8. The temperatures of thermal radiation obtained for the second radiation source from the SEDs of young stars have a high degree of correlation with the temperatures of stars corresponding to their spectral classes. When taking into account the mass-temperature relation for stars, it can be assumed that the larger the mass of the central star, the greater the likelihood to formation of more massive protostar at the system.

Here are the scientific results obtained in the work of H.N. Adygezalzade together with other researchers [97-99]:

1. For the first time it was shown that the spectral parameters of the group of lines of the emission spectrum of RY Tau, both in the UV (MgII, HeII, CIV, etc.), and in the optical part of the spectrum (Hε + H and K CaII) is varied with a period of P = 23.26 ± 0.06 days.
2. According to the combined light curve of RY Tau in the time interval of 1983–2004 the two most probable long-term periods of the RY Tau star brightness variation were revealed - 14 and 6 years. In a combination of these periods, we constructed a synthetic light curve that satisfactorily describes the average annual light curve of the star.

3. Variations in the V values of the brightness and the emission doublet MgII λ2800 Å for RY Tau over time have shown that it is impossible to unequivocally talk about any correlation of the brightness and the emission spectrum of the star. This suggests that the variability of the emission spectrum and the brightness of the star are a different nature.
4. It is shown that in the period from 1983 to 2004 the variation in the brightness of the star RY Tau is periodic, but sometimes deviations are observed. The period $P_1 = 377 \pm 10$ days with an amplitude of $\Delta V \sim 1^m$ was found. The phase shift of the found period after 1983 and after 1995 was suspected. The presence of periodic variations in brightness according to seasonal observations with a period of $P_2 = 146 \pm 3$ days was also suspected.
5. According to the SED of program stars RY Tau and DR Tau, the temperatures of all sources that create additional radiation excess in the energy distribution are determined. It is shown that the highest temperature of IR sources is 2500-3000 K, and the lowest is about 90-100 K. The temperature of 90 K, apparently, corresponds to the emission of the dust component of circumstellar matter, while the IR source with a temperature of 2500 K, possible is a protostar.
6. Measurement of the intensities of both the absorption and emission lines shows that the spectrum of the star DR Tau is highly variable. The spectral class of the star according to the UV absorption spectrum was determined as K5-M0. At least three groups of absorption spectral lines with a similar nature of variability were identified. This shows that in the star's atmosphere, regions with local physical conditions are observed.
7. It was shown that, according to the photometric V values of the DR Tau brightness, two significant periods are detected, $P_1 = 5.8$ and $P_2 = 7.4$ days. These periods were found from several seasons of observation. The search for periodic variations in the parameters of individual spectral lines from the UV spectrum of the star was unsuccessful.
8. For DR Tau, the Fourier spectral analysis showed that there are two significant reliable periods - 2 and 6 years, taking into account which it is possible to satisfactorily explain the observed average annual combined light curve and the color index variation curves.

The results obtained by the work of Khalilov O.V**.** together with co-authors [61,102,105]:

1. According to long-term spectral observations in the optical range, the quasi-cyclic period of a variation in the equivalent widths of the Hβ and H and K CaII emission lines in the spectrum of the T Tau star with a period of 33 ± 1.5 days first time was discovered.
2. According to IUE spectrograms for 1979-1994 a periodic variability of the emission lines was detected in the UV spectrum of T Tau with the same quasi-period, which was also found for emission lines in the optical range. It is shown that the quasiperiodic variability can be associated with the active region located on the star's disk.
3. For the first time, it was established that for the star AB Aur, the profiles of the emission lines of hydrogen Hα and Hβ show active variability in the blue wing, while in the line He I λ 5876 Å the main variability occurs on the red wing.
4. The AB Aur star revealed a synchronous variability of the blue wing in the hydrogen lines Hα and Hβ. The full cycle of the event from occurrence to disappearance of emission on this wing has a characteristic time scale of 3 days. The structure and intensities of individual components of the He I λ 5876 Å and D1, D2 Na I lines from night to night and in separate years were also found to be variable.
5. For the first time in the UV spectra of the star AB Aur, obtained for 1978-1992 it was shown that the intensities of some absorption lines, including of Mg II, FeII, and others, are varied with a period of 6.1 ± 0.1 days. A synchronous periodic variability of the

equivalent emission widths was found for the hydrogen and helium lines, and the radial velocities of these lines variation in antiphase with a period of 6.1 days. Taking into account the rotation velocity of the star, it is shown that the region of active helium formation should be at a distance of no more than 15 R⊙ from the surface of the photosphere.

6. The results of joint spectral observations of AB Aur with a group of employees from the GAO RAS (Pulkovo) showed that there is a noticeable correlation of variations in the equivalent widths of the Hα and HeI λ 5876Å emission lines with a correlation coefficient r = +0.6 8 ± 0.14 and an inverse correlation for He I and D Na I with r = - 0.674 ± 0.14 and for the same lines r = + 0.59 ± 0.14, r = - 0.73 ± 0.10, respectively.
7. A periodogram analysis of all measured equivalent widths for all spectra was carried out in the AB Aur spectrum for three lines - Hα (60 values in total) and He I and D Na I (36 values in total) since 1986 (all data from CrAO, GAO and ShAO) according to the Lafler-Kinman method showed the presence of a period of variability with a period of P = 123.7 ± 0.3 days.
8. It was found for the first time that the star IL Cep for 2006–2011 different spectral parameters of the hydrogen emission lines Hα and Hβ and absorption in the helium line He I λ5876Å show slow variations with time; the extremum of the spectral parameters was reached in 2009–2010. Lines D1, D2 Na I in a weak form repeat the variation in radial velocities in the line Hα. It is assumed that the detected variability in the spectrum of a star can be related to the presence of additional bodies in the system.

Listed below are some of the most important scientific results obtained by N.Z. Ismayilov, together with a group of co-authors:

1. A new radial velocity curve of the individual components was carried out, and the spectroscopic elements of the orbit of the trapezium member θ1 Ori - BM Ori were determined. The variability of the residual intensities of the spectral lines of the BM Ori components at the nodes of the orbit was revealed. It is shown for the first time that a system in hydrogen lines has its own emission.
2. For the BM Ori system, the V-light curve was analysed for all published photoelectric measurements. It is concluded that the figure of the cold component in this eclipsing system cannot be described in the framework of the Roche model. A satisfactory solution to the light curve is obtained in a model with a secondary spheroidal component. The absolute parameters of the individual components of the system are redefined.
3. The atmospheric models were used to determine the fundamental parameters, as well as the abundance of helium and the microturbulent velocity of the bright components BM Ori, V1016 Ori, θ^1 OriD - three members of the trapezoid θ^1 Ori. It was shown that the stars BM Ori and θ^1OriD have normal helium composition, while V1016 Ori has an excess of the helium.
4. Using all the data available in the literature, including the author's measurements, the value of the period of the spectral orbit is refined and the spectroscopic elements of the orbit of the T Ori system are calculated. This star revealed periodic variability of the line profiles of hydrogen and K CaII.
5. For the first time, a flare lasting about 9 days was recorded with the star DI Cep. Spectral observations made before and after the flare allowed us to conclude that the substance was ejected from the star during the flare. This star revealed a fast variability in the intensity of the H_α line, with an amplitude of 0.15 mag in 30 seconds and with an amplitude of 0.25 mag in 1.5 minutes. Fast variability is also found in UBVR bands.
6. Over a long period of observations, the limits of variations in the spectral class of stars DI Cep, T Tau, GW Ori., SU Aur were determined. It is shown that the intervals of spectrum variability for different stars differ. According to statistical diagrams it was shown that these stars show the largest number of identical spectral states for the latest class of spectrum (the "cold dip" effect). It is shown that the range of variations in the

photometric values for the stars GW Ori, SU Aur can be satisfactorily described by a variation in surface temperature up to 1000 K, with a variation in the relative spot area to 25%.

7. For the first time, a periodic fading of T Tau with a period of 6 years with an average amplitude of 0.2 mag was detected in filter V. The most likely explanation for the periodic fading is the existence of at least one protoplanetary formation at a distance of 4.5 AU from the central star.
8. The results of long-term homogeneous spectral observations of classical T Tauri type stars — DI Cep, GW Ori, and T Tau, collected during 1972–1990, are analyzed. A weak correlation is found between the equivalent width of the emission lines and the spectral class determined by the equivalent width of the absorption lines. The spectral classes of the stars show variability spanning different ranges. The maximum range of spectrum variations is observed for DI Cep - F4-K5V, for GW Ori - F2-G5V, for T Tau - G1-K0V. Statistical diagrams show that for all TTSs, the most frequently observed state of the absorption spectrum corresponds to a later spectral class. All TTS spectral classes are not observed later than their most probable state. The variation in the spectral class from the most frequently observed state to earlier spectra occurs smoothly. Taking into account the photometric characteristics, the observational results can be explained by the formation of hot (in the case of DI Cep) and cold (in the case of T Tau and GW Ori) spots on the surface of stars. The variability of the last two stars may be partly due to the variable extinction of the circumstellar envelope.
9. It has been shown that from 1997 to the present, the spectral parameters of the star HD200775 monotonously decreased, and according to the data of 2000, there is a tendency to increase them. It was established that the main variations in the profiles of the H_α, and Hβ lines show that the greatest variability is observed in the upper layers of the star's atmosphere.
10. It was first established that the star HD 200775 is spectrally binary with a period of 1180±60 days. The spectroscopic elements of the orbit are determined. It is assumed that the secondary component of the system is a $\geq 0.5M_\odot$ low-mass protostar, and the eclipse is a translucent, extended circumstellar envelope. According to literature data, the light curve of the HD200775 system is obtained, which confirms the duality of the star. The shell of the system is transparent to the light of the bright component and therefore does not eclipse the second component.
11. A periodic brightness and spectrum variability was detected with a period of 9.24 days of a star of the Tauri type T - DI Cep. Subsequently, this result was confirmed by Crimean astronomers to the nearest hundredth of a period. It is shown that in order to explain the physical characteristics of this star, it must be assumed that there is a hot spot on the surface of the star with a temperature higher by 3000 K than the temperature of the star’s photosphere.
12. A master light curves is analysed for 28 classical T Tauri stars. It has been shown that only 5 types of light curves are found in such young stars. A high degree of correlation was found between the amplitudes of the brightness variability in the active and quiet states of brightness. A new classification scheme for the light curves of young stars has been developed.
13. A new technique has been developed for cleaning the spectrum of emission objects from telluric lines of the earth's atmosphere. The technique was applied to the spectra of Herbig Ae / Be stars - AB Aur and HD 200775.
14. The energy distribution curves in the spectrum of about 90 T Tauri stars and related objects were constructed. An analysis of the X-ray curves of young stars revealed only 5 types of X-ray curves. The distinguished types expand the classification scheme of X-ray diffraction curves in young stars and can describe the evolutionary picture of the circumstellar primary matter during the time when the object reaches to the MS.

15. According to the signs of SED curves, program stars are divided into different groups. Only 5 of the following types of SED curves have been distinguished: 1) objects with several broad maxima located in the near and far IR spectral regions. Similar curves showed mainly IR radiation sources. There are only 9 in our list of such objects; 2) objects with only one broad maximum in the SED curve. This peak can occasionally be located in the optical part, but was mainly detected in the IR part of the spectrum at 1.25–1.62 μm. Our list contains 14 such objects; 3) objects with at least 2 maxima in the SED curves, and the second maximum is greater than the others. Most of these objects have the strongest maximum at 1.25 μm, which corresponds to a temperature of T = 2500 ° K; 4) objects are the same as type 3, with only one distinguishing feature - the first maximum is stronger than the others. Highs are often found around 0.56 μm and 1.25 μm, which correspond to temperatures of 5000 K and 2500 K; 5) objects with one maximum located in the optical part of the spectrum corresponding to ≥5000 K and a very smooth curve of the SED. Most of these objects belong to Herbig Ae/Be stars.
16. A high degree of correlation between the obtained temperatures of the thermal radiation of the circumstellar matter, determined by the excess radiation on the X-ray curves in different parts of the spectrum, was found. The analysis showed that the most probable temperature values for the spectrum of excess radiation are 2500, 1500, and 90-120 K. A high degree of correlation between the temperatures T_1 and T_2 (the first, highest temperatures corresponding to excess radiation by SED) can indicate that during the condensation of the circumstellar envelope the heat sources formed in the circumstellar environment of different stars appear to be collected masses that are dependent on the mass of the central star.
17. The comparison showed that most typical young late-type stars show a systematically elevated temperature (T1), approximately 1000 K higher than the effective temperatures of the stars (Teff) on the SED curve. Certain temperatures of heat sources have characteristic values- most often 1500-2500 K and 90-150 K. This may be a characteristic feature of circumstellar shells in young stars: when condensation occurs, basically only objects of a certain mass and temperature can form.
18. It was shown that for the DI Cep star, the equivalent widths of the hydrogen emission lines have a direct correlation with the brightness of the star, and with increasing brightness the emission spectrum is enhanced. For the first time, such a unique fact was observed that in this star simultaneously on the same spectrograms, weak emission components were found on the emission wings Hα and Hβ shifted to the red and blue parts of the spectrum by ±400 km /sec, respectively.
19. It was shown that the previously detected period of variation in the spectrum and brightness, P = 9.24 days, most likely refers not to the surface of this star itself, but to the upper, more slowly rotating parts of the star's shell. For the first time on the basis of the theory of magnetospheric accretion, the magnetic field intensity on the surface of the DI Cep star was estimated to be in the range of 600-1000 G.
20. The periodicity of the DI Cep star according to the V-values of brightness can be revealed only by highlighting individual observation seasons. The values of the equivalent widths of the emission spectrum along the lines of hydrogen and of H and K of CaII are well correlated with the phases of the found period. According to various authors, a shift in the initial epoch of periodic variations in the spectrum and brightness of the star is observed, which can be explained by the instability of accretion from the circumstellar disk. The value of the angle of inclination of the axis of rotation to the line of sight is 27°± 2°.5.
21. A synchronous spectral and photometric observation of one of the classical of the T Tauri type stars(CTTS), DI Cep, was performed. Variability of the equivalent widths and radial velocities of individual components and profiles of the Hα, Hβ, D1, D2 NaI, and HeI 5876 emission lines was detected. A positive correlation between the brightness and the

equivalent width of the Hα and Hβ hydrogen emission lines was detected with confidence. The star is suspected of duality.

22. Spectrograms with high spectral resolution revealed the fragmentation structure of the shells of star type Ae/Be Herbig - AB Aur and MWC 361.
23. For WTTS stars, a significant correlation was found for the first time between radiation in the near UV and IR spectral regions. Classical T Tauri stars have practically no dependence between the excess radiation in the near UV and IR spectral regions.
24. To search for protostellar or protoplanetary formations surrounded by young stars, a method was used to distinguish long-period components from the observed light curve. A statistical spectral analysis of the annual average light curves of the selected stars was carried out, and synthetic light curves were constructed for each star from the most reliable periods. The result obtained, to a first approximation, indicates a good agreement between the obtained synthetic curves and the initial light curves, which makes the hypothesis that the systems of these stars have protostellar or protoplanetary formations quite reliable. An analysis of the energy distributions of the stars under study in the region of 0.36–20 μm also led us to conclude that the observed anomalies in the infrared part of the spectrum in young stars are most likely related to the thermal radiation of unformed satellites in a circumstellar environment.
25. Despite the fact that within each 6-year cycle the brightness of the star T Tau varies with an approximately constant amplitude of - 0.2 mag in the V band, the activity of the emission spectrum of the star in this case shows an independent variation from brightness variations within such a cycle. An increase in the activity of the emission spectrum with an increase in the total average brightness of the star is observed.
26. The level of variation in the total brightness T Tau does not coincide with the level of variations in the equivalent emission widths. This indicates the existence of an additional emission source in the spectral lines with a bright state of brightness. Such a source may be a hot spot formed as a result of disk accretion. A variation in the equivalent emission widths from 2 to 5 times is observed, respectively, with a weak and bright state of the total brightness of the star. This phenomenon can be called as a variation in the activity of the emission spectrum.
27. From long-term spectral observations in the optical range of the T Tau star, a period of variation in the equivalent widths of the Hβ and H and K CaII emission lines in the T Tau spectrum with a period of 33 ± 1.5 days was first discovered. The emission spectrum in the UV range, as well as polarization observations independently confirm the existence of this period. The calculation showed that, apparently, the detected periodicity is the result of rotation of an additional comet-shaped component with the disk, as a result of which rotation of the active zone of the component in the disk results in modulation of the equivalent widths of the emission lines.
28. A study of the ultraviolet spectrum from the IUE archive of the classic T Tauri star - BP Tau. The spectral parameters of the strongest emission lines were measured. The most comprehensive array of measurements of the emission of the MgII doublet λ2800 Å confidently revealed a variation in the line intensity with a period of P = 8.275 ± 0.005 days. Although the variability is cyclical in two dense series of observations, the frequency for many lines is not observed across the entire array of measurements. It is shown that a group of emission lines is distinguished in which the line intensities show a monotonic decrease over more than 10 years of observation.
29. It was shown that the absorption component of the Hα line in the star AB Aur has a negative variable shift on different days, reaching up to -280 km/s. On August 17, 2009, an additional emission peak was observed superimposed on the red wing of the line. This peak is very unstable and with a characteristic time of 1 day can completely disappear. At the same time, there is an increase in absorption on the red wing of the line. In the spectrogram obtained every other day, August 19, 2009, a significant increase and

expansion of the blue absorption is observed. In this case, the equivalent width of the emission component of the line did not show significant fluctuations.

30. We also obtained profiles for the Hβ line, the structure of which is a complete analogue with the Hα line. Such variations on the violet wing can be the result of frequent unsteady release of matter and as a result of an increase in the concentration of luminous gas at high speeds. Based on the results of this work, it was concluded that the main variability in the atmosphere of AB Aur occurs in the lower layers of the shell, in nearby areas to the surface of the star, where the outflow velocity reaches 300 km/s. Such variations have a characteristic time scale of one day.
31. The analysis of the composite light curve of one of the classical stars of the T Tauri type - RY Tau is carried out. It is first shown that in the interval 1983-1996 the brightness of the star in band V is cyclical. Data analysis by the method of frequency analysis Fourier makes it possible to isolate a period of 377 ± 10 days with an amplitude $\Delta V \sim 1^m$. Statistical analysis of the brightness distribution showed that the brightness variability cannot be described by a normal distribution. The colour indices of U-B and B-V are weakly dependent on the brightness variations of V. The amplitudes of the brightness variation in individual bands were 3.66 mag in U (9.47-13.13 mag), 3.10 mag in B (9.5-12.6 mag) and 2.29 mag in V (9.35-11. 64 mag) bands, respectively.
32. The brightness of the star RY Tau is completely unstable in any of the considered UBV bands, and the relative number of identical states does not exceed even 10%. In addition, each of these brightness distributions for individual filters has an asymmetric appearance, which may be the result of non-random processes.
33. According to the SED, the temperature of the main star of the RY Tau system was determined, which turned out to be equal to 6000 ± 200 K, which corresponds to the spectral class G1-G2. The temperature of 90 K corresponds to the radiation of the dust component of circumstellar matter. The second temperature, corresponding to 3000 K, detected by an excess of radiation of about 1 μm, indicates that the system has an additional radiation source.

Currently, under the supervision of N.Z. Ismayilov group of researchers of young stars continues research in the following areas:

1. The study of the spectrum in the optical range.
2. The study of the spectral energy distribution in the range 0.36-100 μm.
3. Investigation of the UV spectrum from observations of IUE and HST satellites.
4. Photometric activity, the search for periodic processes.
5. Spectral activity of HAeBe type stars

Thus, taking into account the above, it should be noted that in the field of research of objects at an early stage of evolution, more than 400 scientific papers were written in ShAO, the results were reported at many international, regional and republican conferences. One scientific monograph has been published. On the 2 m telescope, a total of more than 1000 spectrograms were obtained, photometric observations of individual objects were performed. In cooperation with CrAO and the SAI, joint scientific work was carried out. On this topic, 10 Ph.D and 1 Science Doctoral thesis were defended.

If we compare the above scientific results on young stars with the results obtained so far around the world, our studies have a certain weight in the field of studies of the spectral and photometric characteristics of individual stars over a long observation period. For young stars, this is of particular importance, because the same star often shows characteristics related to different stars of the subgroup.

Below in general terms we list all the main results of observations that have been achieved so far in world science in the field of research of T Tauri, HAeBe stars and related objects, where the studies performed in ShAO by our scientists played a significant role.

1. It was established that the spectra of young stars are variable, the spectrum in the optical range has been studied. It was shown that the emission spectrum of individual stars varies from 10 minutes to several days.
2. A two-dimensional spectral classification of individual stars was carried out and the variability of the spectral class with time was studied.
3. Many young stars show periodic variations in spectrum and brightness. The periods can be both short (several days) and long-term (5-10 years). It is shown that periods of 2-10 days can be the result of the axial rotation of the star in the presence of active formations on the surface. The long-term periodic or quasiperiodic variability of brightness and spectrum in young stars can be the result of duality or multiplicity, as well as cyclic activity of the 11-year cycle of solar activity.
4. In a number of cases, a synchronous variation in the brightness and spectrum of young stars was studied. It has been shown that for different stars, the dependence of the equivalent widths of the emission lines on the brightness is ambiguous and can show both positive and negative correlations. In some cases, an independent variability of brightness and spectrum was established. This shows that the shell spectrum of young stars can be excited due to the activity of the inner parts of the disk (for example, photospheric flares, magnetic activity), and also external factors (for example, accretion of matter from the circumstellar disk, multiplicity systems).
5. The varieties of young stars are established - CTTS, WTTS, NTTS, fuors. More massive related objects are allocated to a group of Herbig Ae/Be stars. The basic properties of these groups are established. The characteristics of young stars at different stages of activity, as well as over the entire range of electromagnetic radiation, were studied. It was shown that NTTS type stars possess the highest x-ray radiation, but this radiation is average for a given cluster of stars.
6. It is shown that duality and multiplicity is a very common event among young stars. More than half of young stars have an optical or infrared component. Spectral and eclipsing binary systems have been discovered in a number of cases by spectrum and brightness. To date, only at 100 spectrally and eclipsing binary young systems are known, many of which have more accurately estimated masses and orbital elements.
7. The photometric properties of many subgroups are established, and the photometric light curves are classified. The classification of light curves proposed by Parenago in 1953 has been improved. It is shown that there are only 5 varieties of light curves.
8. The energy distributions of young stars are classified according to the IR spectrum. This classification was further improved. It is established that there is a relationship between the shape of the energy distribution curves and the evolutionary stage of such objects.
9. The magnetic fields of a group of young stars were measured. It is shown that the typical magnitude of the magnetic field for T Tauri stars is about 1 kG. Herbig Ae/Be stars were not found to have strong magnetic fields.
10. Some success has been achieved in interpreting the physical characteristics of young stars. In particular, it was shown that the application of the magnetospheric accretion model for classical CTTS stars with a strong circumstellar disk gives satisfactory results for explaining UV and IR excess radiation, veiling the spectrum in the optical range, and exciting emission lines with a high excitation potential. To explain the physical properties of young stars of the WTTS type, magnetic activity models and models of cold spots on the surface of the star are used.

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