ON THE EXPECTED OBSERVATIONAL BEHAVIOUR OF THE ACCRETION FLOW IN A CLOSE BINARY

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Here is presented one idea about the origin of the quick non-periodic or quasi-periodic oscillation of the X-ray luminosity in close binary systems. It is shown that a change in the inflow gas stream can produce those variations in the inner part of the flow.

As it is well known, nearly all X-ray binaries involving mass exchange between the two components display quick quasi-periodic or non-periodic oscillations with different amplitudes and time scales [1-3]. We are talking about variations with small amplitudes that cannot be identified as individual events, such as bursts, eclipses, etc.

So far, most of authors believe that these variations are produced as a result of some instabilities at the inner boundary of the accretion flow [1, 3-5].

Our studies on the behaviour of a gas flow with variable inflow parameters [6] revealed that such variations of the inflow parameters travel along the spiral shock fronts and, as a result, variations in the X-ray luminosity at the inner boundary of the flow are produced.

Based on the two-dimensional model described in [7], involving the full energy-exchange equation [8], a series of calculations are made, attempting to describe the influence of such exchanges in inflow gas debit through the inner Lagrangean point over the X-ray luminosity.

The calculations are made for a close binary, containing a compact object with mass Ì$_1$ = 1.5 M_o, a star that is filling its Rosh lobe with mass equal to Ì$_2$ = 4 M_o, a distance between the components $R_{12} = 10^{11}$ cm and an accretion rate equal to 10^{-9} M_o per year.

As a base, the steady state reached by the flow after some orbital periods was used. Calculations are made, where for about five seconds, the accretion rates increase respectively 2, 4, 6, 8, and 10 times. In Figs.1-3, the behaviour of X-ray luminosity is shown during the first 30 seconds, after these increases in the last three cases.

As it is seen in the figures, the increase in the inflow accretion rate produced quasi-periodic oscillations accompanying the increase of X-ray luminosity.

The described model, however, is very far from the possibility to be base for modelling of the luminosity that we can observe. It rather aims to study the structure of the accretion flow and its stability.

The model is only a first step in trying to determine the influence of the different physical parameters in the flow on the produced luminosity. It attempts to emphasize the most important details in a future three-dimensional model which will calculate radiation production and its interaction with the gas flow.

The X-ray luminosity L_x calculated here is integral both by frequency and by space distribution. Moreover, in these calculations we assume that the whole gravitational energy of the gas fallen onto the surface of the compact object is converted to X-ray luminosity.

To be able to calculate the observation behaviour of the object we must know the frequency and the space distribution of this luminosity, and to give an account of the interaction between this luminosity and the gas flow.

Nevertheless, we can provide quality estimation.

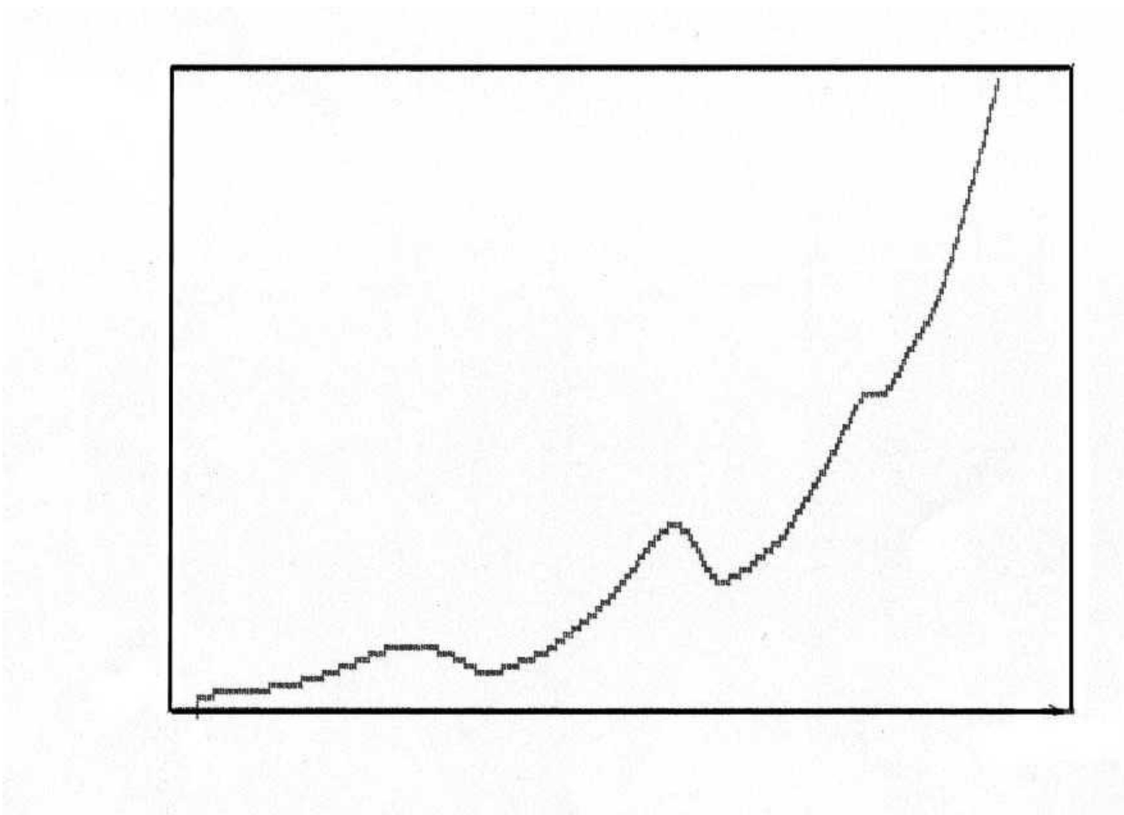

Fig. 1 The behaviour of X-Ray luminocity on the compact object surface during thr first 30s after a 6 time increase of the inflow accretion rate

First, the calculated variations in X-ray luminosity shown in Figs. 1-3 provide an idea of the possible origin of the same kinds of quick variations observed in most of the X-ray binaries, as a product of the exchange in the inflow gas stream parameters. These curves are calculated as a product of a one-time increase in the accretion rate at the first Lagrangean point. The same behaviour was observed after the changes of the inflow gas direction [6].

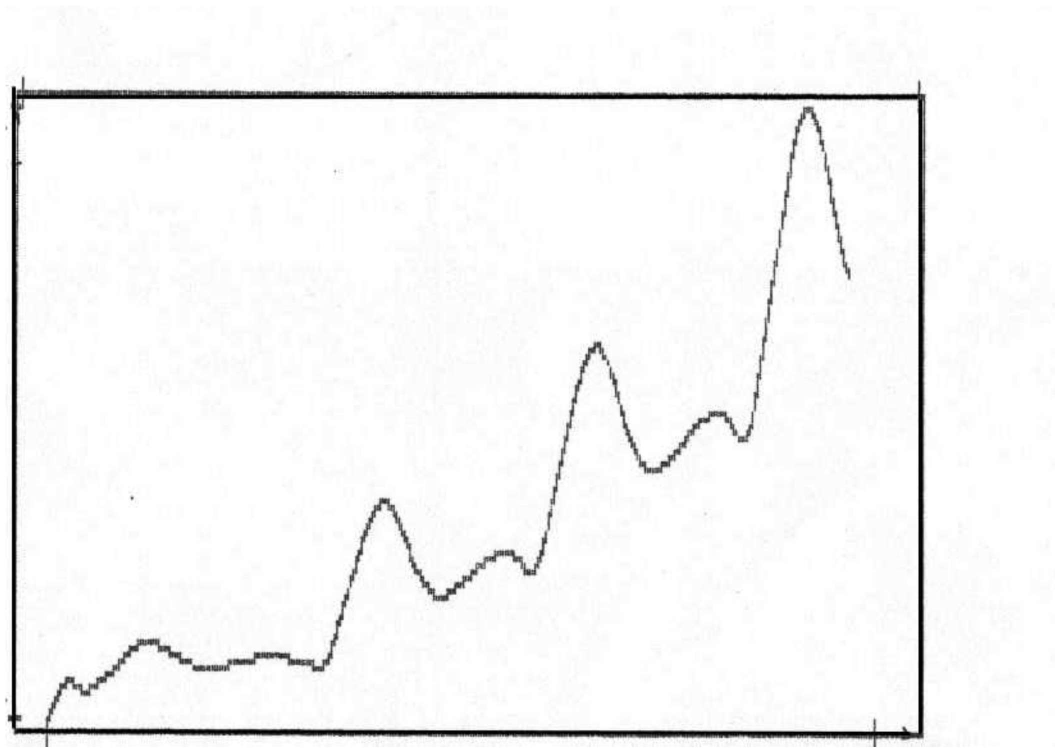

Fig.2 The behaviour of X-Ray luminocity on the compact object surface during thr first 30s after a 8 time increase of the inflow accretion rate

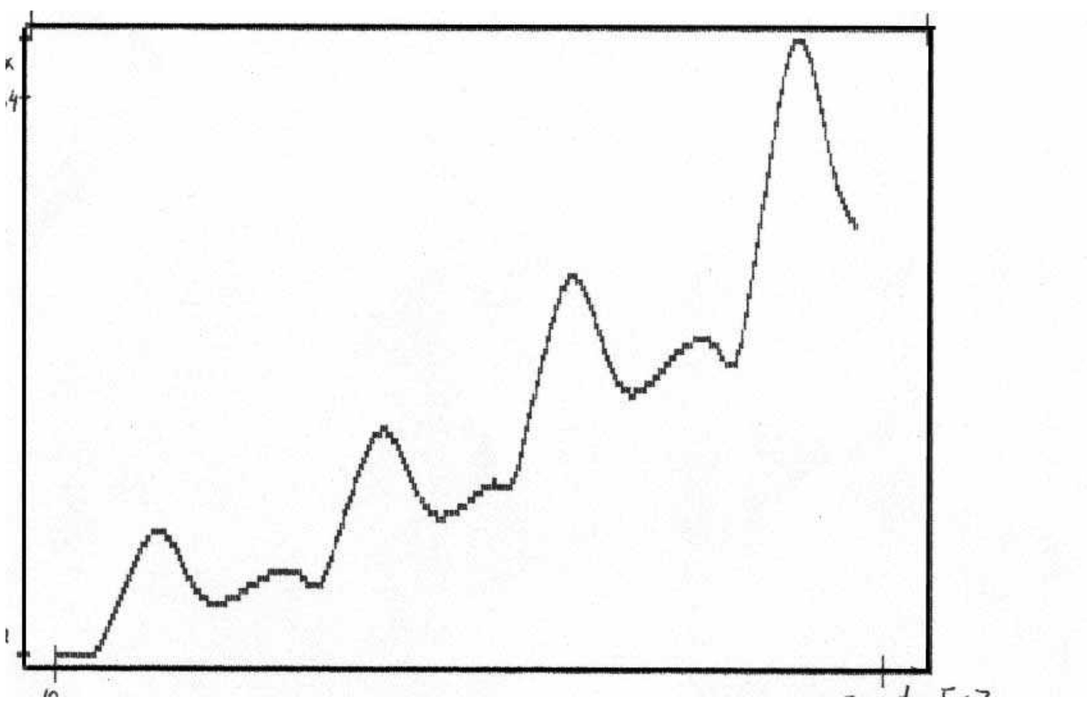

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Fig. 3 The behaviour of X-Ray luminocity on the compact object surface during thr first 30s after a 10 time increase of the inflow accretion rate

To be comparable with the observations, such variability must be calculated by a model admitted for the physical activity of the companion star.

The second prediction of our model is that, because of the non-uniform disk thickness, when the object is observable at low angle with respect to the binary plane, we must observe some kind of eclipses of the central X-ray luminosity.

A more detailed study on these issues will be carried out in the future.

References:

1. Ì. van der Klis, “Rapid aperiodic variability in X-ray binaries”, 1993, AIAP-1993-009
2. White, N.E., Astron. and Astrophys. review, 10.2.1989
3. Hayakawa S., Physics Reports, v.121, N 6, 1985
4. Collins, T.G.B., H.L. Helfer, H.M. van Horn, Ap.J. 508, p. 159, 1998
5. Collins, T.G.B., H.L. Helfer, H.M. van Horn, A&A, 193, p. 5205, 1998
6. Dimitrova, M.M., Àåðîêîñìè÷åñêè èçñëåäâàíèÿ â Áúëãàðèÿ, 13, ñ. 19, 1997
7. Dimitrova, M.M., Àåðîêîñìè÷åñêè èçñëåäâàíèÿ â Áúëãàðèÿ, 13, ñ. 27, 1997
8. Dimitrova, M.M., Àåðîêîñìè÷åñêè èçñëåäâàíèÿ â Áúëãàðèÿ, 15, ñ. 3, 1999