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A B S T R A C T

of the dissertation for the degree of doctor of sciences on astronomy

SPECTRAL AND PHOTOMETRIC PROPERTIES OF MASSIVE CLOSE BINARY SYSTEMS IN DIFFERENT STAGES OF EVOLUTION

Speciality: 2108.01 – Astrophysics, stellar astronomy

Field of science: Astronomy

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BAKU – 2021

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GENERAL DESCRIPTION OF WORK

Relevance of the research topic. This dissertation is devoted to the spectral and photometric studies of massive close binary systems (MCBS) at different stages of evolution. Due to the fact that MCBS are populated only in spiral galaxies, and these galaxies played an extremely important role in understanding the evolutionary properties of MCBS, we also carried out studies of formation of spiral structures in galaxies.

It is known that the massive components of the MCBS at the end of evolution explode as supernovae, and due to this explotion the interstellar medium of the galaxy enriches with the heavy chemical elements. As a result of this explosion, a huge amount of mechanical energy also transferred to the interstellar medium.The enrichment of the interstellar medium with heavy chemical elements and transferring of enormous mechanical energy to this medium play an important role in the evolution of galaxies. On the other hand, due to its high luminosity, MCBS are the only sources of information about spiral galaxies located at great distances from us.

In the last century, astronomers did not understand why type II supernova explosions occur only in spiral galaxies. After the development of the theory of evolution of MCBS, it became clear that the occurrence of type II supernova explosions in spiral galaxies is directly related to the presence of MCBS in these galaxies. Since, MCBS at the end of evolution explode as type II supernovae. Note that type II supernovae are observed in the spiral arms of spiral galaxies. Supernova explosions of this type do not occur in elliptical galaxies.

Despite the fact that numerous works have been devoted to the study of MCBS, there are still a lot of unsolved problems in this area of research. Revealing the new observational data is important for testing the conclusions and refining the theory of evolution of the MCBS.

A star is considered as massive if its mass exceeds ~10 $M_{\odot}$. This value of mass is due to the fact that stars with masses greater than ~10 $M_\odot$ explode as supernovae at the end of their evolution. More different physical phenomena occur when a massive star is a member of a binary system. According to modern view, more than half of the stars in our Galaxy are members of binary and multiple systems. The binary becomes even more interesting if the binary is close binary. Close binary systems (CBS) are those binary systems in which, at some stage of evolution, takes place an intensive exchange of mass between the components[1]. According to modern theories evolution of MCBS, the more massive component of the binary system evolves faster, since the rate of a star's evolution critically depends on its mass. Consequently, the massive component of the MCBS, evolving faster, first fills its Roche lobe, and begins an intensive process of overflow of mass from a more massive component to another, through the inner Lagrange point (Fig. 1).

The relevance studying of MCBS is associated with the following global problems of modern astrophysics:

1. The formation of exotic astrophysical objects of modern astrophysics, such as Wolf-Rayet (WR) stars, neutron stars and black holes, is associated with the evolution of MCBS. At the end of their evolution, the massive components of the MCBS explode as supernovae and, depending on its initial mass, neutron stars or black holes are formed.

2. MCBS exploding as a supernova, at the end of evolution, enrich galaxies with the heavy chemical elements. According to modern view, the Universe was formed ~13.8 billion years ago as a result of the Big Bang (BB). In the era of primary nucleosynthesis of BB, nuclei of hydrogen (~75%), helium (~25%) and a negligible fraction of lithium nuclei were formed. In the epoch of recombination, ~ 380 000 years after the BB, atoms of hydrogen (~75%) and helium (~25%) were formed. The other chemical elements (up to the elements of the iron group) were formed in nuclear reactions occurring in the cores of massive stars. Chemical elements heavier than iron were formed only during the explosion of

[1]Cherepashchuk A.M. Close binary stars / Part I, Moscow, Fizmatlit, - 2013, - p.559.

MCBS as a supernova, at the end of evolution. Consequently, the MCBS exploding as supernovae enriches the interstellar medium with the heavy chemical elements, which plays an important role in the formation of next generations of stars.

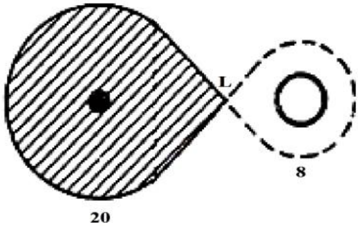

Fig.1. MCBS consisting of components with the masses of 20 $M_{\odot}$ and 8 $M_{\odot}$.

3. It turns out that MCBS enriches galaxies with heavy elements; increases the "metallicity" of the interstellar medium. In contrast to chemistry in astronomy, chemical elements, heavy than helium, are called "metals". It is known that the "metallicity" of the interstellar medium plays an important role in the formation of next generations of stars. Taking into account that galaxies are the main fundamental structural elements of the Universe, it can be argued that MCBS play an important role in understanding of evolutionary features of the Universe as a whole.

4. Due to its high luminosity, MCBS are the only sources of information about spiral galaxies located at great distances.

Despite the fact that by now several hypotheses have been proposed, with the help of which astronomers try to explain the origin of spiral structures of galaxies, to date, there is no satisfactory theory about the origin of these structures. It is known that the majority (more than 50%) of galaxies in the Universe are spiral galaxies. However, to date, the mechanism formation of spiral structures in galaxies is not fully understood. It is known that the spiral structures of galaxies are quite stable, since this structure does not decay for billions of years. It turns out that the study of the origin of spiral structures of galaxies is one of the actual problems of modern astrophysics. We have proposed an original hypothesis explaining the formation of spiral structures in galaxies. We believe that the “embryos” of the spiral structure of galaxies can be formed during the first microseconds after the BB and the arguments in favor of this assumption were given.

Object and subject of research. The main objects of dissertation are MCBS at different stages of evolution (HD 206267, HD 191765, HD 192163, HD 197406, HD 50896, LZ Cep, β Lyr) and spiral galaxies. The subject of research is spectral and photometric studies of MCBS and the origin of spiral structures in galaxies.

The purpose and tasks of the work. The main goal and task of the thesis is the spectral and photometric study of MCBS at different stages of evolution, as well as the study of the origin of spiral structures of galaxies.

The tasks were as follows:

1. Selection of MCBS that are at various stages of evolution. Accordingly, the following objects have been selected: HD 206267, HD 191765, HD 192163, HD 197406, HD 50896, LZ Cep, β Lyr.
2. Carrying out the spectral observations of the selected stars at 2-m and photometric observations at 60-cm telescopes of ShAO named after N. Tusi of Azerbaijan National Academy of Sciences.
3. The choice programs for processing and analysis of the obtained spectral and photometric observational data. The spectral observations were processed by using the DECH, and the photometric data were processed by using the MaxImDL software correspondingly.
4. Analysis of the possible origin of spiral structures of galaxies, considering the possibility of the formation of these structures in the first microseconds of BB. Search for possible methods for the revealing the spiral structures.
5. Processing, analysis and interpretation of the data obtained.

Research methods. In processing spectral and photometric observations, the DECH and MaxImDL software packages were used. The study of the spiral structure of galaxies was carried out by using self-similarity. A method for the revealing the spiral structures are proposed.

The main provisions submitted to the defence: The following propositions are submitted to the defence.

1. Revealed the unusual photometric variability of WR star HD 191765. From photometric observations it was revealed that, the magnitude of this star varies from $8^m.0$ to $8^m.1$ within ~ 10 minutes, i.e. the magnitude increased by $0^m.1$ within 10 minutes! Such brightness change for the first time was revealed for this star [19, p.33-35].
2. Revealed that some WR stars with the probable compact components (HD 191765, HD 192163, HD 50896 and HD197406) are progenitors of X-ray binaries with the "normal" low-mass K-M components. As a result of spectral and photometric studies of stars HD 192163 and HD 191765 and from an analysis of the literature data for the stars HD 50896 and HD 197406, we have confirmed the persistence of the periodic variability of these stars for many years. Therefore, the indicated stars are WR + (K-M) binaries. According to the theory of evolution of MCBS, WR + (K-M) binaries are evolutionary progenitors of X-ray binaries, with the "normal" low-mass (K-M) components [18, p.380-392], [50, p.109-110].
3. The revealed contribution of the Ring Nebula NGC 6888, surrounding the stars HD 192163, to the formation of the lines NaI 5890 and NaI 5896. The asymmetry of these profiles is an argument in favor of the contribution of other sources to the formation of these lines. By investigation of high-resolution spectra of the star HD 192163 the asymmetry of the lines NaI 5890 and NaI 5896 in the spectrum of this star has been revealed. We believe that in formation of these lines there is also contribution of Ring Nebula NGC 6888 [23, c.14-16], [45, c.75-76].
4. The revealed difference in the spectral classification of WR stars, HD 191765 and HD 192163. By using the logarithm of the ratio

of line intensities, the dependence of log (CIV5808 / HeI5875) on log (HeII5411 / HeI5875) was plotted. Despite the fact that both stars in the indicated dependence fall into the region corresponding to the WN6 subtype, there are differences between them. Since the star HD 192163 more closely corresponds to the subtype WN6, and the star HD 191765 is located on the border between WN5 and WN6. The difference between these stars may be due to the fact that the initial mass of these stars was different [20, c.27-29], [43, c.142-143], [48, c.308-309].

5. Revealed stable weak emission in the violet wing of line H_α, the appearance and motion of Discrete Absorption Components (DACs) in the core of line H_α in the spectrum of the star HD 206267. Appearance and movement of DACs is revealed in the core of this line. DACs appeared in the red side of core of the line H_α and within about 1.5 h moved to the violet side [27, c.147-149], [28, c.3-5], [29, c.15-18].
6. The revealed asymmetry of the H_α and H_β lines in the spectrum of the star HD 206267, and the change of these asymmetries over time (approximately one hour). For the H_α and H_β lines, the opposite asymmetry was found, i.e. when the line H_α is asymmetric on the violet wing, the line H_β is asymmetric on the red wing and vice versa [29, c.13-15], [55, c.79-80].
7. The determined value of the orbital period of the star β Lyr corresponding to our observational season (July-August 2016) as 12.9414 days. It is known that due to the intense mass loss of the main component of the star β Lyr, the value of the orbital period of this system increases by ~19 seconds in one year. Consequently, when studying this star, it is necessary to determine the value of the orbital period corresponding to the observational season [39, c.20-25], [40, c.143-145], [57, c.152-153].
8. Revealed additional observational argument indicating the presence of two hot spots near phases 0.4 and 0.8 of the orbital period on the disk, surrounding secondary component of the star β Lyr. We revealed two maxima in the dependence of the ratio of the intensities of the violet and red components of the H_α and HeI

6678 lines on the phase of the orbital period, at phases of about 0.4 and 0.8 [39, c.18-23], [40, c.145-147].

9. Assumption that the "embryos" of the spiral structure of galaxies can be formed during the first microseconds of the BB, and the arguments in favor of this assumption are presented. If the collision of particles occurs near the critical point, because the correlation length approaches infinity, the so-called self-similarity and fractality appear. It is known that the most successful self-similar figure is the logarithmic spiral. Consequently, in the first microseconds of the BB, during the transition from quark gluon plasma to hadronic matter, a spiral structure develops near the critical point. This spiral structure is the "embryos" of spiral structures of galaxies [30, c.2-4], [36, c.75-78], [37, c.15-17].
10. Revealed new indicator for phase transitions of the second order. The spiral structure, which forms near the critical point, can be used as one of the signs of second order phase transitions, i.e. the spiral structure can be used as an indicator in predicting (or identifying) second order phase transitions [30, 3-5], [36, c.75-78].

Scientific novelty of the research. The scientific novelty of the work is determined by the following results:

1. The revealed unusual photometric variability of the WR star, HD 191765. From photometric observations of this star, an increase in the magnitude of the star HD 191765 by $0^m.1$ during ~ 10 minutes was found.
2. It was revealed that some WR stars with the probable compact components may be the progenitors of X-ray binaries with the low-mass K-M components.
3. The stable weak emission in the violet wing of the line H_α, the appearance and motion of DACs in the core of the line H_α in the spectrum of the star HD 206267 was revealed. DACs appeared in the red side of the core of line H_α and within about 1.5 h moved to the violet side .
4. The additional observational fact was revealed, indicating the presence of two hot spots near the phase of ~0.4 and ~0.8 of the

orbital period, on the disk, surrounding secondary component of the star β Lyr.

5. The hypothesis has been proposed that the "embryo" of the spiral structure of galaxies can be formed during the first microseconds after the BB. We believe that if the collision of particles occurs near the critical point, a spiral structure develops and this can be the "embryo" of the spiral structure of galaxies.
6. The new indicator (spiral structure) has been revealed for a second order phase transition. This indicator was discovered when studying the origin of spiral structures of galaxies. The spiral structure can be used as an indicator in predicting (or detecting) second order phase transitions.

The practical and theoretical value of the work. The practical and theoretical value of the work is as follows:

1. The applied method of processing and analysis of observational (spectral and photometric) data as well as the interpretation of results can be used in similar studies.
2. The results of spectral and photometric studies are a source of data for corresponding catalogs.
3. The results obtained by us are important in theoretical studies of the evolutionary properties of the MCBS. Our observational data are important sources of information for the plotting of physical models of MCBS.
4. Our hypothesis that the "embryos" of the spiral structure of spiral galaxies were formed during the first microseconds after the BB is a subject for further comprehensive studies in the field of understanding the origin of spiral structures of galaxies.
5. The indicator for the second order phase transition revealed by us is important for the detection of second order phase transitions.

The credibility of the thesis. The reliability of the thesis is connected by the using of precise methods in obtaining and processing of observational data. Were used the software packages (DECH, MaxImDL, etc.), widely used at this time, by the astronomers in various advanced observatories in the world. Our results have been repeatedly reported in Republican and International scientific conferences, and received positive feedbacks.

Approbation of work. The main results of the dissertation were reported and discussed at the following Respublican, International conferences and scientific seminars:

1. I Republican Scientific Conference "Modern Problems of Physics", Baku State University, Baku, December 6-8, 2007.
2. International Conference on Physical, Mathematical and Technical Sciences, Nakhichevan, November 07-08, 2008
3. International Conference on Astronomy, Physics and Mathematics, dedicated to the International Year of Astronomy, Nakhichevan, November 16-17, 2009.
4. International conference dedicated to the 90th anniversary of Baku State University, Baku, October 30-31, 2009.
5. III Republican Scientific Conference "Modern Problems of Physics", Baku State University, Baku, December 17-18, 2009.
6. VI Republican Scientific Conference "Actual Problems of Physics", Baku State University, Baku, November 20, 2010.
7. VII Republican Scientific Conference "Actual Problems of Physics", BSU, Azerbaijan, November 26, 2012.
8. VI Republican Scientific Conference "Modern Problems of Physics", Baku State University, Baku, December 14-15, 2012.
9. International Scientific Conference "Actual Problems of Physics" dedicated to the 80th anniversary of the birth of acad. B.M. Askerova, Baku State University, Baku, December 6, 2013.
10. VII Republican Scientific Conference "Modern Problems of Physics", Baku State University, Baku, December 14-15, 2013.
11. II International Scientific Conference dedicated to the 91st anniversary of the National Leader of the Azerbaijani people G. Aliyev, Baku, April 18-19, 2014.
12. All-Union Scientific Conference, Astronomical School of Young Scientists, Ukraine, Kiev, May 20-22, 2015.
13. III International Scientific Conference dedicated to the 92 nd anniversary of the National Leader of the Azerbaijani people G. Aliyev, Baku, April 17-18, 2015.

14. IV International Scientific Conference dedicated to the 93 rd anniversary of the National Leader of the Azerbaijani people G. Aliyev, Baku, April 29-30, 2016.

15. All-Union Scientific Conference, Astronomical School of Young Scientists, Ukraine, Kiev, May 26-27, 2016.

16. I scientific-practical conference "Creative potential of youth in solving aerospace problems", February 29 - March 01, 2016.

17. International Astronomical Conference "Physics of Stars: from Collapse to Collapse", Special Astrophysical Observatory of the Russian Academy of Sciences, Nizhny Arkhyz, Russia, October 3-7, 2016.

18. International conference "Physics of stars and planets: atmospheres, activity, magnetic fields", Shamakhy Astrophysical Observatory, Shamakhy, September 16-20, 2019

19. I scientific-practical conference "Creative potential of youth in solving aerospace problems", Baku, February 02-04, 2021.

20. General Scientific “Astroseminars” of the Shamakhy Astrophysical Observatory.

21. At scientific seminars of the State Astronomical Institute. P.K. Sternberg (GAISH) at the Moscow State University of Russia.

22. At scientific seminars of the Department of Astronomy and Space Geodesy of the Kazan Federal University of Russia.

23. At scientific seminars at the Montreal University of Canada.

24. At scientific seminars of the European Center for Nuclear Research (CERN).

Publications on the topic of the dissertation. 39 scientific articles in scientific journals recommended by the Supreme Attestation Commission under the President of the Azerbaijan Republic, 17 abstracts of reports at conferences and one monograph were published on the topic of the dissertation. 8 scientific articles were published in foreign journals with the high impact factor. 17 articles and 5 abstracts are without coauthors.

The name of the organization in which the dissertation work was performed: The work was performed in the department “Physics of stellar atmospheres and magnetism”, of Shamakhy

Astrophysical Observatory named after N. Tusi of the Azerbaijan National Academy of Sciences.

Personal contribution of the author. All spectral observations at 2-m telescope and photometric observations at 60-cm telescope of ShAO named after N. Tusi of the Azerbaijan National Academy of Sciences were performed by the author. Photometric data processing was also carried out by the author. A.F. Abdulkarimova, an employee of the Department of "Physics of Stellar Atmospheres and Magnetism", partly participated in the processing of the spectral data obtained for the star HD 206267. The processing of spectral observations of the remaining stars was carried out by the author. The author gave an analysis of the data obtained, prepared articles for publication.

The volume and structure of the thesis. The thesis consists of the introduction of 82 098 signs (title page - 363 signs, table of contents - 5218 signs) from six chapters (chapter I – 96 252 signs, chapter II – 32 186 signs, chapter III – 32 585 signs, chapter IV – 50 921 signs, chapter V – 54 283 signs, chapter VI – 85 455 signs), results - 5207 signs and a list of cited literature, numbering 285 titles. The total volume of the thesis is 433 890 signs.

The author is deeply grateful to academician of the Russian Academy of Sciences A.M.Cherepashchuk, who instilled in me an interest in WR stars and massive close binary systems, to the staff of the department of "Stellar Astronomy" of the State Astronomical Institute named after P.K.Sternberg, at Moscow State University, with whom many of the results presented in the thesis were discussed.

The author is deeply grateful to all scientific researchers of ShAO for useful discussions of the results presented in the thesis and valuable comments that stimulated the performing of this work.

THE MAIN CONTENT OF THE DISSERTATION

The dissertation consists of an introduction, six chapters and a list of cited references.

In the introduction, substantiates the relevance of the topic, shows the unsolved problems in this area of research, formulates the goals and objectives of the research, sets out the provisions for defense, the scientific novelty and practical value of the results obtained, and the methodology used. The list of Republican and International scientific conferences, as well as scientific seminars, at which the results of the dissertation were discussed, the structure of the dissertation is described.

The first chapter describes the evolutionary features of the MCBS, the formation of WR stars in these systems, and the observational properties of WR stars.

Binary stellar systems, consisting of two massive stars, between which, at some stage of evolution, takes place an exchange of mass between the components, belong to the MCBS. Note that in the MCBS the value of the radii of the components are comparable with the values of the semi-major axes of their orbit. The orbital periods of these systems range from several days to several tens of days. Note that for ordinary binary stars the value of the orbital periods can be several years. The most interesting objects are MCBS, which are at the stages of evolution after the primary exchange of matter between the components. According to the results of theoretical studies[2], the evolution of MCBS occurs according to the following scheme: $O_1 + O_2 \rightarrow WR_1 + O_{2*} \rightarrow C + O_{2*} \rightarrow C + WR_2 \rightarrow C + C$.

At the initial stage, the system consists of two O stars: $O_1 + O_2$. It is known that the rate of evolution of a star critically depends on its mass. Therefore, the more massive component of the MCBS (for example, O_1), evolving faster, fills its Roche lobe and begins intensively lose mass through the inner Lagrange point (Fig. 1).

[2]Масевич А.Г., Тутуков А.В. Эволюция звезд: теория и наблюдения / Изд-во Москва, Наука, – 1988, – 280 с.

This process is called the primary mass exchange. The massive component O_1, losing its hydrogen abundant outer shell, turns into the WR star and the $WR_1 + O_{2*}$ system is formed. The sign * in the subscript of O_2 indicates the fact that the mass of this star has increased due to the stat O_1 during the primary mass exchange. Note that dozens of WR binary stars with O components are known from the observations.

During the subsequent evolution, the star WR_1 explodes as a supernova and, depending on the initial mass of this star, a neutron star or a black hole is formed. The binary $WR_1 + O_{2*}$ system transforms to the $C + O_{2*}$ system, which is called the O star with a compact component. The compact component (C) could be a neutron star or a black hole. O stars with compact components are called “runaway” stars in the scientific literature. This name is due to the fact that they are mainly located at great distances from the galactic plane. After some time, the O_{2*} star in the $C + O_{2*}$ binary system fills its Roche lobe and undergoes intense mass loss through the inner Lagrange point. This process is called the process of secondary mass exchange in MCBS. After the secondary mass exchange, a WR star with a compact component is formed: $C + WR_2$.

Note that the existence of WR stars with the compact components was first predicted theoretically. An observational search for these objects has so far discovered only one WR star with a compact component in our galaxy: Cyg X-3 (WN3-7 + C). Two more such objects have been discovered in other galaxies: IC10 X-1 (WNE + C) and NGC 300 X-1 (WN5 + C).

Ultimately, in binary system $C + WR_2$ the star WR_2 explodes as a supernova. Theorists believed that in this case the binary system should disintegrate, since the more massive component of this system explodes. However, contrary to theoretical statements, to date, a fairly large number of double pulsars have been discovered from the observations.

The main properties of WR stars revealed from observations are presented. The spectra of these stars contain very strong and broad emission lines of nitrogen, carbon, oxygen, helium and hydrogen corresponding to different stages of ionization (NII-NV, CII-CIV, OIV-OVI, HeI, HeII, HI). According to the ratios of intensities, selected lines of nitrogen, carbon and oxygen ions, WR stars are subdivided into three types: nitrogen (WN), carbon (WC), and oxygen (WO). The spectra of WN stars mainly contain nitrogen lines, the spectra of WC stars mainly contain carbon lines, and the spectra of WO stars contain oxygen and carbon lines. The spectra of WR stars of all types contain helium and hydrogen lines. However, the hydrogen lines are weak; the number of hydrogen atoms in the envelopes of these stars is several times smaller than the number of helium atoms. For comparison, note that there is about 10 times more hydrogen on the Sun than helium.

About half of the WR stars are part of close binary systems (CBS), which makes it possible to determine their masses. The masses of WR stars determined from binary stars are in the range from 10 $M_{\odot}$ to 83 $M_{\odot}$. However, the WR star R136a1 with a mass of 265 $M_{\odot}$ was discovered in the Large Magellanic Cloud (LMC), which seriously contradicts the theory of the internal structure of stars. Since the value of the mass of this star is greatly overestimated from the value of the upper mass limit (~ 140 $M_{\odot}$) of a theoretically possible star.

There are single and double WR stars. About half of the WR stars are part of the CBS. The mechanism of formation of WR stars in binary and single systems is different. In the MCBS, consisting of two O stars, at some stage of evolution, by the losing of mass through the inner Lagrange point, a more massive O star, losing its hydrogen abundant outer envelope, turns into a WR star. A single star with a mass of about > 60 $M_{\odot}$ also transforms to WR stars as a result of intense mass loss by stellar wind.

According to modern view, WR stars are at the final stage of evolution, at the stage of exhaustion of nuclear energy reserves, after which the collapse of the star should follow with the formation of a neutron star or black hole, depending on its initial mass. Hence, WR stars are potential progenitors of neutron stars and black holes.

WN, WC and WO stars are subdivided into subtypes. The criteria by which these subtypes are determined are given. The various classification schemes proposed for WR stars to date have been comprehensively discussed. The spectral features of WR stars of various types are analyzed.

The second chapter presents the main properties of various galaxies, the classification scheme of galaxies proposed by the american astronomer E.Hubble, the presence of MCBS in spiral galaxies, and observational facts related to the presence of MCBS in spiral galaxies.

A brief historical review of the development of ideas from observations of mysterious “nebulae” to the elucidation of the true nature of these “nebulae” is given. In 1926, E. Hubble proposed the classification scheme of galaxies, according to which galaxies with regular shapes were separated into elliptical, spiral and lenticular. Galaxies that do not have the regular shape have been called irregular galaxies.

According to the Hubble classification, spiral galaxies are subdivided into normal spirals (S) and bar spirals (SB). In S type spiral galaxies, spiral arms emerge from the core region, and in SB-type spiral galaxies, spiral arms emerge from the ends of an oblong formation (bar), in the center of which the galactic nucleus is located. On going from Sa to Sc, we find a development from tightly twisted spiral arms to a more open one.

Elliptical galaxies are devided into 8 subtypes, from E0 to E7. The numbers determine the degree of ellipticity of the galaxy. In the photographs of these galaxies, have no structure, the brightness smoothly decreases from the center to the periphery, there is a uniform distribution of stars without a clear core.

Lenticular galaxies are designated as S0. In photographs, these galaxies have a board-like shape with a pronounced, central bulge (core) and spiral arms are not found.

Irregular galaxies are designated as Irr, and a characteristic feature of these galaxies is a weakly expressed core and bulge. In some cases, the core is completely absent. The luminosity of these galaxies is very low. Typical examples of irregular galaxies are LMC and SMC, satellites of our galaxy.

Some interesting observational facts related to the presence of MCBS in spiral galaxies are presented. These facts played a decisive role in understanding the evolutionary properties of spiral galaxies and MCBS. One of these facts is the occurrence of type II supernovae only in spiral galaxies. For a long time, astronomers did not understand why a type II supernova explosion occurs only in spiral galaxies.

Supernovae are subdivided into two types: type I and type II. The light curves of type I supernovae are very similar to each other: within 2-3 days takes place a sharp rise in brightness, then a significant decrease occurs within 25-40 days, after which takes place an almost linear slow decay. The absolute magnitude of type Ia and Ib\c supernovae at the maximum is on average – $19^m.5$, and – $18^m.0$, respectively.

However, the light curves of type II supernovae are quite different. The light curves of some supernovae of this type are similar to the light curves of type I supernovae, with the difference that a slower decrease in brightness occurs before the beginning of the linear stage. However, some type II supernovae, having reached their maximum brightness, remain in this stage for up to 100 days, after which they rapidly decrease in brightness and approach the linear end. The absolute magnitude of type II supernovae at maximum brightness varies in a very wide range, from -20^m to -13^m. As noted above, type II supernovae are found only in spiral galaxies and are not observed in elliptical ones.

According to modern view, the mechanisms of supernova explosions of type I and II are different. Type I supernovae are formed as a result of a thermonuclear explosion, and type II supernovae as a result of gravitational collapse at the end of the evolution of massive star.

Type II supernova explosions are associated with the evolution of massive stars, i.e. massive stars complete their evolutionary path by exploding as type II supernovae. A brief evolutionary path of a massive star is outlined.

The energy released by the conversion of hydrogen to helium in the core of stars creates pressure that keeps the star from gravitational collapse and the star is in hydrostatic equilibrium. However, when hydrogen is depleted in a star's core, the star's gravity forces the core to shrink. As a result of this compression, the core temperature rises and reaches to a level sufficient for a thermonuclear reaction involving helium. After exhaustion of helium in the core, with the next compression, the carbon in the core of the star begins to enter a fusion reaction. When the thermonuclear synthesis of the next chemical element stops in the core of a star, the core of the star shrinks until the pressure and temperature become sufficient to start the next stage of synthesis, which stops the contraction of the star. Obviously, the amount of energy released during thermonuclear fusion depends on the binding energy that holds the nucleons in the atomic nucleus. When heavier nuclei are formed in the core of a star, less and less energy is released during fusion. Thermonuclear combustion continues until the chemical element Ni-56 is formed, which radioactively decays into cobalt-56, and then into Fe-56 over several months. Due to the fact that Fe and Ni have the highest binding energy per nucleon, among all chemical elements, the release of energy in the star due to thermonuclear fusion stops and the formed iron core is under tremendous gravitational pressure. Due to the lack of an energy source to further increase the temperature of the star, gravitational contraction is constrained only by the repulsion pressure of electrons. When the mass of the forming iron core of the star exceeds the Chandrasekhar limit (1.4 $M_{\odot}$), the repulsive pressure of electrons can no longer hold back the compression, and a catastrophic collapse occurs. The rapidly shrinking nucleus, heating up strongly, emits high-energy gamma rays, takes place fission the iron nuclei through the nuclear photoelectric effect, and at the same time the nuclei of helium and free neutrons are emitted. As the density of the nucleus increases, the neutronization reaction becomes energetically favorable, in which electrons and protons merge through reverse beta decay, in which neutrons and neutrinos are formed. The loss of energy due to the escape of neutrinos accelerates the collapse of the star, which occurs within milliseconds. When the density reaches the density of the atomic nucleus, the collapse is stopped by the repulsive forces of neutrons. As a result of these processes, a neutron star or a black hole is formed, depending on the initial mass of the massive star. This is a type II supernova explosion.

Consequently, the explosion of type II supernovae is closely related to the evolution of the MCBS. The mystery has been solved; the occurrence of type II supernovae in spiral galaxies is associated with the presence of MCBS in these galaxies.

The third chapter describes the observational equipment and the technique used in obtaining and processing of spectral and photometric observations. The spectral material used in the thesis was obtained at the Cassegrain focus of 2-m telescope of ShAO by using the following echelle spectrometers:

- echelle spectrometer of the Cassegrain focus of the 2-m telescope of ShAO;
- fiber echelle spectrograph ShAFES (Shamakhy Fiber Echelle Spectrograph) of the Cassegrain focus of the 2-m telescope of ShAO.

In obtaining echelle spectrograms by using an echelle spectrometer and a fiber echelle spectrograph ShAFES of the Cassegrain focus of 2-m telescope of ShAO the DECH software package developed at SAO RAS and the Owl 3.01 software package were used, respectively. The processing of the obtained echelle spectrograms was carried out by using the DECH software package.

The echelle spectrometer of the Cassegrain focus of the 2-m telescope of ShAO is described. This echelle spectrometer was made on the basis of a universal diffraction astrospectrograph - UAGS (Universal Astro Grid Spectrograph). Note that the UAGS was previously mainly used to obtain low and medium dispersion spectra of celestial objects. The main goal of constructing an echelle spectrometer was to increase the spectral resolution of the UAGS astrospectrograph by using an echelle grating.

In echelle spectrometer of the Cassegrain focus of the 2-m telescope of the ShAO uses a CCD light detector, with the 530x580 pixel matrix cooled by liquid nitrogen. With this echelle spectrometer, echelle spectrograms of the studied stars were obtained in the spectral range of λλ 4000-7000 ÅÅ, with a spectral resolution of R = 14000, the signal-to-noise ratio is S/N ~ 100.

It should be noted that the size and weight of the suspended echelle spectrometer of the Cassegrain focus of the 2-m telescope of ShAO, which we used, fully meets modern requirements and one of its important properties is good stability. The echelle spectrograms obtained by using this equipment allow us to determine the physical parameters of spectral lines with a fairly high accuracy. To date, with the help of this spectrometer, tens of thousands of echelle spectrograms have been obtained, and based on the analysis of this observational material, dozens of thesis have been defended at the ShAO.

The ShAFES fiber echelle spectrograph of the Cassegrain focus of the 2-m telescope of ShAO is described. At present, in astronomical observations, high-resolution echelle spectrometers are often used, in which light from celestial bodies is directed to the echelle spectrometer through an optical fiber.

In fiber echelle spectrograph of the Cassegrain focus of the 2-m telescope of ShAO uses a CCD light detector, with the 4000×4000 pixel matrix cooled by liquid nitrogen. With the help of this echelle spectrograph, echelle spectrograms of the studied stars were obtained, with the spectral resolution R = 56000, the wavelength range is λλ 3800–8500 ÅÅ.

A technique for performing observations on the echelle spectrometer of the Cassegrain focus of a 2-m telescope and processing of the echelle spectrograms obtained are described. One of the important stages of processing is the plotting of the dispersion curve. The accuracy of measuring the radial velocities of spectral lines critically depends on the accuracy of plotting the dispersion curve. To plot the dispersion curve, the spectra of the daytime sky are used, which are obtained in the dates of obtaining the echelle spectrograms of the studied stars.

A technique for the performing observations with the fiber-optic echelle spectrograph ShAFES and processing of the obtained echelle spectrograms are described. Note that the processing of the obtained spectra by using a fiber echelle spectrograph and the spectra obtained with the echelle spectrometer of the Cassegrain focus of the 2-m telescope was carried out by using the DECH software package.

Photometric observations were carried out with a 60-cm ShAO telescope by using an Apogee Alta U-47 CCD photometer. The main characteristics of this photometer are presented. The MaxImDL program was used to obtain and process the photometric observational material. The main stages of processing photometric images of stars by using this program are outlined. Before starting the observation, before turning on the telescope, the work of the CCD was checked. Flat images were obtained in the evening twilight. The telescope is directed to the north-west of the sky, where there are no clouds, in the clear sky in which the stars are not yet visible.

When processing photometric data, firstly it is necessary to calibrate the images of investigating star. For this purpose, we sequentially enter the Sbias, Sdark, and Sflat, and the images of the investigated object are calibrated. Note that the calibration removes the thorn current (Dark), matrix electric currents (Bias) and flat field (Flat). The calibrated images of the object under study can already be processed. First you need to choose the correct aperture - Aperture. The correct choice of the radius of the inner circle is necessary, since the measurement is carried out in this circle. Therefore, the radius of this circle must be accurate. The object must be completely inside the inner circle. If the circle is larger than the object, then the radius of the inner circle must be reduced and vice versa, if the object does not interfere inside the circle, then the radius is increased. After that, you should to select an outer circle, in which the background of the sky around the object is taken. When measuring with MaxImDL, the background in the outer circle is subtracted from the inner circle where the object is. By subtracting the outer from the inner, we get a star image cleared from the background. The outer circle should be chosen so that there is a lot of background. After that, all the calibrated spectra of the object under study are opened in the MaxImDL working window, and by using the Photometry subroutine located in the Analyze menu, the photometry of the object under study is carried out.

The fourth chapter presents the results of spectral studies of MCBS: HD 206267, LZ Cep, and β Lyr.

The star HD 206267 (O6.5V + O9V, V = 5.6) is a spectral binary system with the 3.709784 day period. In connection with the discovery of the X-ray source Ser X-4 (GS 2138 + 56) in the vicinity of this star in 1972, interest in it increased greatly. However, the study of this star in the wavelength range λλ 3750-6680 ÅÅ did not reveal emission lines that could be indicators of X-ray radiation.

The star HD 206267 has some interesting properties. One of these properties is that this system is a member of a multiple trapezoidal stellar system - Trap 857. Trapezoidal systems are very similar to open clusters and differ from them only in that the number there is few members in the trapezium. Note that the trapezoid Trap 857 is a member of the young (~ 3 million years old) open star cluster Trumpler 37. This cluster, in turn, is a member of the Cep OB2 association.

Another distinctive feature of this star is its high rate of mass loss. The star HD 206267 has a high stellar wind velocity. For O stars of the early subtype, the wind velocities are in the range from ~ 1000 to 3000 km/s. In particular, for stars of spectral type O6-O7, the wind velocity is in the range from 1425 to 2420 km/s. However, for the star HD 206267, the wind velocity is 3225 km/s, i.e. the terminal wind velocity is the maximum among the 181 studied O stars.

The spectral observations of this star were carried out during 2011-2014 at the Cassegrain focus of the 2-m telescope of ShAO. Echelle spectrograms were obtained and processed by using the DECH software packages developed at SAO RAS. The observation was carried out by using the Cassegrain focus echelle spectrometer of a 2-m telescope with the CCD matrix 530x580 pixels. Spectral range λλ 4700-6700 ÅÅ, spectral resolution R = 14000, signal-to-noise ratio S/N~100. By analyzing the echelle spectrograms of star HD 206267, the following results were obtained:

1. A stable weak emission was found in the violet wing of line H_α.
2. The DAC (discrete absorption components) lines in the core of the line H_α have been revealed. The DAC line first appears in the red

part of the core of line H_α and within about 1.5 hours moves to the violet part of the core. The DAC lines in the core of the line H_α in the spectrum of HD 206267 were revealed by us for the first time.

3. The spectral feature (for example, strong emission) has not been found, according to which this star can be identified with the X-ray source CepX-4.
4. The asymmetry of lines H_α, H_β and the change of these asymmetries over time (approximately one hour) were revealed. Note that the asymmetry of both lines is mainly observed at residual intensities above 0.90 (line wings). Below the residual intensity values of 0.90 (line core), the profiles of both lines are approximately symmetric. Note that the opposite asymmetry was detected for the H_α and H_β lines; when the line H_α is asymmetric on the violet wing; the H_β line is asymmetric on the red wing and vice versa.
5. In those cases when DAC is not observed, the H_β line width at different levels of residual intensity hardly changes with time, but the H_α line widths undergo significant changes, there is no correlation between changes in H_α and H_β line widths.
6. In those cases when DAC lines are observed, significant variability of both lines (H_α and H_β) is observed, the widths of both lines change almost synchronously (if we do not take into account the level of residual intensity 0.80).
7. The largest changes in the width of the H_α and H_β lines are observed at the residual intensity levels 0.90–0.95, in the wings of the line.
8. The radial velocity of the main component varies from approximately +80 km/s to -110 km/s for the lines H_α and H_β, from +60 km/s to -100 km/s for the line HeII 5411. The amplitude of changes in the radial velocities of the main component does not differ significantly for the lines H_α, H_β and HeII 5411.
9. The radial velocity and the equivalent width of line H_α change in antiphase, the equivalent widths of the H_β and HeI 5875 lines do not depend on the phase of the orbital period, the radial velocity and the equivalent width of line HeII 5411 change synchronously.

The star LZ Cep (O9 III + ON9.7V, V = 5.54) is an eclipsing binary, with the 3.070507 day period. Note that the LZ Cep binary is in a more advanced evolutionary stage compared to the star HD 206267. Since the star LZ Cep is almost at the final stage of primary mass exchange, and the star HD 206267 is at the stage of forming an envelope around the main component. Signs of nitrogen sequence WR stars are already appearing in the main component of the star LZ Cep.

The light curve of the star LZ Cep shows the ellipsoidal variability with an amplitude of $\Delta m < 0.1$ magnitude. The value $i = 48^0$ was found from the light curve for the inclination of the orbit to the line of sight. The ellipsoidal light curve of this star indicates the deformation of at least one of the components of this binary system. Two models for the star LZ Cep are considered: a contact and a semi-separated binary system. A semi-separated system, in which a less massive component filled its Roche lobe, turned out to be more acceptable for observations.

The spectral observations of the star LZ Cep were also carried out with the Cassegrain focus echelle spectrometer and the parameters of the echelle spectrograms obtained are identical to those obtained for the echelle spectrograms obtained for the star HD 206267.

As a result of spectral studies of the star LZ Cep, the following main results were obtained:

1. Near the phase $\phi = 0.00$ (when the low-mass component of the binary system approaches us with the maximum speed) of 3.709784 day orbital period, the H_α line profile is strongly distorted: the core of this line consists of red and highly distorted violet parts.
2. The variability of the parameters of the LZ Cep line was investigated by using 23 echelle spectrograms obtained during one night near the phase $\phi = 0.00$. It is shown that the equivalent width of the line H_α shows the rapid variability. Despite the fact that the radial velocity determined at the half-width level changes in a chaotic manner, the radial velocity determined from the red component of the nucleus reflects the orbital motion better.

3. A jump is revealed in the radial-velocity curve near the phase ϕ = 0.25 (when the low-mass component is between us and the massive component).
4. In the spectrum of this star, at some phases, the profile of the HeI 5875 line doubles; at a phase of about ϕ = 0.00, the secondary component of this line appears in the violet side of line HeI 5875, and at a phase of about ϕ = 0.50, the secondary component of this line appears in the red side. In other phases, the profiles of this line are strongly distorted by the presence of a secondary component.
5. The H_β line profile does not double, however, at some phases, the H_β line exhibits a component; moreover, at a phase of about ϕ= 0.00, the secondary component of this line appears in the violet side of line H_β, and at a phase of about ϕ = 0.50, the secondary component of this line appears in the red side. In other phases, the profiles of this line are strongly distorted by the presence of a secondary component.

The star β Lyr is a bright ($V_{max} = 3^m.4$, $B - V = 0^m.0$) semi-separated, eclipsing, closely-binary system with an orbital period of 12.941428 days. The star β Lyr consists of a main component (B8 III), which fills its Roche lobe, and a secondary, invisible, surrounded by a thick accretion disk.

One of the interesting features of this star is the fact that the main component has a lower mass (~ 2.9 $M_\odot$) than the secondary (~ 13$M_\odot$). The temperatures of the main and secondary components are 13 3000 K and 23 0000 K, respectively. The inclination of the orbital plane to the line of sight is slightly less than 900 (~81^0) and the orbit is almost circular.

Optical and spectropolarimetric observations revealed the presence of bipolar jets in binary star β Lyr, which are perpendicular to the orbital plane, and the H_α and HeI 6678 emission lines are mainly formed in these jets. Due to the fact that the main component of the star, β Lyr, is losing mass at a high rate, the value of the orbital period of this binary system increases by about 19 seconds over the course of the year.

The binary star β Lyr is at the stage of rapid mass exchange between its components. Therefore, in this star, stronger spectral changes are observed, in contrast to the stars HD 206267 and LZ Cep.

One of the interesting features of this star is the fact that the main component has a lower mass (~ 2.9 $M_{\odot}$) than the secondary (~ 13$M_{\odot}$). The mass of the main (M1) and secondary (M2) components is determined by the expressions:

$$M_1 \sin \iota = (2.88 \pm 0.10)\ M_{\odot}$$
$$M_2 \sin \iota = (12.94 \pm 0.05)\ M_{\odot}$$

Here M_1 and M_2 are the masses of the primary and secondary components, respectively, ι - is the inclination of the orbital plane of the binary system to the line of sight of the observer, the value of which is most likely in the range $80^0 – 90^0$. Assuming a conservative mass loss and taking into account the detected increase in the period, the value of the rate of mass loss by the main component was found to be $20\cdot10^{-6}$ $M_{\odot}$ per year[4].

The lower mass of the main component is explained by the fact that, filling its Roche lobe, it underwent an intense loss of mass through the internal Lagrange point. As usual, we call the massive component of the binary system the primary and the low-mass secondary. However, in the case of the star β Lyr, the inverse ratio of the masses of the components is observed.

According to modern concepts, the low-mass main component of the star β Lyr, in fact, was originally a massive star. It is known that the rate of evolution of stars depends decisively on their mass. Therefore, the more massive (main) component of the binary system, evolving rapidly, first fills its Roche lobe. After that, the main component begins to intensively lose matter through the internal Lagrange points and, over time, the mass of this component decreases, and the mass of the secondary increases.

[4]Harmanec, P., Scholz, G. Astronomy and Astrophysics, 1993, 279, p. 131-147.

At the end of this process, the so-called "paradox of Algol" is obtained, i.e. the less massive component of the binary system is more evolved.

The spectral observations of the star β Lyr were carried out at the Cassegrain focus of 2-m telescope of ShAO in July-August of 2019. The ShAFES fiber echelle spectrograph with CCD (4000x4000 px), cooled with liquid nitrogen was used. The spectral range is λλ 3800–8500 ÅÅ, the spectral resolution is 56 000, the signal-to-noise ratio (S/N) is ~300. The processing of the echelle spectrograms was carried out by using the DECH20T software package developed at the SAO RAS. The root-mean-square errors in determining the equivalent widths and radial velocities were 5% and 300 m/s respectively. The following results were obtained from the analysis of the echelle spectrograms of the star β Lyr:

1. To plot the radial velocity curve of the main component, we used the measured radial velocities of the SiII 6347, MgII 4481, and FeII 4233 lines. The choice of these lines is due to the fact that these lines are narrower, which allows us to determine the radial velocities of these lines with high precision.
2. The value of the orbital period corresponding to our observational season was determined as 12.9414 days. Due to the intense mass loss of the main component of star β Lyr, the value of the orbital period of this system increases by 19 sec. in one year. Consequently, when studying this star, it is necessary to determine the value of the period corresponding to the observation season.
3. It was revealed that the line H_α consists of narrow violet (V - violet), wide red (R-red) components and absorption between them. In all phases of the orbital period, the so-called S-wave emission is also observed in the H_α line. Note that S-wave emission is characteristic for cataclysmic variables.
4. The dependences of the radial velocity, central intensities, equivalent widths and half-widths of the H_α and HeI 6678 lines on the phase of the orbital period were plotted. All these dependences are in fairly good agreement with these plotted by other researchers.

5. An additional observational fact indicating the presence of two hot spots at phases ~0.4 and ~0.8 of the orbital period on the disk surrounding secondary component was revealed. The temperature of these spots is 10% and 20% higher than in the environment, respectively. We found two maxima in the dependence of the ratio of the intensities of the violet and red components of H_α and HeI 6678 lines on the phase of the orbital period, at phases of about 0.4 and 0.8. It is known that the emission lines H_α and HeI 6678 are formed mainly in bipolar jets. The jets are directed perpendicular to the orbital plane in the region where the wind from the main component collides with the disk. A comparison of the curves for H_α and HeI 6678 shows that the maximum for the line H_α is more distinct. This fact may be connected with that the jets contribute more in the formation of line H_α than of HeI 6678. Note that the circumstellar envelope and the wind from the main star also contributes to the formation of these lines.
6. It was revealed for the first time that the dependence of the radial velocities of the S wave emission changes approximately synchronously with the radial velocity curve of the main component, but with a smaller amplitude.

These results are important for the understanding the physical nature of the processes taking place in star β Lyr and should be taken into account in constructing the physical model of this star.

The fifth chapter presents the results of a study of WR stars, with the probable compact components. In the 1980s, the spectral and photometric variability of 16 “single” WR stars was discovered, which were surrounded by ring nebulae and located at large distances from the galactic plane. These objects were considered as WR stars with the probable compact components (WR + C). The compact component could be a neutron star or a black hole. The periodic variability of the radial velocities of some spectral lines and brightness revealed for these “single” WR stars was an argument in favor of the binarity of these stars. However, further research did not confirm that the above mentioned 16 stars can be WR + C systems. First, the observed spectral and photometric periodicities for most of these objects turned out to be not strictly periodic, but quasiperiodic. On the other hand, X-ray observations have shown that the X-ray luminosity of these stars is too low ($L_x \leq 10^{33}$ erg/s) for accreting neutron stars. In fact, if these stars were indeed WR + C systems, their X-ray brightness would be ~ 10^{38} erg/s. After that, the physical nature of these 16 stars turned out to be uncertain.

The first attempt to explain the physical nature of these 16 stars was made by academician A.M. Cherepashchuk. According to A.M. Cherepashchuk, “single” WR stars located in the centers of ring nebulae can be CBS containing low-mass “normal” K-M stars as components.

The basis for this hypothesis is that to date, several dozen low-mass X-ray Binaries (LMXB) have been discovered, consisting of a low-mass optical star of spectral type K - M, filling its Roshe lobe and an accreting relativistic object (neutron stars or black holes). The orbital periods of these objects lie in the interval P ~ 0.2 - 33.5 days, the orbital eccentricities are e = 0. Spectral types of optical components: B, A, K, M. According to the luminosity class, these components correspond to dwarfs, subgiants, and giants. The duration of the LMXB X-ray flares is on the order of months. During an X-ray flare, their X-ray luminosity increases by a factor of 10^2-10^6 and reaches the value Lx ~ 10^{37}-10^{38} erg/s. Quiescent X-ray luminosity Lx ~ 10^{31}-10^{33} erg/s. The duration of a calm state can be up to several years. The relativistic components of the LMXB are neutron stars or black holes.

According to the theory of evolution of MCBS, the progenitors of low-mass X-ray binaries should be WR stars with low-mass K-M stars. The WR + (K-M) system is formed after the stage of primary mass exchange. The subsequent explosion of the WR star as a supernova formed after the initial mass exchange leads to the formation of an X-ray binary system with a relativistic object and a low-mass K-M star.

To test for the correctness of A.M. Cherepashchuk's hypothesis, it is necessary to answer the question: does the periodic variability of these 16 stars persist during very long time. To answer this question, we examined four of these stars: HD 191765, HD 192163, HD50896, and HD197406.

The spectral observations of the stars HD 191765 and HD 192163 were carried out at the Cassegrain focus of 2-m telescope of ShAO during 2005-2010. The echelle spectrometer of the Cassegrain focus of 2-m telescope, with the CCD light detector 530x580 px was used. The spectral range λλ 4000-7000 ÅÅ, spectral resolution R = 14000, signal-to-noise ratio S/N ~ 100. Echelle spectrograms were obtained and processed by using the DECH software packages, developed at SAO RAS.

The photometric observations of the star HD 191765 were carried out with the 60-cm telescope of ShAO in July-September of 2010. The Apogee Alta U-27 1024x1024 pixel CCD photometer was used. The filter V was chosed because the contribution of emission lines in this filter is about 7% and the variability in this filter is mainly related to the variability of the continuous spectrum. Photometric data were obtained and processed by using the MaxIm DL program. The photometric variability of the star HD 191765 was revealed, both during the night and from night to night. The root-mean-square error of one measurement, determined from the control star, varies from $0^m.0006$ to $0^m.0009$.

The information concerning on the revealed variability of the profiles of the (HeII + H_α) 6560 emission band in the spectra of the stars HD 191765 and HD 192163 is given. It is known that the H_α emission is formed in the outer regions of the expanding envelope of the WR star, and the orbital motion of the K-M star can lead to the perturbation of the region of formation of the H_α emission, which should cause variability of the profile shape of this line. The variability of the profile of the (HeII + H_α) 6560 emission band may serve as an additional indication of the presence of a companion near the star WR, which, according to our hypothesis, could be identified as the low-mass K-M star.

Of the 17 profiles of the (HeII + H_α) 6560 emission band studied by us in the spectrum of the star HD 191765, only in one case a more or less symmetric profile was detected, and in other cases the variability of different degrees are observed. Note that the signal-to-noise ratio is the same for all used echelle spectrograms and is equal to S/N ~ 100.

Comparison of the shape of the profiles of the (HeII + H_α) 6560 emission band in the spectrum of the star, HD 192163, obtained on different dates, showed that the profile variability is observed mainly in the violet wing (the region from ~ 6496 Å to ~ 6532 Å). In this region, sometimes narrow emission features appear (mainly at a wavelength of ~ 6510 Å), the height of which is three times higher than the probable error (0.9%).

By using the measured radial velocities of the (HeII + H_α) 6560 emission band for the star HD 192163, we carried out a frequency spectral analysis of the radial velocities to reveal the possible periodicity. Using the method proposed by Scargle[5] and the "clean" algorithm obtained the period as 5.1287 days. This period is interpreted by the binarity of HD 192163, a component that may be a "normal", low-mass K-M star.

The results of the frequency spectral analysis of the photometric data of the star HD 191765 are presented to reveal the possible periodicity. By using the method proposed by Scargle[5] and the "clean" algorithm obtained the period as 1.887 days. This period is interpreted by the binarity of HD 191765, a component that may be a "normal", low-mass K-M star.

By analyzing the data published in the scientific literature for the stars HD50896 and HD197406, it was determined that their periodic variability persists for a long time. Thus, we came to the conclusion that these four stars (HD 192163, HD191765, HD50896 and HD197406) may be a binary WR + (K-M) system. According to the modern theory of evolution of the MTDS, this binary stellar system could have been the progenitors of X-ray sources with low-mass K-M components.

As a result of spectral and photometric studies of the stars HD 191765 and HD 192163, we have confirmed the preservation of the periodic variability of these two stars during long time.

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[5]Scargle J.D., Astrophysical Journal, 1982, 263, p.835-853.

From an analysis of the literature data, we have established that the periodic variability of the stars HD 50896 and HD 197406 also persists for many years. Consequently, for four stars the periodic variability is conserved.

Note that the orbital periods for the stars HD 191765 (P = $1^d.887$), HD 192163 (P = $5^d.218$), HD50896 (P = $3^d.766$), and HD197406 (P = $4^d.31364$) fall into the intervals that were determined for X-ray novae with low-mass components. The assumed masses of the low-mass components are ~ 1 $M_\odot$ and 4 $M_\odot$ for the stars HD 50896 and HD 197406, respectively. These masses are in very good agreement with the masses of the low-mass components of the X-ray novae.

Taking into account the above observational facts, we believe that the stars HD 191765, HD 192163, HD50896, and HD197406 can be evolutionary precursors of X-ray novae with low-mass K-M components.

A study of the interstellar lines NaI 5890 and NaI 5896 in the spectrum of a WR star, HD 192163, is presented in order to reveal the possible contribution of the Ring Nebula NGC 6888 to the formation of these lines. Note that the star HD 192163 is located in the center of the Ring Nebula NGC 6888. Note that the lines NaI 5890 and NaI 5896 are formed mainly in the interstellar medium and should be symmetric. The asymmetry of these lines is an argument in favor of the contribution of other sources to the formation of these lines. In our case, it is reasonable to assume that the Ring Nebula NGC 6888 contributes to the formation of these lines. Note that the asymmetry of these lines was not detected by us in the spectra of another WR star, HD 191765, and the standard star HD 189847. This observational fact is an additional argument in favor of the reality of the revealed asymmetry of the studied absorption lines NaI 5890 and NaI 5896 in the spectrum of the star HD 192163, since the spectra of all stars were obtained and processed under the same conditions.

Information on the study of the ionization structure of the envelopes and the spectral classification of the WR, HD 191765 and HD 192163 stars is given. The ionization structure of the envelopes of these stars is studied by plotting the relationship between the emission line half-widths and the ionization potentials. It is shown that the structures of the envelopes of these stars are different. These differences may be related to the difference in their evolutionary states.

The spectral classification of WR stars, HD 191765 and HD 192163 was carried out. By using the logarithm of the ratio of line intensities, the dependence of log (CIV5808/HeI5875) on log (HeII5411/HeI5875) was plotted. It is known that this dependence is used for the spectral classification of WR stars of nitrogen sequence. Despite the fact that both stars in this dependence fall into the region corresponding to the WN6 subtype, there are differences between them. HD 192163 more closely corresponds to the WN6 subtype, while HD 191765 is located on the border between WN5 and WN6. Note that the atmosphere of the star HD 192163 contains hydrogen, while the star HD 191765 has completely lost its outer hydrogen envelope. The difference between these stars may be due to both this circumstance and the fact that the initial mass of these stars was different.

The sixth chapter presents the results of studies the origin of spiral galaxies. The hypothesis proposed by us concerning to the origin of spiral galaxies is explained.

According to the classification scheme proposed by the American astronomer E. Hubble, according to the degree of development of spiral branches and size, spiral galaxies are subdivided into subtypes: Sa, Sв, and Sc. Along the sequence Sa, Sb, Sc, the core decreases and the spiral arms become stronger.

It is possible that the separation of galaxies into spiral and elliptical is associated with the rotation (angular momentum) of these galaxies. Galaxies that, had a sufficient amount of rotation, had a favorable condition for the development of a spiral structure, however, galaxies with a smaller amount of rotation were formed as elliptical galaxies, galaxies with the least amount of rotation remained shapeless (irregular).

It is known that the majority (more than 50%) of galaxies in the Universe is spiral galaxies and the spiral structures of galaxies are quite stable, since this structure does not decay for billions of years. Despite the fact that by now several hypotheses have been proposed, with the help of which astronomers try to explain the origin of spiral structures of galaxies, to date, there is no satisfactory theory about the origin and evolution of these structures. We believe that the "emboys" of the spiral structure of galaxies are formed in the first microseconds of the Big Bang (BB).

According to modern concepts, the Universe was formed ~13.8 billion years ago from a singular state as a result of BB, and has been expanding and cooling since that time. BB is a generally accepted cosmological model, which successfully describes the physical state of the early stages of the evolution of the Universe.

According to modern concepts, BB is subdivided into the following epoch: Planck epoch, Grand Unification epoch, inflationary epoch, electroweak epoch, quark epoch, hadrons epoch, leptons epoch, nucleosynthesis epoch, photon epoch, recombination epoch (Recombination/Decoupling), Dark Ages or Dark Era, the era of the formation of stars and galaxies. The properties of these eras are briefly outlined.

At present, in modern particle accelerators, it has been possible to create a state of matter that corresponds to the first microseconds of the Universe after the BB. In the Large Hadron Collider (LHC), it was possible to reach up to 10^{-12} seconds after the BB. This state roughly corresponds to the post-inflationary era of the BB. According to modern concepts in this era, the Universe consisted of a quark-gluon plasma and experiments carried out at the LHC showed that this quark-gluon plasma behaves more like a liquid than a gas. After revealing this fact, it became possible to apply van der Waals curves to quark-gluon plasma.

Numerous experiments have shown that the state of the liquid near the critical point is extremely unstable. Physically, this means that at the critical point, the correlation length approaches infinity, fractality and self-similarity, the repetition of oneself appear.

We assume that if the collision of particles occurs near the critical point, self-similarity appears due to the approach of the correlation length to infinity. Any object is called self-similar if this object exactly or approximately coincides with a part of itself. Self-similarity is a characteristic property of a fractal. A fractal is a self-similarity set. It is known that the most suitable figure of a self-similar object is a logarithmic spiral.

We have proposed a method for the revealing the spiral structure. We believe that spiral structures can be revealed by plotting the dependence of the logarithm of the radius vector on the azimuthal angle. It is known that the equation of the logarithmic spiral in polar coordinates has the form:

$$r(\phi) = r_0 e^{k\phi}$$

where, ϕ - is the polar angle of the points on the spiral, r - is the radius vector of these points, r_0 - is the coefficient by which the radius of the turns is determined, k - is the coefficient by which the distance between the turns is determined.

If we take the logarithm of the spiral equation we get:

$$\ln(r(\phi)) = \ln(r_0) + k \times \phi$$

After this transformation, the equation of the logarithmic spiral is transformed to the equation of a straight line, which can be easily identified from the experiment.

The logarithmic spiral has some interesting features. Of the various properties of the logarithmic spiral, the following features are more important for our problem:

- with an increase in the size of the turns of the logarithmic spiral, its shape remains unchanged;
- after various transformations, the logarithmic spiral has the ability to restore its shape;
- the tangent at any point to the logarithmic spiral forms the same angle with the radius vector;
- polar angles that correspond to different points of the logarithmic spiral are proportional to the logarithms of the radius vectors of these points.

Namely these features of the logarithmic spiral make it a suitable self-similar figure.

So we conclude:

- in the first microseconds of the BB during the transition from quark-gluon plasma to hadron (proton and neutron) matter, due to the approximation of the correlation length at infinity, near the critical point, a spiral structure develops [36, p.75-80];
- this spiral structure can be the “embryo” of spiral structures of galaxies [37, p.15-17];
- a spiral structure, which, formed near the critical point, can be used as one of the signs of second-order phase transitions, i.e. the spiral structure can be used as an indicator in predicting (or identifying) second-order phase transitions [36, p.77-80].

Despite the fact that most of the galaxies in the universe are spiral galaxies, we also meet with elliptical and irregular galaxies. To clarify the possible evolutionary relationships between these types of galaxies, it is necessary to compare the distinctive properties of these galaxies. We believe that angular momentum plays a decisive role in the division of galaxies into different morphological types. As noted above, near the critical point, due to the fact that the correlation length approaches infinity, fractality appears and a spiral structure develops. In this case, infinitely many spiral structures are formed. Different spirals will differ from each other in the value of angular momentum, and these spiral structures can be divided into three groups:

- spiral structures with the highest values of angular momentum;
- spiral structures with average angular momentum values;
- spiral structures with the lowest angular momentum values.

We assume that spiral galaxies are formed from the spiral structures with the highest angular momentum values. Elliptical and irregular galaxies are formed from spiral structures with average and lowest angular momenta, respectively. Therefore, we believe that the “embryos” not only of spiral galaxies, but also of all galaxies are formed during the first microseconds of the BB. This leads to another assumption that the galaxies were formed first, and then its main components - the stars.

In 2012, the oldest galaxy, Q2343-BX442, was identified, with well-formed spiral arms. For the galaxy Q2343-BX442, the redshift is z = 2.1765, which corresponds to a distance of approximately 10.7 billion light years. Consequently, this galaxy was formed ~ 3 billion years after BB. Astronomers believe that “the fact that such a galaxy exists is surprising, because modern common sense says that such spiral galaxies simply should not exist in such early eras of the history of the universe”.

However, according to our assumptions, the presence of such a galaxy in the early epochs of evolution is quite reasonable, since the “embryos” of spral structures were formed during the first microseconds of BB. This observational fact is also in favor of our assumption that galaxies were formed first, and then its main components - stars.

MAIN REZULTS

The main results of the dissertation are as follows:

1. An unusual photometric variability of the WR of the star HD191765 has been revealed. From photometric observations, it was found that the magnitude of the star HD 191765 varied from $8^m.0$ to $8^m.1$ within ~ 10 minutes, i.e. magnitude increased by $0^m.1$ within ~ 10 minutes! [19, pp. 33-35].
2. It was revealed that WR stars with the probable compact components (HD 191765, HD 192163, HD 50896, and HD 197406) are evolutionary precursors of X-ray binaries with “normal” low-mass K-M components. As a result of spectral and photometric studies of the stars HD 192163 and HD 191765, and from an analysis of the literature data for the stars HD 50896 and HD 197406, we concluded that these stars are WR + (K-M) binaries. According to the theory of evolution of MCBS, WR + (K-M) binaries are precursors of X-ray binaries, with “normal” low-mass K-M components [18, p. 380-392], [50, p. 109-110].
3. The contribution of the Ring Nebula NGC 6888 surrounding the star HD 192163 to the formation of the lines NaI 5890 and NaI 5896 was revealed. The asymmetry of these profiles is an argument in favor of the contribution of other sources to the formation of these lines. Based on the high-resolution spectra, we found the asymmetry of the lines NaI 5890 and NaI 5896 in the spectrum of the star HD 192163. We believe that the formation of these lines is due to the Ring Nebula NGC 6888, which surrounds the star HD 192163 [23, p. 14-16], [45, p. 75-76].
4. The revealed difference in the spectral classification of WR stars, HD 191765 and HD 192163. By using the logarithm of the line intensity ratio, the dependence of log (CIV5808/HeI5875) on log (HeII5411/HeI5875) was plotted. Despite the fact that both stars in this dependence fall into the region corresponding to the WN6 subtype, there are also differences between them. HD 192163 more closely matches the WN6 subtype, while HD 191765 is located on the border between WN5 and WN6. The difference

between these stars may be due to the fact that the initial masses of these stars were different [43, p.142-143], [48, p.308-309].

5. A stable weak emission in the violet wing of the H_α line, the appearance and movement of Discrete Absorption Components (DAC) in the core of line H_α in the spectrum of HD 206267 was revealed. The DAC appeared in the red part of the nucleus of line H_α line and within about 1.5 h moved to the violet part [43, p.142-143], [48, p.308-309].
6. The interval of variation of the radial velocities of the main component of the star HD 206267 was determined for the different lines. It was found that the radial velocity of the main component varies from approximately +80 km/s to -110 km/s for the H_α and H_β lines, from +60 km/s to -100 km/s for the line HeII 5411 [32, p. 50-56].
7. The asymmetry of the H_α and H_β lines in the spectrum of the star HD 206267 was revealed. For the lines H_α and H_β, the opposite asymmetry was found, i.e. when the line H_α is asymmetric in the violet wing, the line H_β line is asymmetric in the red wing, and vice versa [29, p. 13-15], [55, p. 79-80].
8. The value of the orbital period of the star β Lyr corresponding to the observational season (July-August 2016) was determined as 12.9414 days. It is known that due to the intense loss of mass of the main component of the star β Lyr, the value of the orbital period of this system increases by 19 second in year. Consequently, when studying this star, it is necessary to determine the value of the period corresponding to the observational season [39, p.18-23].
9. An additional observational argument has been revealed that shows the presence of two hot spots in phases 0.4 and 0.8 of the orbital period on the disk, the surrounding secondary component of the star β Lyr. We found two maxima in the dependence of the ratio of the intensities of the violet and red components of the H_α and HeI 6678 lines on the phase of the orbital period, at phases of about 0.4 and 0.8. [39, c.18-23], [40, c.145-147].

10. It is assumed that the “embryos” of the spiral structure of galaxies can be formed during the first microseconds of the BB. If the collision of particles occurs near the critical point, then due to the correlation length approaches infinity, the so-called self-similarity appears. It is known that the most successful self-similar figure is the logarithmic spiral. Consequently, in the first microseconds of the BB, during the transition from quark-gluon plasma to hadronic matter, a spiral structure develops near the critical point and this spiral structure is the “embroys” of spiral structures of galaxies [30, p. 2-4], [36, p. 75-78].
11. The spiral structure, which forms near the critical point, can be used as one of the signs of second-order phase transitions, i.e. the spiral structure can be used as an indicator in predicting second-order phase transitions [30, p. 2-4], [36, p. 75-78].

The main results of the dissertation are published in the following works:

1. Рустамов Д.Н., Черепащук А.М. Спектральные и фотометрические исследования звезд типа Вольфа-Райе HD16523 и WR145=AS422 // Астрономический журнал, – Москва: – 1989, Т. 66, – с. 67-75.
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Personal contribution of the author in joint works.

[3, 4, 5, 7, 8, 12, 14, 15, 16, 17, 22, 24, 25, 28, 33, 34, 35, 38, 40, 41, 42, 43, 44, 45, 58] – without coauthors,
[6, 9, 10, 11, 13, 19, 20, 23, 26, 27, 29, 31, 32, 39, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57] – obtaining and processing of observational material, interpretation, joint prepearing for printing,
[1, 2, 18, 21] - obtaining and processing of observational material, joint interpretation, prepearing for printing,
[30, 36, 37] – statement of the problem, author of the idea, analysis of literature data, joint interpretation, prepearing for printing.

The defense will be held on at "10" December 2021

"11^00" at the meeting of the Dissertation council BED 3.05 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at the Shamakhy Astrophysical Observatory named after N.Tusi of Azerbaijan National Academy of Sciences.

Adress: Baku, AZ1143, avenue G.Javid 117

Dissertation is accessible at the Shamakhy Astrophysical Observatory named after N.Tusi of ANAS library

Electronic versions of dissertation and its abstract are available on the official website of the Shamakhy Astrophysical Observatory named after N.Tusi of ANAS

Abstract was sent to the required addresses on

"05" November 2021

Signed for print: 01.11.2021

Paper format: A5

Volume: 80 049

Number of hard copies: 20