LINE FORMATION IN SPECTRA OF X-RAY NOVAE

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ABSTRACT. Results of X-ray Novae (XN) optical spectra computation are presented. The continuum and Balmer line are calculated. The model of XN as a self-irradiated accretion disk is used. Local (for given radius) disk atmospheres as model stellar atmospheres, heated due to external X-ray radiation are treated. Changes of spectra shape and equivalent widths of the Balmer lines depending from the luminosity and some others accretion disk parameters are investigated. The comparison of GRO J0422+32 observed spectra with model spectra are curried out.

Key words: accretion: accretion disk - novae: cataclysmic variables, line formation, atmospheres of - stars, individual: GRO J0422+32, X-ray irradiation - stars

I.Introduction

The X-ray Novae (XN) are low-mass X-ray binary systems in which a compact object accretes material from low-mass secondary (Bradt and McClintoc, 1983; Karitskaya, 1996). Sometimes the accretion rate dramatic increases and this system can be seen as XN. X-ray Novae to generate a greater interest because among them there are the most reliable candidates in black holes: V616 Mon (McClintoc and Remillard, 1986), XN Muscae 1991 (Remillard et al, 1992), V404 Cyg (Casares et al, 1992) etc. The optical radiation of these systems is caused by the reprocessed emission from the X-ray irradiated disk. Emission spectra of such disks were computed in approach of photoionization model and photon escape probability method by Ko and Kallman (1994). In given work the optical spectra of such disks have been calculated with use of X-ray irradiated LTE model stellar atmospheres (Sakhibullin and Shimansky 1996).

II. Method of computation

As model XN on given luminosity level a geometrically thin optically thick steady state accretion α - disk (Shakura and Sunyaev 1973) has been considered. The method of computation of such disks and amount of falling X-ray flux on their surface due to self-irradiation has been described by Suleimanov (1996). The spectrum of a disk is summarized from spectra of its rings. The spectrum of each ring has been calculated by numerical solution of an radiation transfer equation as a spectrum of model stellar atmosphere with same T_{eff} and $log\ g$ on surface, and irradiated the same X-ray flux. A method of calculation of such model atmospheres and programs, offered by Sakhibullin and Shimansky (1996) have been used. X-ray flux has been set as power spectrum $F_\nu \sim \nu^{-s}$ in interval from 0.1 up to 200 kev. The effect of differential rotation of a disk to profile of spectral lines has been taken into account.

III. Results

With use of a described above method optical continuous spectra, profiles of 10 Balmer lines and their equivalent width for 45 models of accretion disks have been obtained. As base a sequence of models with parameters $M_{bh} = 5\ M_\odot$, $\alpha = 1$, $s = 1.5$, $R_{out} = min(10^{11}$ cm, R (T_{eff}=7000K)) and luminosities0.5, 0.1, 0.05, 0.01 and 0.005 Eddington luminosity was chosen. In other sequences of models one of parameters was changed, whereas other were constant. Sequences of models with $M_{bh} = 3$ and 10 $M_\odot$, $\alpha = 0.1$ and 0.01, s = 1 and 2, $R_{out} = min(6\ 10^{10}$ cm, R (T_{eff} = 7000K)) and $min(8\ 10^{10}$ cm, R (T_{eff} = 7000K)) were computed. The spectra of each model were calculated for four angles of an disk inclination to line of sight $\mu = cosi$ = 1, 0.8, 0.5 and 0.1.

It is shown, that than black hole mass and parameter α is less, and than it is more angle of an inclination of a disk to line of sight, it luminosity and radius, that it is more intensity of an emission component of Balmer lines. The most emission is shown by H_α, and with increasing of line number its emission components are decrease. Absorption components are well appreciable only from disks with small inclination. The model spectrum of XN GRO J0422+32 also was calculated and a comparison with observed spectrum in 1992 November by Callanan et al (1995) was curried out (Fig.1). Parameters of this system were taken from Karitskaya (1996). Width of absorption components ($\sim$ 100 Å) and separation of double-peaked emission com-

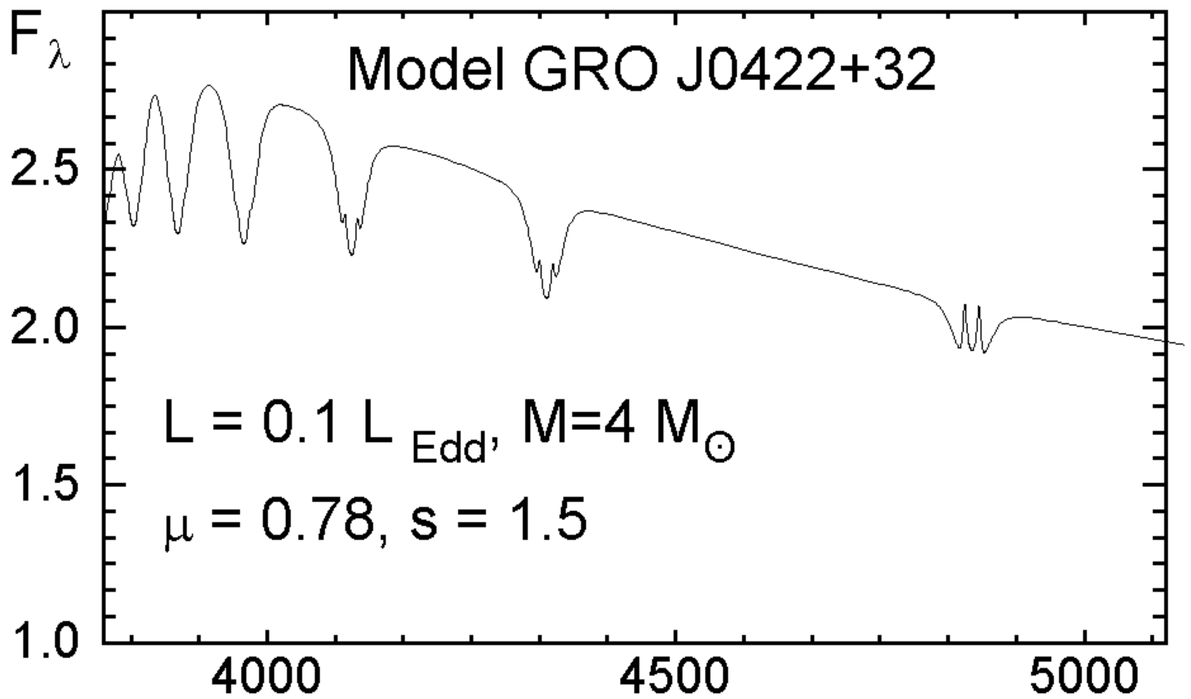

Figure 1. The model spectrum of GRO J0422+32.

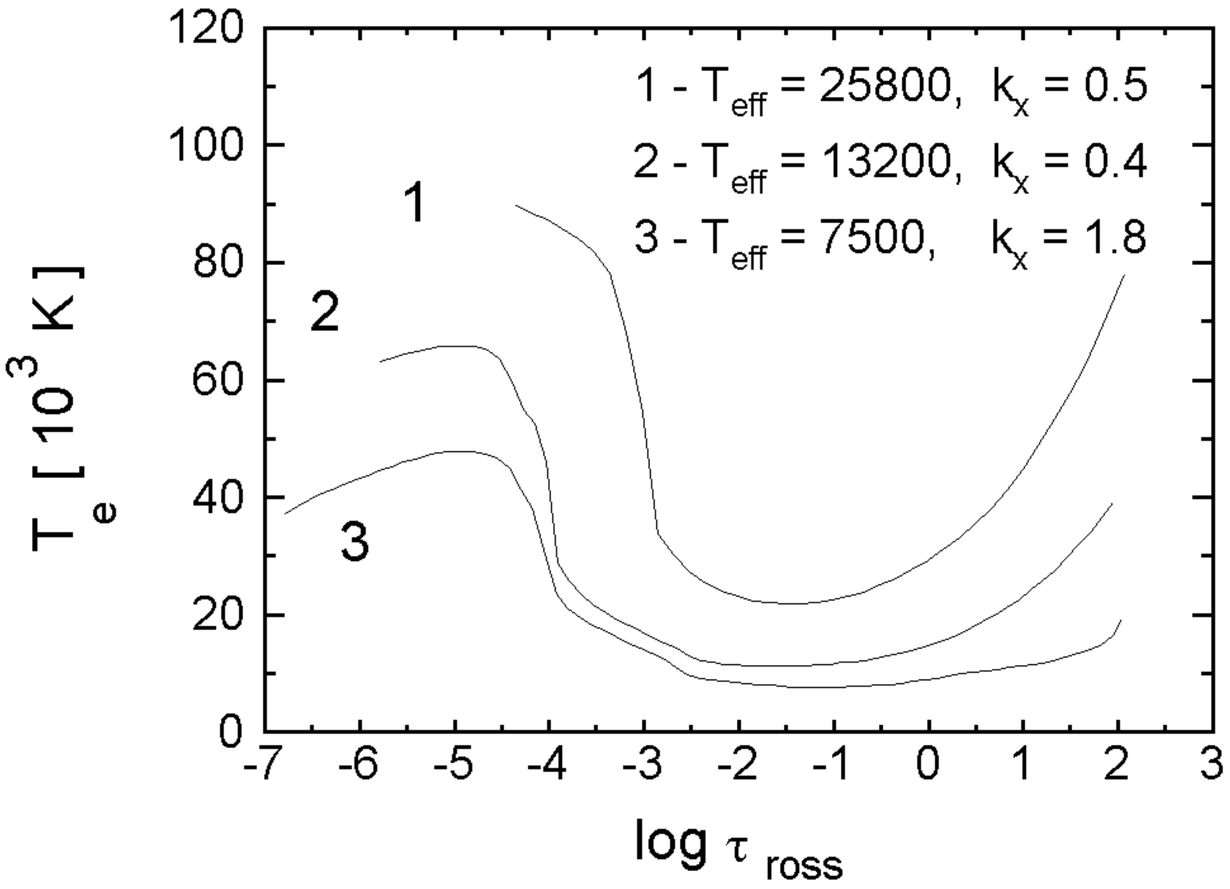

Figure 2. The temperature vs Rosseland optical depth for model atmospheres of three rings of the model of GRO J0422+32 accretion disk.

ponents (~ 1000 km/c) of Balmer lines are close to observed ones, but the observed continuum slope is more flat than the theoretical one, may be due to influence of a hot corona. On Fig.2 the temperature structure of three ring model atmospheres are shown.

IV. Conclusion

The obtained model spectra are similar to observed spectra of GRO J0422+32. Because of the modeling of XN spectra has much potential for yielding information about these systems.

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