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AN APPRAISAL OF USING SOME ABLE OBSERVATIONAL METHODS FOR STUDYING BINARY STAR SYSTEMS WITH ACCRETION DISC.

Daniela Boneva

Space Research Institute-BAS, Sofia, Bulgaria
e-mail: danvasan@space.bas.bg

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Abstract

It is clear from observations that the most stars live with companion one and more of them are known as binary pulsars, Low-mass X-ray binary, cataclysmic variables, symbiotic stars and others. One of the phenomena, running in binaries, is accretion mass flow or accretion disc. In this paper we pay attention and give appreciation to the methods of distinctive observational techniques, which may help us to understand the essence of accretion flow structure and to prove the presence of formations locally in the disc. Then we may compare this evidence with our theoretical statements. Here we point our view on results of UV observatory or spectroscopy devices, X-ray telescopes, Doppler tomography and data of satellites.

I. Introduction

In our theoretical investigations we analyse the instability state in accretion discs around the binary star systems. We examine the situations and the reasons which caused the instabilities and where in the disc's structure the turbulence, vorticity formations and spiral structures are arise. It is known their important role for the angular momentum transportation and existing of accretion discs. Until now, all our suggestions are based on the theoretical results, applying hydrodynamical and other non-linear theoretical methods. Because of this, in the paper below we present the different observational techniques and methods, which display what happens in binaries and prove some of the analytical predictions.

The more fully used observational techniques are based on the photometry and spectroscopy methods. Also, in recent times the Doppler tomography techniques grows up and helps to analyse the sets of velocity-resolved line profiles covering a variety of phases around the binary orbit. Thanks to Doppler tomography it is became possible to identify the presence of spiral structures in the accretion discs.

With the techniques and methods listed above the concrete type of binaries are observed and investigated. On the base of these results we may conclude for the behavior of binary star systems, their kind of spectrum, using spectroscopy techniques and methods. Also, to find the spots and formations, simulating light curves of the chosen binary star with accretion disc.

The paper is organized as follows: In section II we present the what give us the shape of light curves in eclipsing binaries with accretion disc. In section III, it is reviewed the spectroscopy, photometry and UV methods for studying the accretion binary stars. We conclude the paper in section IV.

II. The influence over the light curve shape due to arised non-stable phenomena in accretion disc.

The important examination of disc properties is carried out due to the view of light curves obtained from LMXBs. Observations of Low-mass X-ray Binaries detect dips in their X-ray light curves (Bisikalo et all. 2005). These dips are usually explained with the presence of a thickening at the outer edge of the accretion disk, caused by interaction place of falling matter over the disc.

During the interaction between the stream and the circumdisk halo, a part of the matter takes on a vertical acceleration. The vertical motion of the gas due to the z component of the velocity, together with its motion along the tangential discontinuity at the outer edge of the disk, results in a gradual growth of the thickness of the circumdisc halo. The region of vertical acceleration is restricted to the hot-line zone, and its angular size does not exceed ~ 65°

In gas-dynamical model of Armitage and Livio (1996), after colliding with the disk edge, some of the matter in the stream rises to a considerable height (compared to the disk thickness), forming a stream towards the inner parts of the disk. The computations in that work demonstrated that this stream of matter could explain the presence of the dips observed in LMXB light curves.

The disc thickness is well seen at the data analysis of Doppler tomography, where the bright spot point the place of this interaction (see figure 1). The Doppler tomography can be very useful for tracing the structure of the disk surface when it is seen at a sufficiently large inclination. This method is based on the fact that the radial velocity of its individual components with respect to the observer affects the line spectrum of the source.

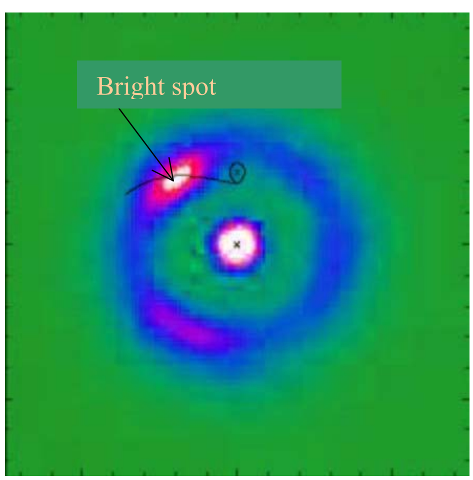

Figure 1. HeI 5015 °A Doppler tomogram of the hydrogen deficient binary CE-315. The cross near the system's center of mass denotes the location of the accreting white dwarf, a uncharacteristically strong emission-line source.

The presence of matter surrounding the X-ray source at a considerable height above the system's orbital plane, along with the matter's uneven distribution in azimuth, can be explained in terms of either the companion's gravitational action on the accretion disc or the interaction between the stream of matter from the inner Lagrangian point (L_1) and the disc. The coincidence of the phase of the observed dips with the assumed position where the stream from L_1 approaches the outer edge of the disk has tended to focus study on this particular region.

It is easiest to identify dips due to the presence of matter located high above the disk in LMXBs, since they contain a very compact source at the center of the disk. However, similar light-curve features in various wavelength ranges have also been recorded for a number of cataclysmic binaries in outburst, such as U Gem, OY Car and Z Cha. Further observations show that light curve dips can also appear when a system is in a stationary or non-stationary state. Studies of the ultraviolet light curves of the eclipsing nova-like cataclysmic binaries UX UMa and RW Tri confirmed this result, and suggested that this phenomenon was universal in semi-detached binaries with accretion disks. As an example, Fig. 2, we create the light curve for U Gem, using the program and data from (Kreiner, 2004).

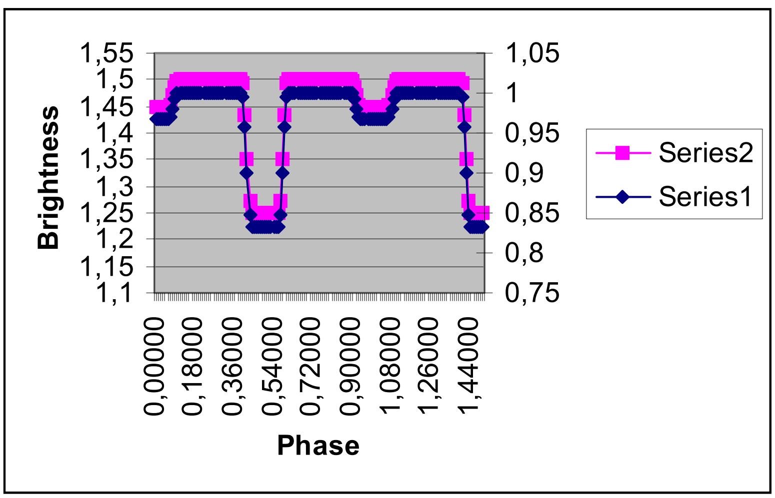

Figure2. Light curve of U Gem. The two series denote the different ratio for the receiving of brightness value.

III.. Methods, proving the existence of binary (photometry, spectroscopy and UV techniques).

The first method, which we present is the spectroscopy method, performed at the ESO's VLT (Werner et all. 2006). It is used the FORSI spectrograph attached to the telescope. The obtained spectra are in regions: 3600-6000 A and 5400 – 7500 A. The observation and examine objects are Ne-rich Ultra compact binaries (UCBs) with P_{orb}<80min. The two ones are the objects 4U1626-67 and 4U0614+91, which are the X-ray binaries with magnitude 18.5.

The spectrum of 4U0614+91 shows numerous emission features that can be assigned to ionized carbon and oxygen named C_{II-IV} and O_{II-III}. The difference in the spectra of both binaries will refer to a different C/O ratio.

After the visualization of the spectrums, it is used them to construct the accretion discs model for these binaries. If disc is divided into concentric annuli and for each annuli is received the radiation transfer equation, energy equation and for the vertical structure, then combining the data for each annuli and integrated specific intensities, it may obtain the integrated disc's spectra, so call synthetic spectra.

In the result of this experiment the studied systems are strong X-ray sources and it is not seen recombination lines from highly ionised species in the optical spectra as might be expected. It is conceivable that the outer parts of the disks in which the optical spectrum arises is shielded from X-ray irradiation by an inflated inner-disk region.

In the case of cataclysmic variables (CVs) the disc is geometrically thin and viscous. There a mass trough the disc is accreted from late type companion star onto a white dwarf. The convenient time scale in CVs /it is rapid brightness variation with viscose time scale within a few days/ allows us to study the changing properties of viscose accretion disc in real time.

Based on the energy and power spectra, (Capitanio et all. 2006), suggested for the object IGR J1709 3624 is an X- ray binary in the low/hard state and probably a black hole system. They use the spectrum data from INTEGRAL and RXTE.

Although Markoff et al. (2005) have recently suggested that the hard state emission could be due to synchrotron self-Compton emission from the base of the jet. They have considered the standard hard-state model with the dominant radiative process being thermal Comptonization of disk blackbody photons. A special feature of hard-state spectra is the rather low electron temperature ~ 20 keV. Such a low temperature may be a characteristic of the hard state of neutron-star low-mass X-ray binaries, although at present it is rather poorly constrained.

Furthermore, the relative normalization of the observed hard and soft state spectra is different. Curiously, the high-energy parts (>~30 keV) of both spectra of IGR J17464–3213, are virtually identical. The various amplitudes of the hard and soft state spectra are often seen in X-ray transients, and are due to the hysteretic behaviour of the accreting systems.

In the paper of (Nagel et all. 2006) the authors use the time-series photometry of SDSS J212531.92010745.9. Its archival spectrum shows the typical signature of PG 1159 star and also indicates the presence of companion. These type of stars are known as a pre-white dwarf stars and hot hydrogen deficiency. The spectrum of the object shows features that indicate the companion presence. H_α and H_δ (from Balmer series) are clearly detected – it is because a cool companion is heated up by irradiation from hydrogen-deficient PG 1159 star.

The parameters of both stellar components are estimates obtained from a qualitative comparison of NLTE models to the single SDSS spectrum. Detailed parameters for both stars need to be derived from a full two-component analysis of orbital phase resolved spectroscopy.

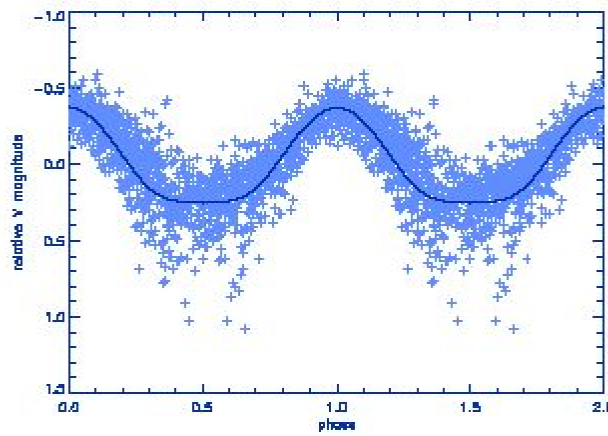

Figure 3. Simulated light curve of binary system, consisting PG1159 star (Teff=90000K) and M dwarf (Teff=3500K-8200K) – thick line. Observed light curve, of all nights– crosses. (Nagel 2006)

The ultraviolet (UV) is of outmost importance in the study of interacting binaries, as a large part of their luminosity is radiated away in this wavelength range, and, more importantly, as the UV hosts a multitude of low and high excitation lines of a large variety of chemical species (Gansicke et all. 2005). Moreover, the physical status of the binary components and in particular the accreting white dwarf primaries in cataclysmic variables, symbiotic stars, and double degenerate binaries can be easily isolated and studied in the UV range. Even though substantial scientific progress has been achieved throughout the last three decades, primarily using the International Ultraviolet Explorer (IUE), the Hubble Space Telescope (HST), and the Far Ultra-violet Spectroscopic Explorer (FUSE), these are still the early days of UV astronomy of interacting binaries, and many key questions are yet without answer.

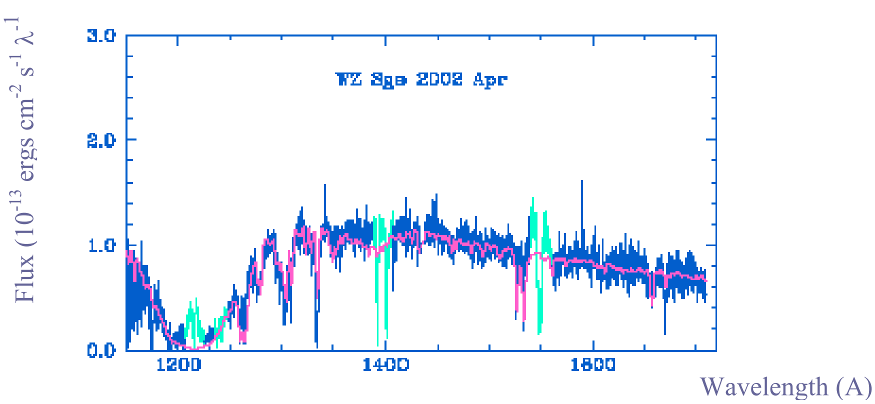

Figure 4. High-quality UV spectroscopy of accreting white dwarfs in CVs is necessary to determine their temperature, mass, rotation rate, and atmospheric abundances from detailed model atmosphere fits (Gansicke et all. 2005).

One of the most studied accretion objects using UV techniques are white dwarfs with binary (as we may see in figure above), because some of the white dwarf characteristics will in turn deeply affect the accretion process - the amount of energy released per accreted gram of matter, the rotation rate of the white dwarf determines the luminosity of the boundary layer and others. The observational study of accreting white dwarfs can only be carried out in the UV, as the emission from the accretion flow dilutes or even completely outshines the white dwarf at optical wavelengths.

Summary

Despite their great importance for a vast range of astrophysical questions, our understanding of close binary stars and their evolution is still very fragmentary.

Here we made an overview of some of the used observational methods, which may help us for further examinations in accretion binary stars systems. The big radiative power of accretion discs gives the possibility of using the spectroscopy methods and techniques. We emphasized our view on the light curve behavior of the close binaries and what kind of information we may obtain from its shape. We receive the light curve of the binary star U Gem for the two series of brightness vs. orbital phase. It is seen the variations in intensity, caused probably of the eclipse phases or of the existence of some formations and mostly of spots.

We would to compare in future the analytical analyses with the results obtained, using various observational techniques. So, the results and suggestion will be more correctly and realistic.

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