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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

NON-STATIONARITY AND CHEMICAL COMPOSITION IN THE SELECTED A AND F SPECTRAL CLASSES STARS

Speciality: 2108.01 – Astrophysics and stellar astronomy

Field of Science: Astronomy

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GENERAL DESCRIPTION OF WORK

Relevance and development of the research work. Supergiant and giant stars have already passed a certain stage of nuclear evolution and have left the main sequence in the Hertzsprung-Russell diagram. Hydrogen has burned out; the nuclear fusion reactions of helium, carbon, nitrogen, and heavier elements have begun in their centers.

As a result of thermal nuclear reactions happening in the center of the star, elements heavier than hydrogen are formed. A star gently sheds its outer layer at a certain stage of evolution (gradually or by explosion). The interstellar medium enriches with heavy elements as a result of this process. The second generation of stars, rich with heavy elements in their chemical composition, is formed at the next stage. Thus, for the purpose of studying the evolution of our galaxy, the determination of the main parameters of stars (effective temperature, surface of gravity, chemical composition, mass, radius, and age) is one of the actual problems of modern practical and theoretical astrophysics.

The supergiants are the brightest stars in our galaxy, as well as the other Galaxies. These stars are young and mainly located in the galactic plane. These stars are widely used for determining the spiral structure, shape, and dimensions of our galaxy and the distance to other Galaxies. The study of the distribution of chemical elements in the Galaxy and the obtained results has great importance in specifying the chemical evolution models of galaxies. It has been defined that giant and supergiant stars pulsate and uninterruptedly lose material because of physical processes occurring inside them. Let’s note that strong mass loss and pulsation occur irregularly in stars with such a large atmosphere. The information obtained from observations about pulsation occurring in the giant and supergiant stars or the explanation of large-scale irregular processes occurring in their atmospheres is quite diverse both observationally and theoretically. That’s why the research of H_α, H_β, H_γ, H_δ, and the other elements of the Balmer series of hydrogen, for example: the spectral lines as *HeI*, dublet *NaI D*, *Fe,* etc., observing the spectra of such stars assumes great importance in modern astrophysics.

The supergiant and giant stars differ from each other according to their spectral features and chemical composition, and the main sequence stars are standard according to their chemical composition have been chosen in the dissertation work. The selection of 89 Her (F2 Ibe) and Post-AGB HD 161796 (F3 Ib) type stars locating at high galactic latitudes from these stars and the comparative study of them assume a great importance in astrophysics. The obtained results can be used in the study of the evolution of stars and our Galaxy, as well as in the formation of theoretical models.

The object and subject of the research. The object and subject of the dissertation work is to conduct systematic observations of A and F spectral type supergiant stars on the 2-meter telescope of SHAO (Shamakhy Astrophysical Observatory) and to process the acquired spectral materials. It is the study of the forms of profiles of the spectral lines as *HeI*, dublet *NaI D*, *Fe,* etc. observing in obtanied spectra and non-stationary processes happening in the atmosphere of stars according to the variation of some spectral parameters in these lines, as well as the determination of the atmospheric parameters and chemical composition of the stars and the comparative study of the obtained results with the chemical composition of the Sun and the other stars.

Aims and objectives of the research work.

1. To study the long-term variability of dublet *NaI D* line profiles and the main spectral parameters of these lines on the basis of the spectra of the 89 Her (F2 Ibe) supergiant star obtained over a long time interval on the 2-meter telescope of SHAO.

2. To detect the H_α, H_β, dublet *NaI D*, etc. line profiles in the spectrum of φ Cas (F0 Ia), HD 207260 (A2 Iae), HD 161796 (F3 Ib), 44 Cyg (F5 Iab) stars and the variation of some spectral parameters of these lines depending on time.

3. Determining the atmosphere parameters and chemical composition of selected stars by the model method, comparing the obtained results with the considerations of modern evolution theory of stars.

The research methods. The main information about the nature of stars, non-stationary processes happening inside them, and their evolution is obtained from the high-quality and high-resoluted spectra. The lines of the elements observed in the spectra (for example, the Balmer series of hydrogen as H_α, H_β, H_γ, H_δ, dublet *NaI D*, *HeI*, *Fe*, etc.) give extensive information about the physical condition and chemical composition of the outer layers called stellar atmospheres. The Scargle method was applied with the aim of studying the periodical variation of equivalent width *(W_λ)* and radial velocity *(V_r)* in the lines of the mentioned elements[1].

It is necessary to use more sophisticated and modern methods for accurately determining the abundance of elements in stellar atmospheres. Therefore, the abundance of elements was determined by the most accurate method – the model method in this work. While using this method, the calculated and measured values of some photometric and spectral quantities that characterize the stars are compared. Observationally measured values of the equivalent widths of the spectral lines are used to analyze the microturbulence and determine the abundance of elements. The parallax method was also applied in the determination of the atmospheric parameters of stars.

The main provisions for defense are:

1. The result about the radial velocity of the absorption components and the variation of the equivalent width over a period of 5000 days in the profiles of the dublet *NaI D* line according to the spectra of the 89 Her (F2 Ibe) star found in 1975-2017 years.

2. The result about the synchronical variation of the radial velocity and equivalent width of the absorption component, as well as the value of the radial velocity of the radiation component of the H_α line over a quasiperiod of 35-40 days by depending on the time according to the spectra of HD 207260 (A2 Iae) supergiant star in 2018 year.

3. The result about the variation of spectral parameters (equivalent width and radial velocity) of the *NaI D2 (λ5889.953Å)*

[1]Antokhin, I., The enigmatic WN8 stars: intensive photometry of four southern stars on time scales from 30 min to 3 months./ I. Antokhin, J. Bertrand, R. Lamontagne // The Astronomical Journal, - 1995. vol.109, - p.817-834.

line profile over a period of 62 days in the spectra of HD 161796 (F3 Ib) supergiant star.

4. The results of the analysis about the variation of equivalent width *(W_λ)* and radial velocity *(V_r)* in the profiles of Balmer series of hydrogen *(H_α, H_β, H_γ, H_δ, H_8, H_9, H_{10} and H_{11})* which prove the pulsation of the stellar atmosphere in the spectra of φ Cas (F0 Ia) supergiant star.

5. The determination of the atmospheric parameters of HD 80290 (F3 V), HD 138917 (F0 IV), HD 224014 (F8 I), HD 9544 (F5 V), HD 9896 (F3 V) stars.

6. The analysis of microturbulence, the determination of metallicity, and the comparison of the obtained results with the metallicity of the Sun in the atmosphere of HD 80290, HD 224014, and Post-AGB HD 161796 stars.

Scientific novelty of the research.

1. For the first time, a 5000 day period was found in the variation of the radial velocity and equivalent width of the absorption components in the profiles of dublet *NaI D* lines on the basis of the spectra of 89 Her supergiant star obtained in 1975-2017.

2. The variation of radial velocity and equivalent width of the dublet *NaI D (λ5889.953Å)* line over a period of 62 days by depending on the time in the spectra of HD 161796 supergiant star. The curve of luminosity[2] changes synchronously with the variation of the equivalent width of the line, and with the curve of the radial velocity in counterspace.

3. For the first time, the following results obtained from our observations of us in φ Cas star prove that the noted variations occur as a result of the pulsation of the stellar atmosphere: The Balmer series of hydrogen and dublet *NaI D* lines have been studied on the basis of the spectra of φ Cas supergiant star. It has been revealed that, equivalent width of H_β, H_γ and H_δ lines change, $\Delta W \approx 1.2$ Å (approximately 1.4 times). Also, the radial velocity of H_α, H_β and H_γ lines that are appointed for the half width of the profiles changes and

[2]Ferro, A.A. Periodicity and pulsational mode of five bright yellow supergiants // Monthly Notices of the Royal Astronomical Society, - 1985. vol. 216, №3, - p.571-587.

the amplitude of this variation is properly $\Delta Vr \approx$ *-19 km/h*, *-20 km/h* and *-19 km/h*. It was found that, the layers of H_α, H_β, H_γ, H_δ, and H_8 lines formed in the atmosphere properly expand with *-38 km/h*, *-12 km/h*, *-4 km/h*, *-2 km/h*, *-8 km/h* velocity by moving from the center of the star towards the observer. But, instead of them, the layers of H_9, H_{10} and H_{11} lines formed effectively become narrow by moving from the observer towards the center of the star with *+8 km/h*,*+6 km/h* and *+1 km/h* velocities.

4. For the first time, it was proved on the basis of the spectra of the HD 207260 supergiant star obtained in 2018 that, the radial velocity of the absorption and emission component, and also the value of the equivalent width of the absorption component changes synchronously in the profile of P Cyg typed H_α line and this variation happens over a quasiperiod of 35-40 days.

5. For the first time, the effective temperature (T_{eff}) and surface of gravity *(logg)* of HD 80290, HD 138917, HD 9544, HD 9896 stars were appointed by the model way and the atmospheric models of these stars were calculated.

6. For the first time, the velocity (ξ_t) of microturbulent velocity was appointed in the atmosphere of HD 80290 and HD 224014 stars.

7. For the first time, it was revealed that, the metallicity of the HD 80290 star is similar with the Sun.

The theoretical and practical significance of research.

1. High-resolution similar echelle spectra of 89 Her, HD 207260, HD 161796, etc. supergiant and giant stars on the 2-meter telescope of SHAO were obtained. Other authors can study those stars alternatively by using these materials.

2. The profiles of dublet *NaI D* absorption lines were studied in the spectra of 89 Her star obtained in 1975-2017. For the first time, it was found that, the radial velocity of the noted lines and their equivalent width change over a period of 5000 days. The parameters of the orbital elements of the binary star system were calculated over a period of 5000 days within the framework of the model of the spectral double system.

The period of 5000 days that found by us about the duality of 89 Her star can be used to determine the evolution of this star and reconstruction of the theoretical model.

3. Balmer series of hydrogen, also the metal lines that observed in the spectra of HD 207260, HD187982, HD 195593, HD 164613, HD 80290, HD 138917, HD 224014, HD 9544, HD 9896, Post-AGB HD 161796 program stars were identified and the spectral parameters of these lines were appointed. The database was created on the base of these dimensions. It can be used in the appointment of chemical composition and study of non-stationary processes.

4. Atmospheric models of HD 80290, HD 138917, HD 224014, HD 9544, HD 9896 stars were calculated. These models can be used in several researches of theoretical astrophysics in future.

5. The non-stationary processes happening in the supergiant and giant stars, also the results obtained for chemical composition researched in the dissertation can be rich database for the theoretical researches in the study of evolution of stars and our Galaxy in future.

Authenticity of the research work. The observation materials were obtained by the use of CCD (Charge-coupled device) camera on the 2-meter telescope of Shamakhy Astrophysical Observatory named after N.Tusi of the Ministry of Science and Education of the Republic of Azerbaijan. The observations and spectral dimensions were carried out with the modern devices and programs. The results obtained for atmospheric parameters and chemical compositions of standard stars prove the correct selection of the used theoretical models. Most of the obtained results are completely new, while some results make good match with the results obtained by other authors and complete them. All of them ensure that the obtained results are exact and reliable.

Approbation and application. The main results were widely discussed many times at scientific seminars of SHAO, international scientific conferences held in Ukraine, as well as local and international conferences held within the Republic of Azerbaijan during the implementation of the dissertation work:

1. III International Scientific Conference of the Young Scientists and Researchers, Baku, Qafqaz University, 17-18 April 2015.

2. International Scientific Conference: “School of Astronomy

of the Young Scientists”, Ukraine, Zhytomyr, 20-22 May, 2015.

3. IV International Scientific Conference of the Young Scientists and Researchers, Baku, Qafqaz University, 29-30 April 2016.

4. Modern Directions in Physics, Baku State University, International Conference, 20-22 April 2017.

5. The Creative Potensial of the Youth in the Solving of the Aerospace Issues (February reports) Materials of the III International Scientific-Practical conferences of the Youth, Baku, 12-14 February 2018.

6. II International Scientific Conference of the Young Scientists and Researchers, Baku, Qafqaz University, 27-28 April 2018.

7. Physics of Stars and Planets; International Scientific Conference for Atmospheres, Activity, Magnetical Fields, Shamakhy, 16-20 September, 2019.

8. The 7th International Conference on the Application of Industrial technologies in Management and Optimization, Baku, 26-28 August, 2020.

9. The Conference dedicated to the 100th Anniversary of Genius Azerbaijani Scientist Lotfi A.Zadeh, Shamakhy, Azerbaijan, 4 August, 2021.

10. The VII International Conference FMI-2021 (MDP): Modern Directions on Physics, Baku, 15-17 December 2021.

The scientific results obtained from the dissertation work can be used in the institutes and astrophysical observatories researching in the direction of stellar astrophysics, the department of Astrophysics of Baku State University, Batabat Astrophysical Observatory of the Ministry of Science and Education of the Republic of Azerbaijan, Special Astrophysical Observatory (Russian Federation) and Crimean Astrophysical Observatory (Ukraine), Astronomical Institute named after P.K.Shternberg of Moscow State University and etc.

The name of the organization where the dissertation was performed: The dissertation work was performed at the Department of “Physics of Stellar Atmospheres and Magnetism” of the Shamakhy

Astrophysical Observatory named after N.Tusi of the Ministry of Science and Education of the Republic of Azerbaijan.

Personal attendance of the author: The helping of applicant and co-others is equal in the acquisition and processing of observation materials, calculations, obtaining results, analysis and compiling of articles.

Publications. The main results of the dissertation work were published within 15 articles and theses. The publications belonging to the dissertation work were published in several prestigious foreign and local scientific journals, in different international and local conferences.

The total volume of the dissertation with a character including a separate volume of the structural units of the dissertation. The dissertation work consists of introduction, 3 chapters, 153 named list of literature. The total volume of the dissertation with a character consists of 169309 characters. The title page - 450 characters, table of contents - 2543 characters, introduction - 13 293 characters. Chapter I -26 695 marks, Chapter II-76681 simbols, Chapter III - 46288 simbols. Result – 3808 simbols. Reference list – 26035 simbols.

THE CONTENT OF THE DISSERTATION

The relevance of the work, short content of the scientific works that have been researched about the stars till today and chosing of the observation objects were based, the aim of the work was commented, the scientific novelty, the theoretical and practical importance of the obtained scientific results were noted, as well as the approbation of the work was shown, the main provisions for defense were enumerated and the structure of the dissertation was described in the **Introduction.**

The used devices and the method of processing of the obtained observation materials were described in the **first chapter**. The level of modern spectroscopy of the spectral observations of our researched stars was carried out by CCD matrix spectrograph on the 2-meter telescope of Shamakhy Astrophysical Observatory during 2000-2020 years. The spectra of the program stars were obtained with

Coude and Cassegrain Echelle spectrometers in this level. The received observation materials of the stars were processed by the DECH software packages.

The extensive information about the parameters of the 2-meter telescope of Shamakhy Astrophysical Observatory and the observation devices up to the year 2000 year were given in **1.1 paragraph.**

The information about the classical spectroscopy of spectral observations (photographic plate), Coude and Cassegrain spectrographs, as well as modern light receivers (CCD – light receiver) of spectral observations, echelle diffraction gratings were given in **1.2 paragraph.**

The processing of the spectra of the HD 207260, HD 7927, HD 195593, 89 Her, HD 80290, HD 138917, HD 9544, HD 9896, HD 224014, Post-AGB HD 161796 stars by the DECH software package, the methodology of measuring of the equivalent lines and radial velocity of the spectral lines of the stars was widely explained in **1.3 and 1.4 paragraphs.** Also, brief information about the statistical spectral Fourier analysis using in the study of periodicity by the way of Scargle method was given in this section.

The scientific work on supergiant stars was presented in general in the **second chapter.** The problems being in stellar astrophysics in this field in the modern time were listed. Besides, brief information on the study of 89 Her, HD 161796, φ Cas, 44 Cyg, HD 207260 supergiant stars that specifically selected was given. Later, the results of the calculations obtained from the analysis of the supergiant stars mentioned on the basis of the recieved spectra were shown.

The supergiant stars and their atmospheric characteristic features were noted in **2.1 paragraph.** The main features of them that known to us till today from observations and scientific literature were given. The location of these stars in the diagram of the Hertzsprung-Russell diagram was shown. It has been noted that, all supergiant stars have a very large mass, luminosity and radius compared with the Sun. They have a sparse and non-stationary atmosphere. One of the interesting facts is that, most of the supergiants are surrounded by the peristellar mantle. Non-stationary processes, the pulsation of a star, stellar mass loss or supernova explosions and etc. occuring in the atmospheres of stars reflect themselves prominently in the appreciation of the parameters and in the forms of profiles characterizing the spectral lines. Also it has been noted that, the scientific research work carried out on the basis of long-term and continuous observations of supergiant stars assumes great importance in the study of the causes of changing the parameters characterizing the atmosphere, as well as the study of characteristics and nature of non-stationary processes.

The relevance of the study of 89 Her (F2 Ibe) star and a brief historical chronicle of its study by different authors were given in **2.2 and 2.2.1 sections.** The information about the main parameters of the star known till today and the models describing its atmospheric structure was given.

According to the observational information obtained in a short time in the researches, the variation of radial velocities of the photospheric lines, as well as the photometric parameters of 89 Her star over the period of 63.5, 285 and 65.2, 283 days is noted. Existing of the relation with very wide, long-termed periodic processes of the variations occuring in the atmosphere in virtually all dependences is shown in this presented research work.

It is noted that, the observational information obtained during a long period of time (> 15000 days) provides unique opportunities for determining long-termed periodic variations in the atmosphere of the 89 Her star.

For the first time, the result confirming the doubleness of 89 Her supergiant star on the basis of analysis of the radial velocity and equivalent width measuring in the absorption component in the profiles of doublet *NaI D2* $\lambda 5890 Å$ and *NaI D1* $\lambda 5896 Å$ lines obtained from the observations in 2004-2017 years was performed. Let's note that, absorption profile of doublet sodium *NaI D* line has a complicated structure. The profile of line consists of two, three and sometimes four components in the observations made in different phases of the orbital motion of binary system. Unfortunately, there is very little information for the third and especially for the fourth component from the observations. Therefore, only the values of parameters of the second component are mainly analyzed in the research work. Also, the results obtained from the analysis of the spectra got by means of the 103a-F photoplate by the classical method in 1975-1986 were given. It is noted that, four absorption components are observed in the profile of the doublet sodium line in 1975. Here, the first component was formed in the interstellar medium as a result of absorption and the odd components were formed in the stellar and peristellar mantle. But only two components are observed in the profile of the doublet sodium line in the spectra obtained in 1985-1986.

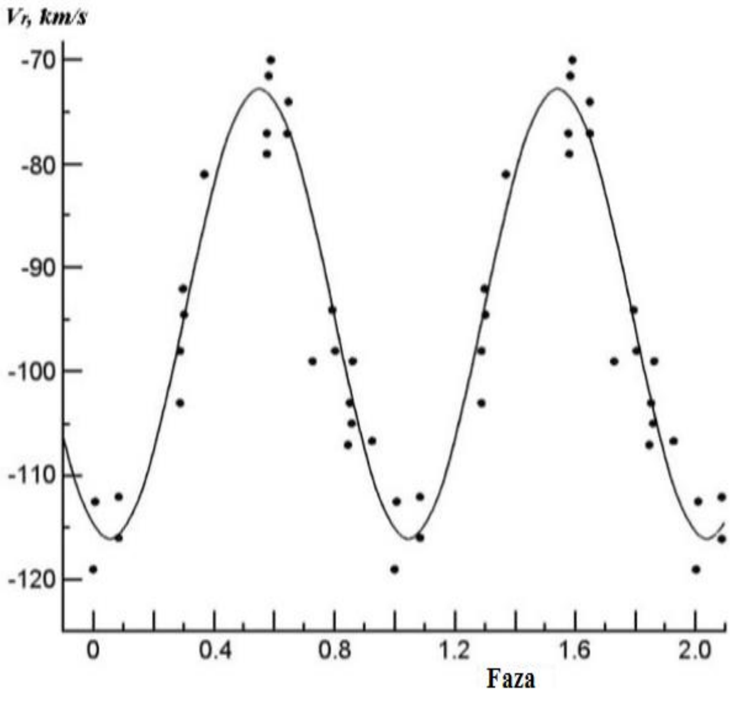

Figure 2.2.1. Phase curve of radial velocities of the second component in the profile of dublet *NaI D* line of 89 Her star, P = 5000 days. Start date: JD 2453949.58, *Vr = –119 km/h*.

The statistical spectral Fourier analysis was applied to the radial velocity *(Vr)* of doublet *NaI D2* line of 89 Her star measured from observation by using from the Scargle method in 2004-2017 years. For the first time, $P=5000\pm300$ daily periodical variation was found for radial velocities. This period characterizes the motion of the 89 Her star around the invisible component.

The orbital parameters of this double system were calculated within the model of the spectral – double system: they have been constructed with data as $\gamma=-94.2\pm0.1$ km/h (the velocity of mass center); $e=0.298\pm0.008$ (eccentricity of the ellipse); $f_1=0.201$ (mass function); $K=21$ *km/h*, amplitude of variation $(\Delta Vr/2)$ of the radial velocity *(Vr)*; *asini=9.1a.v.* (the semi-major axis of the orbit), angle between the *i*-viewing ray and the orbital plane; *Vr* phase curve of radial velocities *MinRV=JD2453949.58*, $Vr=-119$ *km/h*, $P=5000$ day (figure 2.2.1).

The information about the main parameters of HD 161796 (F3 Ib) star that knowing till today and the models describing their atmospheric structure is given in **2.3 and 2.3.1 sections of the II chapter.** It is noted that, HD 161796 star behaves like a pulsating star. The luminosity, radial velocity, intensity of spectral lines, shape of profiles of line and other parameters vary with an undefined and extremely small amplitude in this star.

The equivalent width and central depth (R_λ) of the H_α, H_β, H_γ and H_δ lines of Balmer series of hydrogen observing on the spectrum of the star were calculated. Also, all observing *FeI* and *FeII* lines were identified, their equivalent widths (W_λ) and the central depths (R_λ) of lines were determined. The equivalent width of the line is measured based on the provided program as a rule. But the equivalent widths of some blended lines whose profiles are strongly perverted by neighboring lines have been measured by a special method. For this purpose, a graph of the dependence of the equivalent width of the line $(W\lambda)$ from the depth of the line $(R\lambda)$ was constructed by using the equivalent widths of the unblended lines whose profiles were not perverted by the neighboring lines. The equivalent width of those lines by using this graph was determined by knowing the depth of the blended line.

The calculating of the equivalent width of the H_α, H_β, H_γ, H_δ and *FeI* and *FeII* lines observing in the spectrum of the HD 161796 star plays an important role in determining the fundamental parameters characterizing the atmosphere of this star and its chemical composition, as well as in building its theoretical model and is used practically.

The profiles of doublet *NaI D2* and *NaI D1* lines in the spectrum of the HD 161796 star obtained in 2004-2010 years were studied in **2.3.2 section.** It is known that these lines are mainly called interstellar lines, as well, they are formed in the interstellar medium. Therefore, the profile of these lines should be symmetrical. Being non-symmetrical of these lines proves the existing of the influence of other sources in the formation of those lines. The obtained results showed that, there's also an addition of the mantle around the star and the interstellar medium except the star in the formation of doublet *NaI D* lines. Asymmetry is observed in the red wing of profiles of the sodium doublet line in all obtained Echelle spectra. Therefore, the profile of the line was compared with the Gaussian profile for detecting the asymmetry. The equivalent width (W_λ) and the variation of radial velocity (V_r) of studied lines over a period of 62 days by depending on the time were determined. The obtained results were compared with the curve of luminosity[2] (*V*) (figure 2.3.1). The following results were obtained from the comparison:

1. It was determined that, the value of equivalent width and the curve of luminosity of doublet natrium *(NaI D2, λ5889.953Å)* line varies synchronously.

2. The variation of radial velocity of doublet natrium line occurs by the variation of the curve of luminosity in antiphase.

3. The results obtained from the calculations show that, these variations occur in the result of the pulsation of the star and the interaction bteween the star and the circumstellar mantle.

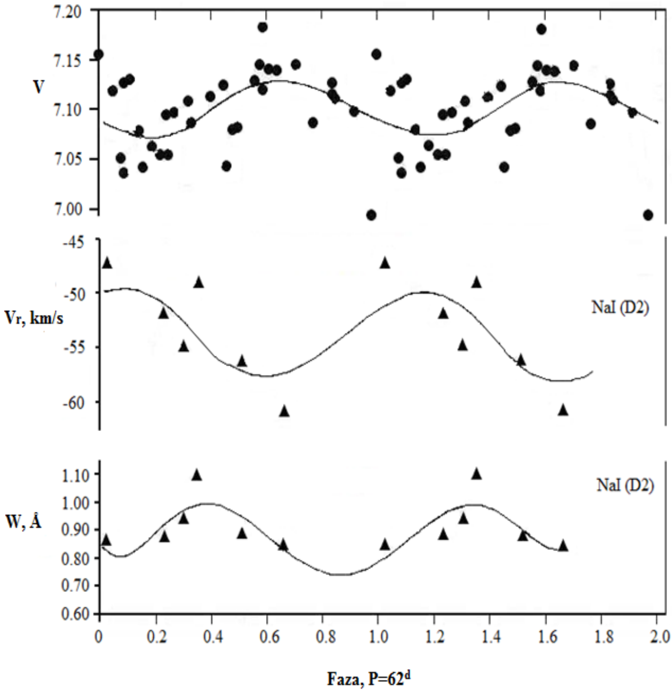

Figure 2.3.1. The variation of the value of radial velocity and equivalent width of doublet *NaI λ 5889.953 Å* line by depending on the phase in the spectra of HD 161796 star, P = 62^{d}. Start period JD2444701.8008.

The information about the atmospheric and photometric parameters of 44 Cyg (F5 Iab) supergiant stellar atmosphere appointed by different observators, its chemical composition, as well as the models describing their atmospheric structure was given in **2.4 paragraph.** The equivalent width and central depth *(R_λ)* of the H_α, H_β, H_γ and H_δ lines of Balmer series of hydrogen observing on the basis of the spectra of this star obtained on the 2-meter telescope of SHAO in 2004 were calculated.

Also, all observing *FeI* and *FeII* lines were identified (about 150 lines), their equivalent widths *(W_λ)* and the central depths *(R_λ)* of lines were determined.

The variation in the lines of Balmer series from the H_α line to the H_{12} line was studied in the spectra of φ Cas supergiant star in **2.5 paragraph.** However, in contrast to the Balmer series lines, no variability was detected in the profiles of the studied doublet *NaI D* lines. The spectral parameters of the noted lines were appointed as W_λ, V_r and R_λ.

It was revealed that, the layers of H_α, H_β, H_γ, H_δ, H_8 lines formed in atmosphere properly expands with *-38 km/h*, *-12 km/h*, *-4 km/h*, *-2 km/h*, *-8 km/h* velocity by moving from the center of the star towards the observer. But, instead of them, the layers of H_9, H_{10} and H_{11} lines formed effectively becomes narrow by moving from the observer towards the center of the star with the *+8 km/h*,*+6 km/h* and *+1 km/h* velocity. This result obtained by us is the fact of observation proving the pulsation of star.

The information about the parameters, chemical composition of HD 207260 (A2 Iae) supergiant stellar atmosphere is given in **2.6 paragraph.** The study of magnetic field of the star and its variation up to *+2000 Qs* are noted.

The variation of profile of the H_α line was researched according to the spectra of HD 207260 star obtained in 2018, the radial velocity and equivalent width of the line were appointed. It has been revealed that, the profile of H_α line observes in two forms:

a) complete absorption profile;

b) normal P Cyg typed profile: absorption and radiation component in red wing.

The profile of H_α line of HD 207260 star mainly observes in the form of P Cyg typed profile. But sometimes the radiation component completely disappear and the profile of H_α line observes in complete absorption. The form of the profile of H_α line, the radial velocity and equivalent width of the components are varying during 70 days and shorter time period. The radiation component observing in the red wing completely disappeared in the profile of H_α line in the spectrum of HD 207260 star and H_α lined profile observed in complete absorption in 16.08.2018.

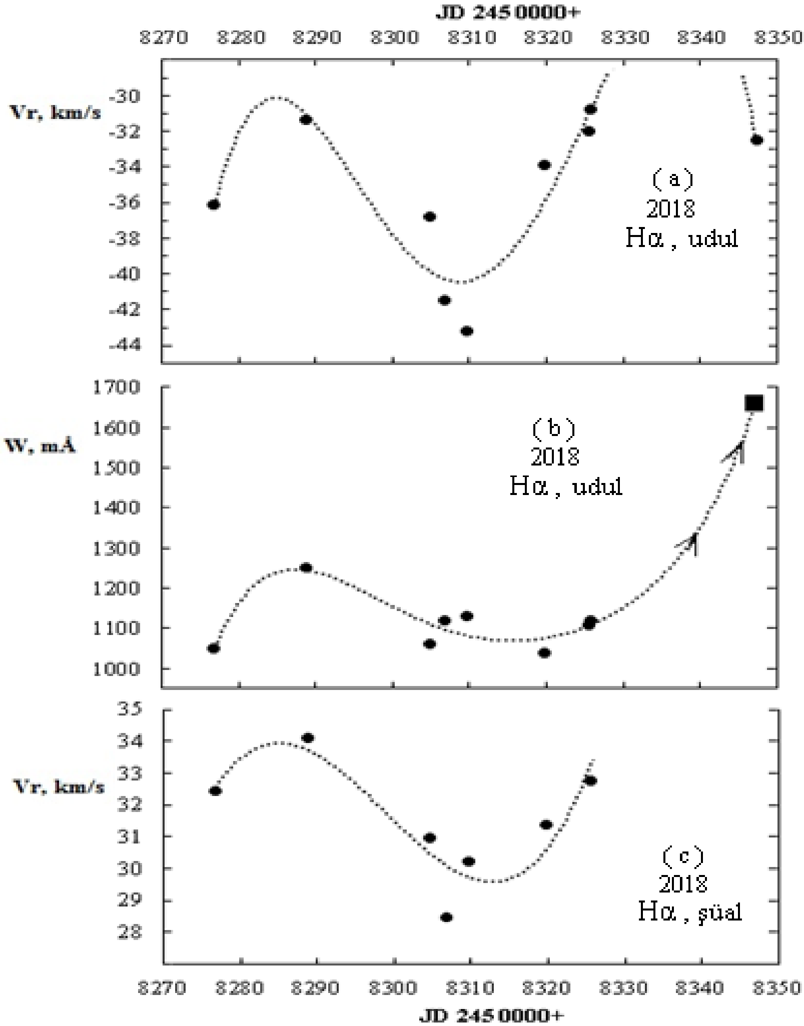

Figure 2.6.1. The radial velocity of the component of absorption and radiation of the profile of H_α line observing in the spectrum of HD 207260 supergiant star, as well as the variation of equivalent width of the component of absorption by depending on the time shows the variation of quadrangular equivalent width noted with an axis in (b). This case corresponds to the case where the H_α line profile is fully absorbed.

In this case, equivalent width of H_α line increases with a jump (about $\Delta W \approx 540\ m\mathring{A}$) and becomes maximum, $W=1662\ m\mathring{A}$. This case was noted with an axis in the figure 2.6.1 (b). But strong variation doesn't observe in the radial velocity of the line.

It has been found that, the radial velocity of the component of the absorption and radiation of the profile of H_α line, as well as the value of equivalent width of the absorption component vary synchronically. This variation occurs over a quasiperiod of 35-40 days (figure 2.6.1.).

Atmospheric parameters of chosen F spectral type stars: effevtive temperature, urgency of surface of gravity were determined in the **third chapter.** By using from these two parameters, the models of atmospheres of stars were calculated and chemical composition was appointed. The evolution parameters of some stars: mass, radius, luminosity were calculated on the basis of evolution curves.

Applied methods of model and parallax of the determination of acceleration of the surface of gravity and effective temperature were explained in **3.1 paragraph.**

The model method is based on the comparison of the values of some spectral and photometric quantities measured by the observation and the values calculated theoretically, and it is the most accurate method of determination of the atmospheric parameters of the stars[3].

Mainly, the profiles (or equivalent widths) of spectral lines of Balmer series of hydrogen as the spectral qualities, Q and $[c_1]$ indexes appointing in the UBV and $uvby\beta$ photometric systems as the photometric qualities are used. The Q index is defined as $Q = (U - B) - 0.72\ (B - V)$ in the UBV photometric system, the index $[c_1]$ is defined as $[c_1] = c_1 - 0.2(b - y)$ in the $uvby\beta$ photometric system. These indexes are free from the effect of absorption in interstellar space. Let's note that, mainly two color indicators are determined in the UBV photometric system: $(U\text{-}B)$ ultraviolet, $(B\text{-}V)$

[3]Leonid, S.L. Accurate fundamental parameters for A-, F- and G-type Supergiants in the solar neighbourhood/ S.L. Leonid, L.L. David, I.R. Sergey // Monthly Notices of the Royal Astronomical Society, - 2010. vol.402, № 2, - p. 1369-1379.

basic color indicators, b-y, u-v, v-b color indicators in the $u\mathrm{v}by\beta$ photometric system, $c_1 = (u - \mathrm{v}) - (\mathrm{v} - b)$ is the determined index. Later, β quality was included into the $u\mathrm{v}by\beta$ photometric system. This quality characterizes the intensity of the H_β line.

The parallax method was also used to determine the atmospheric parameters of the stars. Let's note that, the applied method of parallax is considered a new method for determining the effective temperature and surface of gravity of the stars. This method doesn't depend on the selection of atmospheric models. The parallax method is based on the application of this known expression as the following formula (1):

$$logg - log\,{}^{M}/_{M_\odot} - 0.4BC - 4logT_{eff} = -10.50 + 2log\pi'' + 0.4m_\mathrm{v} - 0.4A_v \qquad (1)$$

The right part is found from the observation for a given star in the formula (1).

The left part of the equation depends on the values of T_{eff} and *logg* parameters. A_v – is the quality of absorption in interstellar zone, m_v – apparent star size, π – the annual parallax of the studied star, BC–bolometric correction, M – star's mass, $M_\odot$ – Sun's mass. $M/M_\odot$ is found from the evolution curves by using from the T_{eff} and *logg* values. *BC* parameter is found by using from the models of stellar atmosphere. T_{eff} and *logg* values, where the equation of the formula (1) can be completed, are chosen by using from the values of the $M/M_\odot$ and *BC* parameters and the left part of equation is calculated. The annual parallax of the star –π which using in the application of this style, apparent star size – m_v, the quality of absorption in interstellar zone – A_v are taken from the star catalogues.

The pairs of T_{eff} and *logg* determined by using from the values of criteria and parallax noted above are described in the $logg \div T_{eff}$ diagram. According to various criteria, the lines constructed in the diagram should theoretically intersect at the same point. The coordinates of the intersection point would give the value of the *logg*

÷ T_{eff} parameters. But in practice, the lines can intersect at several points because there are certain errors in the primary information. Therefore, the average value of the intersection points, as well as the coordinates of the geometric center is chosen for the effective temperature (T_{eff}) and the value of surface of gravity (*logg)* of the star. The variety of intersection points in the diagram characterizes the accuracy of the obtained values for T_{eff} and *logg*.

The determination of the microturbulent velocity by the model method is described in **3.2 paragraph.** Observers know that, theoretically calculated equivalent widths of the spectral lines in the spectra of stars don't coincide with the values of equivalent widths obtained from the observation, though all mechanisms causing to the expansion of the profiles of lines are considered. In order to overcome this contradiction, it is assumed that, there are non-thermal motions of atoms in stellar atmospheres besides with the thermal motions, such motions are called turbulent motions.

Thus, turbulent motion velocity has been included into astrophysics to superimpose the observed and theoretically calculated profiles of spectral lines. Macroturbulent occuring in large-scale and small-scale microturbulent velocities are conditionally distinguished from each other in the stellar atmosphere. Microturbulence varies the value of both the form of profile and equivalent width of the spectral lines. And macroturbulent motion velocity only enlarges the profiles of spectral lines similar to the rotation of stars around their axis, but it doesn't vary the value of equivalent widths.

The determination of microturbulent velocity in the stellar atmosphere is one of the important issues of astrophysics. The determination of chemical components by the model method in stellar atmospheres is based on the comparison of the theoretically calculated values of the spectral lines with the values that measured from the observation. Therefore, to consider microturbulence is necessary in the determination of chemical composition by the model method.

Microturbulent velocity (ξ_t) is determined by the Doppler broadening of spectral lines.

$$\Delta\lambda_D = \frac{\lambda}{c}\sqrt{\frac{2RT}{M} + {\xi_t}^2} \qquad (2)$$

Ionized iron $FeII$ lines are observed more in A and F spectral type stars. Since $FeII$ lines has appeared in deep layers of atmosphere, the deviation from Local Thermodynamic Equilibrium in these lines is weak[4]. Therefore, weak $FeII$ lines are used in the determination of microturbulent velocity in the atmosphere of this type of stars. Several quantities of the given element are calculated according to several selected values of microturbulent velocity. Then a graph of the dependence of the amount of the specified element from the equivalent width of the spectral line is constructed. ξ_t in the graph where the amount of the element *(logε)* doesn't depend on the equivalent width of the spectral line *(Wλ)* is taken as the value of the microturbulent velocity in the atmosphere of the star.

The methodology for determining the chemical composition of stellar atmospheres is given in **3.3 paragraph**.

We compare the values of equivalent widths *(W_λ)* of the spectral lines measured from the observation and calculated from the model for determining the chemical composition. We give various values to the abundance of element *(logε)*. After that, we calculate the equivalent widths of the spectral lines belonging to the element and compare them with the equivalent widths measured from the observation, later the abundance *(logε)* of the element corresponding to the coincidence of theoretical and observational equivalent widths is determined.

The chemical composition of stellar atmospheres is determined by the ratio of the total concentration of atoms of other elements to the concentration of hydrogen atoms:

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[4] Boyarchuk, A.A. Atmosphere of the Canopus I. Model of the atmosphere and the distribution of microturbulence / A.A. Boyarchuk, S.L.Lyubimkov // Astrophysics, -1982. vol.18, - p.375-385.

$$log\varepsilon(x) = log\frac{N(x)}{N(H)} + 12 \quad (3)$$

here *N(x)* is the total concentration of atoms of the given element, *N(H)* is the total concentration of atoms of the hydrogen element, all degrees of ionization are considered. The amount of the $log\varepsilon(H)=12$ corresponds to hydrogen in this scale. The parameter of $\left[\frac{Fe}{H}\right]$ is often used in astrophysics.

This parameter is called the metallicity of the star. This is explained by the fact that, Fe lines are the most observed in the spectrum of most stars.

$$\left[\frac{Fe}{H}\right] = log\varepsilon_*(Fe) - log\varepsilon_\odot(Fe) \quad (4)$$

Therefore, the calculations for the iron lines are more accurate than the calculations for other metals, ass well as atomic data for iron lines are better studied and more accurate than the lines of other metals. Also, Fe atoms don't participate in thermonuclear reactions during the quite stage of stellars' evolution, the primary amount of iron is preserved in atmosphere and doesn't vary. The amount of iron is the same with the amount at the time of star formation. For these noted reasons, metallicity in stellar atmospheres is determined according to iron lines. If $[Fe/H]=0$, metallicity considers normal.

The atmospheric parameters of the HD 80290, HD 224014 stars: effective temperature (T_{eff}), the urgency of surface of gravity (g), microturbulent velocity (ξt) in atmosphere were determined in the dissertation work. The chemical composition was calculated on the basis of our appointed atmospheric parameters.

The information about observation of HD 80290, HD 207260, HD 164613, HD 138917, HD 224014, HD 9544, HD 9896, Post-AGB HD 161796 stars, their characteristical features was given in the sections of **3.4 paragraph.** The spectra of these stars obtained from the observation was studied and their atmospheric parameters were determined.

In 3.4.1 section, the diagram *logg-T_{eff}* for the HD 80290 star was shown in the figure 3.4.1. The comparison of the observed and theoretically calculated values of the *[c_1]* photometric index and the spectral lines of the Balmer series of hydrogen, as well as the lines constructed on the basis of the application of parallax were shown in diagram. The numerical average of the points of intersection of these lines determines the effective temperature of the star and the the urgency of surface of gravity: T_{eff} = 6490±200 K, *logg* = 3.95±0.2.

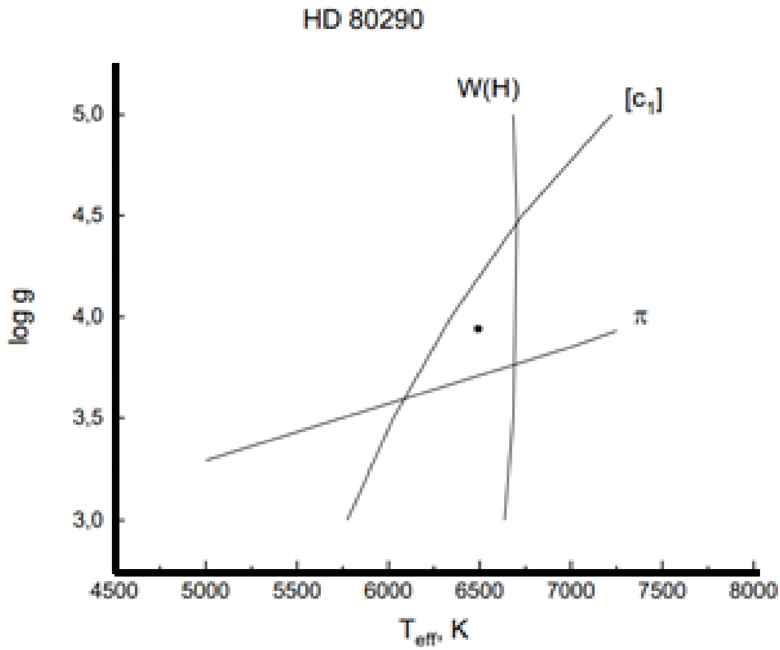

Figure 3.4.1. ***logg-T_{eff}*** **diagram for HD 80290 star**

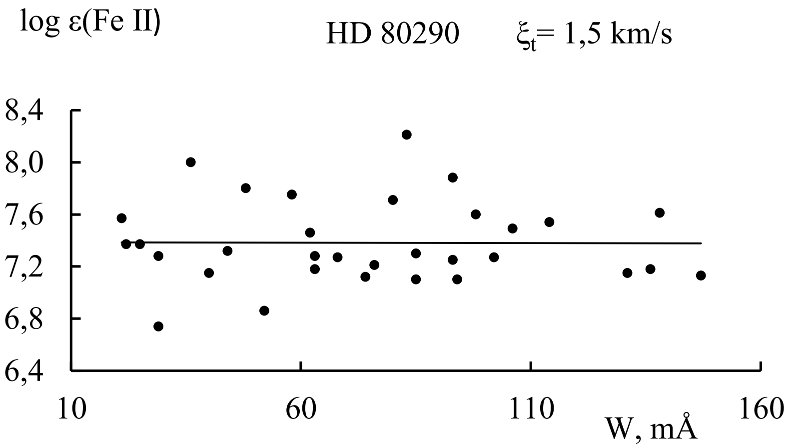

Figure 3.4.2. Determination of microturbulent motion velocity

The determination of microturbulent velocity of the HD 80290 star in its atmosphere was shown as sample in the figure 3.4.2.

ξ_t =1.5 km/h for the HD 80290 star is accepted, because there is no correlation between the amounts determined for the lines of iron element *(FeII)* and equivalent widths of those lines at the ξ_t=1.5 km/h value of microturbulent velocity.

T_{eff}, *logg* parameters of the F spectral class stars that determined by us were given in the table 3.4.1.

Table 3.4.1.
T_{eff}, *logg* parameters of program stars

Name of star	Sp	T_{eff}	logg
HD 80290	F3 V	6490±200 K	3.95±0.2
HD 138917	F0 IV	7200±200 K	3.25±0.2
HD 224014	F8 I	5450±200 K	0.1±0.2
HD 9544	F5 V	6700±200 K	3.75±0.2
HD 9896	F3 V	6800±200 K	4.00±0.2

As an example **in point 3.4.5,** in table 3.4.2, the amount of some elements in the star HD 224014 (F8 I), and in table 3.4.3, the difference of amounts the of those elements with the amount[5,6,7] in the Sun:

$$[el/H] = lg\varepsilon_*(el) - lg\varepsilon_\odot(el) \quad (5)$$

is presented.

Table 3.4.2.
List of lines studied in the spectrum of the star HD 224014 (F8 I) and element abundances based on those lines

Line (λ, Å)	E_{excit} (eV)	log gf	W, mÅ	logε
CI				
4775.89	7.46	-2.30	51	8.05
5800.60	7.95	-2.34	15	7.95
6010.68	8.64	-1.94	6	7.82
6413.55	8.77	-2.00	10	8.17
6587.61	8.54	-1.00	105	8.15
6671.85	8.85	-1.65	11	7.94
7087.83	8.65	-1.44	23	7.90
7108.93	8.64	-1.59	32	8.19
7111.47	8.64	-1.08	54	7.96
7115.17	8.64	-0.93	75	8.00
7476.18	8.77	-1.57	24	8.16
				logε(C)=8.03±0.13

5 Scott, P. The elemental composition of the Sun I. The intermediate mass elements Na to Ca/P. Scott, N. Grevesse, M. Asplund[et al.] // Astronomy and Astrophysics, -2015. vol.573, №A25, - p. 1-19.
6 Scott, P. The elemental composition of the Sun. II. The iron group elements Sc to Ni / P. Scott, M. Asplund, N. Grevesse[et al.] // Astronomy and Astrophysics, -2015. vol.573, №A26, - p. 1-33.
7 Grevesse, N. The elemental composition of the Sun III. The heavy elements Cu to Th / N. Grevesse, P. Scott, M. Asplund [et al.] // Astronomy and Astrophysics, -2015. vol.573, №A27, - p. 1-23.

Table 3.4.2 follows

Line (λ, Å)	E_{excit} (eV)	log gf	W, mÅ	logε
NI				
7442.30	10.33	-0.38	80	8.58
7468.31	10.33	-0.19	100	8.55
				logε(N)=8.57±0.02
OI				
6155.97	10.74	-1.01	16	8.88
6156.78	10.74	-0.69	24	8.74
				logε(O)=8.81±0.1
NaI				
5682.63	2.09	-0.70	281	6.54
6160.75	2.10	-1.26	280	6.83
				logε(Na)=6.69±0.21
AlI				
5557.06	3.13	-2.11	12	6.38
7836.13	4.00	-0.49	107	6.62
				logε(Al)=6.50±0.17
SiI				
5754.22	4.93	-1.84	44	7.13
5772.15	5.06	-1.36	94	7.14
6527.20	5.85	-1.07	120	7.74
6848.58	5.84	-1.53	8	7.24
7034.90	5.85	-0.62	90	7.11
7405.77	5.59	-0.31	217	7.35
7424.61	5.59	-1.61	19	7.11
				logε(Si)=7.26±0.23
SI				
4694.11	6.50	-1.77	140	7.39
4695.44	6.50	-1.92	39	7.33
6052.66	7.84	-0.83	84	7.38
6757.15	7.84	-0.45	152	7.39
				logε(S)=7.37±0.03

Table 3.4.2 follows

Line (λ, Å)	E_{excit} (eV)	log gf	W, mÅ	logε
ScI				
5671.82	1.44	0.54	23	3.17
				logε(ScI)=3.17
ScII				
5318.35	1.35	-1.87	290	3.11
5357.20	1.50	-2.11	214	3.26
5552.22	1.45	-2.09	110	2.75
				logε(ScII)=3.04±0.26
TiI				
4299.63	0.82	-0.43	269	5.13
4639.36	1.73	0.03	85	4.96
4639.94	1.73	-0.08	62	4.73
4650.01	1.73	-0.56	17	4.62
5035.90	1.45	0.41	75	4.75
5219.70	0.02	-2.11	28	4.59
5460.50	0.05	-2.68	22	5.10
5739.48	2.24	-0.47	24	5.11
5739.98	2.23	-0.69	10	4.92
6258.10	1.44	-0.39	51	4.69
				logε(Ti)=4.86±0.21
CrI				
4042.24	2.53	-1.21	66	5.93
4257.35	3.00	-1.26	22	5.91
4261.34	2.90	-0.53	39	5.33
4381.11	2.70	-1.50	8	5.39
4410.30	3.00	-1.22	31	5.98
4458.54	3.00	-0.41	39	5.29
4569.52	3.11	-0.74	10	5.13
4646.21	1.03	-1.63	129	5.13
4633.26	3.11	-1.18	30	6.01
4637.76	2.53	-0.72	77	5.43
4697.84	3.35	-0.64	16	5.43

Table 3.4.2 follows

Line (λ, Å)	**E_{excit} (eV)**	**log gf**	**W, mÅ**	**logε**
CrI				
5287.18	3.42	-0.93	14	5.68
5390.38	3.35	-0.99	17	5.76
5648.26	3.81	-0.77	3	5.38
5694.74	3.84	-0.26	14	5.39
5719.82	3.00	-1.51	5	5.41
				logε(Cr)=5.53±0.28
MnI				
4070.27	2.18	-1.09	109	5.1
4452.99	2.93	-0.64	179	5.64
4671.68	2.88	-1.68	20	5.48
4727.48	2.91	-0.47	92	5.52
5388.50	3.36	-1.37	10	5.28
5457.46	2.15	-2.89	8	5.52
6013.49	3.06	-0.48	23	5.05
				logε(Mn)=5.37±0.23
FeII				
6446.41	6.20	-2.02	88	7.48
6179.39	5.54	-2.60	69	7.28
6084.10	3.19	-3.85	259	7.21
6113.32	3.21	-4.20	208	7.30
6482.20	6.19	-1.84	133	7.54
6369.46	2.88	-4.29	223	7.30
5627.49	3.37	-4.06	151	7.20
5161.18	2.84	-4.55	276	7.57
5100.85	5.89	-1.92	186	7.58
				logε(Fe)=7.39±0.16
CoI				
4068.54	1.95	-1.11	99	4.99
4110.53	1.04	-1.82	186	5.13
4570.02	3.62	-0.40	8	4.71
4727.94	0.43	-3.33	34	5.02

Table 3.4.2 follows

Line (λ, Å)	E_{excit} (eV)	log gf	W, mÅ	logε
CoI				
5094.95	2.03	-2.12	7	4.71
5287.79	4.03	-0.33	5	4.83
7417.38	2.03	-1.98	28	5.05
				logε(Co)=4.92±0.17
NiI				
4009.98	3.62	-1.17	94	6.48
4017.57	3.69	-0.53	113	5.99
4023.99	3.69	-0.81	118	6.23
4551.22	4.15	-0.86	20	5.89
4600.36	3.58	-0.40	220	6.14
4715.76	3.53	-0.30	226	6.00
4752.42	3.64	-0.60	90	5.83
4814.60	3.58	-1.62	26	6.17
4832.69	3.78	-0.95	95	6.33
4841.97	4.15	-1.20	10	5.91
4918.36	3.82	-0.08	294	6.32
4930.80	3.83	-1.56	26	6.36
4952.28	3.59	-1.69	38	6.43
4980.17	3.59	-0.36	197	5.98
5606.80	3.88	-1.70	16	6.28
6025.75	4.22	-1.53	24	6.59
6116.18	4.07	-1.08	41	6.24
6327.60	1.67	-3.21	41	5.92
6370.35	3.53	-1.80	50	6.50
				logε(Ni)=6.19±0.23
ZnI				
6362.34	5.77	0.15	75	4.52
				logε(Zn)=4.52

Table 3.4.2 follows

Line (λ, Å)	**E_{excit} (eV)**	**log gf**	**W, mÅ**	**logε**
ZrI				
4241.69	0.65	0.14	7	2.38
4027.20	0.62	-0.23	9	2.87
				logε(ZrI)=2.63±0.35
ZrII				
4071.09	0.99	-1.66	162	2.53
4110.06	0.75	-1.40	230	2.28
4264.92	1.66	-1.41	62	2.40
				logε(ZrII)=2.40±0.13
LaI				
5377.05	2.29	-0.43	23	1.35
				logε(La)=1.35
SmII				
4123.95	0.48	-0.69	80	0.75
4256.39	0.38	-0.15	232	0.73
4265.08	0.18	-1.04	64	0.66
				logε(Sm)=0.71±0.05

Table 3.4.3.
Difference of the amount of elements in the HD 224014 star and in the Sun

Element	**logε**	**$\log\varepsilon_\odot$**	**Δ logε= logε- $\log\varepsilon_\odot$**
C	8.03	8.43	-0.4
N	8.57	7.83	0.74
O	8.81	8.69	0.12
Na	6.69	6.21	0.48
Al	6.50	6.43	0.07
Si	7.26	7.51	-0.25
S	7.37	7.13	0.24

Table 3.4.3 follows

Element	logε	logε⊙	Δ logε= logε- logε⊙
Sc	3.04	3.16	-0.12
Ti	4.86	4.93	-0.07
Cr	5.53	5.62	-0.09
Fe	7.39	7.47	-0.08
Mn	5.37	5.42	-0.05
Co	4.92	4.93	-0.01
Ni	6.19	6.20	-0.01
Zn	4.52	4.56	-0.04
Zr	2.40	2.59	-0.19
La	1.35	1.11	0.24
Sm	0.71	0.95	-0.24

The amount of 25 elements in the atmosphere of the HD 161796 star was calculated as a sample for Post – AGB stars in **3.4.7 section.** It has been found that, the amount of these elements in the stellar atmosphere is less than the Sun. However, the amount of the *Ca*, *Sc*, *Mn*, *Zn*, *Y*, *Zr*, *Ba* and *Sm* elements differs most from that of the Sun, on average, it is less as *Δlogε≤-0.55dex.* According to the status of the Post-AGB stars, being less of the amount of iron *[Fe/H]=-0,36* in comparing with the Sun and with the I type located normal supergiant star, as well as being higher of the amount of sulfur *([S/Fe]=0.48)* than the amount of iron and the I type located normal supergiant stars shows that this star has formed not on the surface of Galaxy, but in the thick part of the galactic disk or the halo of the Galaxy.

The scientific results in the dissertation are following:

1. For the first time, 5000 day period was found in the variation of the radial velocity and equivalent width of the absorption components in the profiles of dublet *NaI D* line on the basis of the long-term observations of the 89 Her (F2 Ibe) supergiant star in the

optical range. The orbital parameters of the system were calculated on the basis of 5000 day period within the model of the spectral double system.

2. The variation of radial velocity and equivalent width of the doublet *NaI D2 (λ5889.953Å)* line over a period of 62 days by depending on the time in the spectrum of the HD 161796 (F3 Ib) supergiant star was occurred.

The variation of equivalent width of the line with the curve of luminosity (*V)* synchronously, and the variation of radial velocity with the curve of luminosity in counterspace were determined from the comparative analysis of the obtained results with the curve of luminosity.

The variation of the noted parameters of the H_α and doublet *NaID* lines in counterspace was also found in the RM_1-667 supergiant star being in Great Magellanic Cloud (LMC) by the other authors.[8] All of them suggests that, some groups of supergiant stars undergo similar evolutionary ways in short time from the point of view of stellar evolution at some stages of the evolutionary process.

4. As the result of the study of profiles of H_α line on the basis of the obtained spectra of the HD 207260 (A2 Iae) supergiant star in 2018, it became clear that, the profile of the H_α line is the P Cyg type profile, it consists of absorption and the component of radiation observed in the red wing. The radial velocity and equivalent width of the components vary by depending on the time.

It has been found that, the radial velocity of the component of the absorption and radiation of the profile of H_α line, as well as the value of equivalent width of the absorption component vary synchronically and this variation occurs over a quasiperiod of 35-40 days.

4. Balmer series of hydrogen and dublet *NaI D2 λ5889.97Å* and *NaI D1 λ5895.93Å* lines have been studied on the basis of the high dispersed spectra of φ Cas (F0 Ia) supergiant star.

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[8] Gopka, V. Preliminary Study of Red Supergiant RM_1-667 in the Large Magellanic Cloud / V.Gopka, A.Shavrina, S.Vasilyeva [et al.] //Odessa, Astrononomical Publications, - 2012. vol.25, - p.64-65.

It has been revealed that, equivalent width of H_β, H_γ and H_δ lines vary, $\Delta W \approx 1.2$ Å (approximately 1.4 times). Also, the radial velocity of H_α, H_β and H_γ lines that appointed for the half width of the profiles changes and the amplitude of this variation is properly $\Delta Vr \approx$ *-19 km/h*, *-20 km/h* and *-19 km/h*.

As the result of the calculations, it was clear that, the radial velocity determined for the center of the profile is smaller than the value determined by the half width of the profile by $\Delta Vr=14$ *km/h* on average. This observational result proves that the velocity of the stellar wind is weaker in the upper layers of the atmosphere than in the layers where the line is effectively formed.

It was found that, the layers of H_α, H_β, H_γ, H_δ, H_8 lines formed in atmosphere properly expands with *-38 km/h*, *-12 km/h*, *-4 km/h*, *-2 km/h*, *-8 km/h* velocity by moving from the center of the star towards the observer. But, instead of them, the layers of H_9, H_{10} and H_{11} lines formed effectively becomes narrow by moving from the observer towards the center of the star with the *+8 km/h*,*+6 km/h* and *+1 km/h* velocity.

For the first time, these results obtained by our observations prove that, the noted variations happen in the result of the pulsation of the stellar atmosphere.

5. The effective temperature(T_{eff}) of the HD 80290, HD 138917, HD 224014, HD 9544, HD 9896 program stars and the urgency of surface of gravity *(logg)* on the surface were determined. T_{eff}, *logg* parameters coincide to the spectral and luminosity classes of these stars.

6. It has been found that, microturbulent velocity (ξ_t) in the atmosphere of the applied stars as HD 80290, HD 224014, Post-AGB HD 161796 depends on the density of the atmosphere (it means, the urgency of gravitational acceleration – *logg*). The microturbulent velocity is high in the stars with sparse atmosphere. Also, the metallicity being in our applied HD 80290, HD 224014 stars has been revealed as being similar in the Sun. It shows that, these stars and the Sun had formed from the same metallic item.

7. The amount of carbon element in our applied HD 224014 supergiant star is less than that of the Sun, however nitrogen and

natrium elements are more. This obtained result practically confirms the consideration of the modern chemical evolution of the stars.

8. It has been determined that, high-latitude F spectral type supergiant star HD 161796 observing far from the galactic plane has less metallicity than that of the amount in the Sun. That's why, it can be assumed that, the HD 161796 star has formed not on the surface of Galaxy, but in the halo of the Galactic.

THE LIST OF SCIENTIFIC ARTICLES PUBLISHED ON THE CONTENT OF DISSERTATION WORK

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The applicant participated in the processing of the observational materials, calculations, discussion of the results and compilation of the articles in the co-authored scientific articles that numbered 3, 5, 10, 11 and 12 in the list of the author's published scientific works on the subject of the dissertation. The applicant and co-authors have an equal share in the perform of observation materials, in the processing, calculation, obtained results, analysis and drafting of the text in the co-authored scientific articles that numbered 1, 2, 4, 7, 9,14 and 15 in the list.

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