POSSIBLE X-RAY FLARES IN A RECURRENT NOVA

Izumi HACHISU
Department of Aeronautical Engineering, Kyoto University, Kyoto 606, Japan
and
Hiroshi ITOH
Department of Astronomy, Kyoto University, Kyoto 606, Japan

ABSTRACT: The dynamical evolution and nonequilibrium X-ray emission of recurrent nova remnants have been investigated by using a spherically symmetric hydrodynamic code. We assume that the nova ejecta expand into a wind from a red-giant companion. The wind material is blast-shocked, and emits copious X-rays. The blast shock soon breaks out of the wind region and the X-ray emission declines drastically. The blast shock eventually catches up with the relatively slow ejecta of the previous outbursts. The X-ray emission may then be rejuvenated in both luminosity and spectral shape.

X-ray observations play an important role in the study of recurrent-nova outbursts. It has long been known from optical observations that some recurrent-nova systems are associated with a dense circumbinary medium (CBM), which is most likely formed by the wind from the red giant between outbursts. After interacting with nova ejecta having expansion velocities of several hundred or several thousand km s^{-1}, the CBM will be shock-heated to X-ray-emitting temperatures. The X-ray emission from RS Ophiuchi during the latest outburst in 1985 (Mason et al. 1987), the detection of which was the first in recurrent novae during the outburst, has been interpreted in terms of this shocked-CBM scenario (Bode and Kahn 1985; Mason et al. 1987).

The blast shock eventually breaks out of the CBM into a rarefied ambient medium. The shocked CBM then undergoes an almost free expansion and, as a result of rarefaction and adiabatic cooling, the X-ray emission will fall sharply. A steep decline of X-ray emission has been observed in RS Ophiuchi during the 1985 outburst (Mason et al. 1987). After the CBM's steep decline in X-ray emission, the black-body radiation from the hot surface of the erupted white dwarf may show up in the X-ray spectrum. The detection of this black-body spectrum will constitute compelling evidence for the TNR model. It will also provide constraints on the duration of the delayed mass ejection from the white dwarf. In classical novae, the explosive mass ejection is known to be followed by a quasi-steady, optically thick wind from the white dwarf with the luminosity being close to the Eddington limit. The X-ray emission becomes substantial only after the wind lulls and the photosphere contracts.

The delayed and relatively slow mass ejection from a previous eruption of the star may have formed a slowly expanding gaseous shell around the stellar system; such a shell has actually been found around T Pyxidis. The shell will be hit by the blast shock which has broken out of the CBM, and will be heated to emit X-rays. A reverse shock will be reflected from the shell, and reheat the CBM.

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We have investigated the time development of the X-ray emission from a recurrent-nova remnant sketched above, taking account of the electron-ion temperature nonequilibrium and the ionization nonequilibrium in the calculation of the X-ray spectrum. The soft X-ray emission expected from our results is shown in Figure 1.

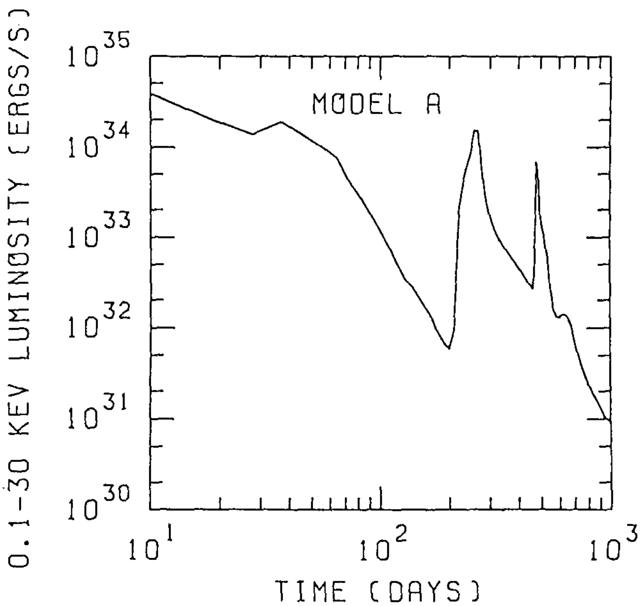

Fig. 1–Time evolution of the 0.1-30 keV luminosity in model A. The secondary X-ray flare around $t = 480$ days might be an artifact of the numerical scheme (see Itoh and Hachisu 1989, for detail).

In this model, the mass and explosion energy of the nova ejecta, and the mass and outer radius of the CBM are taken to be $10^{-6}M_{\odot}$, 10^{44} ergs, $10^{-6}M_{\odot}$, and 10^{15} cm, respectively. The recurrent-nova remnant may be rejuvenated when it collides with the dense shell whose radial distance, mass, and density are taken to be 7×10^{15} cm, $10^{-6}M_{\odot}$, and 5000 amu cm^{-3}, respectively. The collision is accompanied by X-ray and radio flares, and possibly by an infrared flare also. These signatures may be detected in the next outburst of T Pyxidis. They may also be detected shortly in RS Ophiuchi and U Scorpii, which underwent their latest outbursts in 1985 and 1987, respectively.

REFERENCES

Bode, M. F., and Kahn, F. D. 1985, *M. N. R. A. S.*, **217**, 205.

Itoh, H., and Hachisu, I. 1989, *Ap. J.*, submitted.

Mason, K. O., Córdova, F. A., Bode, M. F., and Barr, P. 1987, in *RS Ophiuchi (1985) and the Recurrent Nova Phenomenon*, ed. M. F. Bode (Utrecht: VNU Science Press), p. 167.

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