Viscous evolution of an accretion disk in a binary system *

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Abstract. A new analytical solution describing a time-dependent disk in a binary system at outburst, which has a fixed tidally-truncated outer radius, is applied to 1975 X-ray nova burst of A0620-00. The X-ray flux of a multicolor (black-body) α-disk decays quasi-exponentially with time. Modeling the X-ray and the optical light curves of A0620-00, we can estimate α and obtain 'distance–mass of compact object' relation.

Keywords: accretion disk, close binaries, X-ray novae, A0620-00 (=V616 Mon)

We consider the basic viscous diffusion equation (e.g., Lipunova and Shakura, 2000) as applied to accretion disks. This equation shows that the time behaviour of a disk depends on the relation between kinematic coefficient of turbulent viscosity ν, column density of a disk Σ, and radius r.

If ν is a function of radius alone, the basic differential equation of diffusion type is linear. This case was considered by Weizsäcker (1948), Lüst (1952), Lynden-Bell and Pringle (1974).

The general case, when ν is a power–law function of Σ and r, was considered by Filipov (1984; 1988), Lyubarskii and Shakura (1987).

We adopt the $\nu \propto \Sigma^l\, r^m$ relation and pioneer in considering a confined accretion disk. We assume specific outer boundary conditions for a disk in a binary system (Lipunova and Shakura, 2000) and obtain a new solution. The standard α-model of the viscosity is assumed.

The bolometric luminosity is found to vary with time as a power low with an index of $-5/2$, if Thomson scattering dominates the opacity, and $-10/3$, if free-free and free-bound transitions do.

Assuming the spectrum to be a multi-color black body one, the X-ray luminosity is obtained to vary as $\exp{(-t^{5/6})}$. This is quite close to the exponential behaviour.

To illustrate how the parameters of the disk can be obtained, we model the 1975 burst of A0620-00 (Fig. 1). We used the X-ray data in the 3–6 keV band of *Ariel-5* (Kaluzienski et al. 1977) and the data in B and V optical bands (Kuulkers 1998, and references therein).

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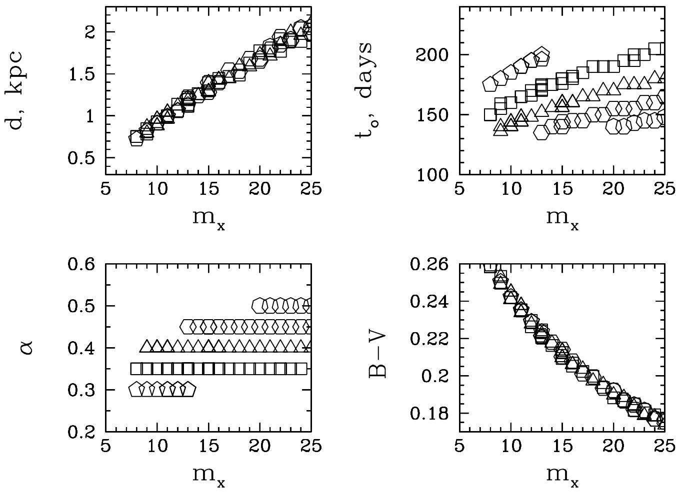

Figure 1. A multitude of models is restricted to the following values of parameters: $m_x = M_{\rm BH}/M_\odot = 5 \div 25$, B−V (27th day after peak) = $0.17 \div 0.26$. We checked the values of α: 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6. d is the distance to the source. The right upper panel displays the corresponding values of t_o (see Lipunova and Shakura, 2000) if we set t to be the time after the peak of the outburst, MJD 42638.4 = 13/08/1975.

We see that the model is consistent with the idea of a black hole in this binary and with the distance estimates available in literature (Barret et al., 1996; Chen et al., 1997). We choose the models with E(B−V)=0.39 (Wu et al., 1976). From Kuulkers (1998) we have B−V (27 d)= 0.24 ($\pm$10%), then BH mass lies in the range 9–14 $M_\odot$.

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