

The Phases of X-Ray Emission of RS Oph

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The recurrent symbiotic nova RS Oph reoccurred after 21 years on 12 February 2006. In contrast to the 1985 outburst, much denser coverage with X-ray observations was achieved. *Swift* observed RS Oph up to several times a day while *Chandra* and *XMM-Newton* observed two to four times during each phase of evolution. While the *Swift* observations provide high resolution in time, the *Chandra* and *XMM-Newton* observations provide high spectral resolution. Refined models can be constrained by the grating spectra, and interpolation of the model parameters can be constrained by the wealth of *Swift* observations. We compared the *Swift* light curve with six X-ray observations taken with *EXOSAT* during the 1985 outburst. We found that the decay from the supersoft X-ray binary (SSS) phase had been observed.

§1. Introduction

RS Oph is a Symbiotic Recurrent Nova (RN) that recurs on time scales of ~ 20 years. The explosion occurs in a binary system consisting of a white dwarf (WD) near the Chandrasekhar limit and a red giant companion orbiting with a period of 455.72 ± 0.83 days.^{2),3),14)} On the surface of the WD a layer of hydrogen-rich material is built up by accretion of material from the red giant. When enough material is accreted, a thermonuclear explosion occurs, and an optically thick shell of ejected material initially blocks all high-energy radiation produced by nuclear burning. The radiative energy output occurs primarily in optical light until the shell clears. During this early phase, all X-ray emission from RS Oph originates from a shock produced by the expanding shell colliding with the pre-existing wind of the red giant.^{1),8),15)} After the shell has cleared, X-ray emission from the WD dominates the shock emission, and X-ray observations allow a view deep into the outflow.^{6),9),12)} The X-ray spectrum during this phase resembles that of the supersoft X-ray binary sources.^{4),16)} After nuclear burning on the WD surface has turned off, residual X-ray emission from the shock and from the ionized surrounding material is observed.⁷⁾

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§2. X-ray observations

The first X-ray observations of RS Oph were carried out during the 1985 outburst with *EXOSAT*. In contrast, the 2006 outburst was monitored in X-rays by RXTE and *Swift*,^{(1),(12),(15)} while twelve observations were carried out with *Chandra* and *XMM-Newton*, using the high spectral resolution of the grating spectrometers.

X-ray observations with *Swift* started three days after outburst, and the evolution was followed until day 251 (2006, October 22). A total of 386.5 ksec of exposure were obtained, and in Fig. 1 we show the X-ray Telescope (XRT) light curve as presented by 12). Until day ~ 30 an emission level between 10 and 30 counts per second was detected with a hard spectrum from the shock.¹⁾ The ascent into the SSS phase occurred very rapidly with an increase in count rate by an order of magnitude, followed by strong variations in brightness.¹¹⁾ The decay occurred after day 55, and in Fig. 1 we compare the Swift light curve with observations of the 1985 outburst carried out with the Low Energy (LE; 0.05–2 keV) Imaging Telescopes aboard *EXOSAT*.⁵⁾ We rescaled the *EXOSAT* count rates with the constant factor given in the legend. With this factor the rescaled count rate and the XRT count rate are the same on day 55.

In Table I we summarize all grating observations of RS Oph taken in 2006 with observation date, day after outburst, instrumental setup, observation ID, and net exposure time. We extracted effective areas for each spectral bin from the calibration

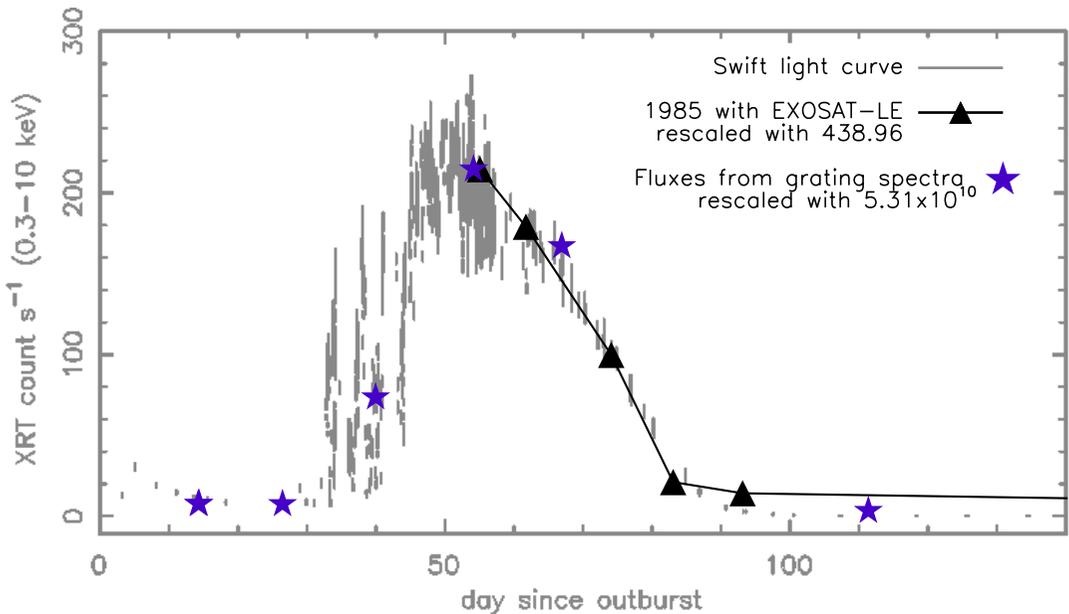


Fig. 1. Light curve of the 2006 outburst taken with *Swift* XRT¹²⁾ compared to *EXOSAT* (LE) count rates measured during the 1985 outburst⁵⁾ and *Chandra/XMM-Newton* grating fluxes (blue; Table I). The count rates and fluxes were rescaled with a constant factor (given in the legend) to reproduce the XRT count rate on day 55. (See the online edition for the color version of this figure.)

Chandra grating data show that the SSS spectrum is far brighter compared to the shock emission at that stage than had been expected.

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