ABSTRACT

dissertations for the degree of "Doctor of Philosophy" (PhD) in the specialty "6D061100 - Physics and Astronomy"

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STRUCTURE OF ACCRETION FLOW IN NOVA – LIKE CATACLYSMIC VARIABLES

The present work is devoted to the study of accretion structures in nova-like cataclysmic variables.

Relevance of the research topic

The achievements of modern civilization are directly related to the development of fundamental sciences. The role of astrophysics in the spectrum of fundamental sciences about the Universe is certainly decisive. Astrophysics gives us not only knowledge about the processes and phenomena occurring in outer space under conditions unattainable in terrestrial laboratories, but also contributes to technological progress in areas related to practical human activities, such as time management, navigation and communications, detection and processing methods signals, computer simulation of the behavior of complex systems.

Stellar astrophysics, associated with the determination of the fundamental parameters of stars and their systems, provides basic ideas about the Universe. The most important role in stellar astrophysics is played by the study of binary stellar systems. More than 70% of stars are part of binary or multiple systems. Binary systems are the main source of information about the fundamental parameters of stars. The most important such parameter, which completely characterizes the evolution of a star, is its mass. Binary systems provide the ability to measure the masses of their components with high accuracy. Observations of binary systems by various astrophysical methods also make it possible to estimate various physical parameters of their components.

Eclipsing systems provide a unique opportunity to study binary systems. The combination of photometric and spectral observations of eclipsing binaries makes it possible to obtain a complete set of their physical characteristics of the components. Observing eclipses also imposes strong restrictions on the orientation of the orbit and the distance between the components. Most eclipsing binaries belong to pairs in which the evolution of one of the components influences the evolution of the other. The components of such pairs are stars with a wide variety of physical properties, the interaction between which leads to the appearance of evolutionary stages that are impossible in the case of isolated stars.

The study of the evolution and physical parameters of close binary systems is necessary to test the theory of the formation and evolution of stars, makes it possible to determine the structure of stellar atmospheres, the physics of accretion processes, and to explain the variety of observed types of binary stars. Studies of a large number of binary systems, the components of which are at different stages of evolution,

make it possible to build statistical dependencies that relate the evolutionary state of the system and the physical characteristics of the components. Particular attention in the study of close binary systems is focused on the analysis of such systems with accretion structures.

In accretion disks, depending on the rate of accretion in the system, a wide variety of phenomena are observed from the formation of spiral density waves, wind, up to relativistic jets. The nature of many of them has not yet found its explanation. Therefore, close binary systems with accretion disks are unique sources of information for determining the nature of physical processes occurring in their accretion structures. At the same time, the most suitable (i.e. miniature laboratory) objects for studying the general characteristics of accretion disks are cataclysmic variables (CV) - close semi-separated binary systems in which a Main Sequence star of a late spectral type fills its Roche lobe and accretes matter onto a more massive white dwarf.

Computer modeling occupies an important place in modern research. In particular, one of the tools to get answers to questions related to the physics of processes in cataclysmic variables is the use of modern programs for modeling their light curves. In addition, the use of the Doppler tomography technique allows one to obtain a detailed analysis of their accretion structures. The latter is a practical tool in the study of binary star systems with accretion, which makes it possible to interpret observational data, study the physics of plasma and the nature of viscosity in disks, the emergence and dissipation of spirals and density waves, the precession of accretion disks, the sources of variability in the flow on different time scales, the nature of the wind from disks and the origin and composition of circumstellar matter.

Aim of this work is to study the nova-like cataclysmic variable star RW Tri and study the structure of accretion flows in similar binary systems.

Research objectives:

1. Analysis of the new data obtained from photometric and spectral observations of the nova-like cataclysmic variable star RW Tri.

2. Determination of fundamental parameters (masses, radius, effective temperatures, mass transfer rate, accretion flow structure, etc.) of the object under study.

3. Determination of radiation sources forming the profile of the Hα Balmer emission line.

4. Comparative analysis of the detected features in the characteristics of the RW Tri system with other previously studied in detail new-like cataclysmic variables with close orbital periods.

Object of study: Accretion flows in nova-like cataclysmic variable stars.

Research methods:

1. Time-resolved photometric and spectral observations of the nova-like cataclysmic variable star RW Tri in order to obtain light curves.

2. Reduction and analysis of the obtained observational data based on the IRAF astrophysical data processing package.

3. Computer simulation by the CVlab program of the obtained light curves of the RW Tri system.

4. Doppler tomography for analyzing the structure of accretion flows in the object under study.

Basic provisions for defense

1. The nova-like cataclysmic variable RW Tri has a multicomponent structure of the Hα Balmer emission line, which consists of a narrow (173 km/s) and a wide (1042 km/s) component.

2. The wide component of the Hα emission line in the RW Tri system is formed in the outflow zone of the accretion disk, located opposite to the hot spot formed by the collision of the flow of matter from the secondary star.

3. The nova-like cataclysmic variables (1RXS J064434+334451, RW Sextantis, RW Tri, BG Tri) with orbital periods of more than 3 hours have a multicomponent structure of the Hα Balmer emission line, the wide component of which is formed in the zone of accretion disk outflow.

The scientific novelty of the work lies in the fact that for the first time:

1. Time-resolved spectral data with high spectral resolution ($R \sim \lambda/\Delta\lambda \sim 18000$) have been obtained and analyzed for the nova-like cataclysmic variable star RW Tri. Based on this, was found a multicomponent structure of the Hα emission line profile.

2. The nature of the radiation sources in the accretion flow that form the observed Hα line profile is determined. The fundamental parameters of the studied object were determined based on the analysis of photometric data and the use of the latest results on the distance to the RW Tri system from the GAIA database.

5. It is concluded that similar structures are formed in accretion disks in nova-like cataclysmic variables with orbital periods close to the period of the RW Tri object.

Theoretical and practical significance of the work

The results obtained in the dissertation work make a certain significant contribution to understanding the physical processes in close binary systems, the features of the formation, structure and physics of accretion disks and can be used to interpret the observed phenomena in similar objects.

Author's personal contribution

The author of the dissertation was mainly involved in the processing of observational data, independently obtained the main results based on the analysis of data from the RW Tri object. The setting of tasks and discussion of the results were carried out jointly with scientific consultants.

Reliability of results

The reliability of scientific results is confirmed by the consistency of the developed theoretical models with the results of the analysis of photometric and spectral data. The results obtained are consistent with the conclusions about the nature of similar objects obtained by other authors. To date, the results of the work published by the applicant have been cited in 6 independent peer-reviewed publications.

Approbation of work

The results obtained in the dissertation work were reported and discussed:

– at the International Scientific Conference of Students and Young Scientists "Farabi Alemi" (2021 Almaty, Kazakhstan);

– at the International Scientific Conference EXPLORING THE ENERGETIC UNIVERSE 2022 (31.08 - 02.09.2022 Nur-Sultan, Kazakhstan);

– at a meeting of the Scientific and Technical Council (STC) of the V.G. Fesenkov Astrophysical Institute;

– at the Kazakh-Uzbek seminar on the topic: “Structures of the accretion flow of the new-like cataclysmic variable RW Tri”.

Based on the results obtained, 5 publications were published.

Articles with a high impact factor in the Thomson Reuters database or in publications included in the international scientific database Scopus:

1 Subebekova, G., Zharikov, S., Tovmassian, G., Neustroev, V., Wolf, M., Hernandez, M. S., H. Kucáková, Khokhlov, S. (2020). Structure of accretion flows in the nova-like cataclysmic variable RW Tri. *Monthly Notices of the Royal Astronomical Society*, *497*(2), 1475-1487.

Articles in publications recommended by COXON Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan:

1. Amantaeva A. E., Subebekova G. R., Khokhlov S. A., Agishev A. T. Determination of the fundamental parameters of the cataclysmic variable star of the intermediate period v1239 Hercules: // Izvestiya NAS RK. Series of physics and information technologies. – 2022. – no. 1. - S. 124-130.

Publications in collections of abstracts:

1. Subebekova G.R. The method of Doppler tomography for the study of the cataclysmic variable RWTri// Proceedings of the international conference of students and young scientists "Farabi Alemi". - Almaty, 2019. - S.

2. Subebekova G.R., Ermekbaev B.S., Alen A.Zh. Determination of the main parameters of the cataclysmic variable RW Tri // Proceedings of the international conference of students and young scientists "Farabi Alemi". - Almaty, 2020. - S.

3. Subebekova G.R. RW TRI zharylgysh aynymaly zhuldyzyn zertteu // Proceedings of the international conference of students and young scientists "Farabi alemi". - Almaty, 2021. - S.

The connection of the dissertation topic with the plans of scientific work

The dissertation work was carried out in accordance with the plans of fundamental research works of the Committee of Science of the Ministry of Education and Science of the Republic of Kazakhstan "Grant funding of scientific research" on the topic: "AP08856419 - Observational manifestations of accretion flows in close binary star systems and their analysis by computer simulation methods."

The structure and scope of the dissertation

The dissertation consists of an introduction, 5 sections, a conclusion and a list of references. The work is presented on 93 typewritten pages, illustrated with 42 figures, 10 formulas, 5 tables, the list of references contains 107 titles.