The Peculiar Slow Nova X Serpentis [1]

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Observations

The very slow nova X Ser ($t_3 = 555^d$), situated at a large distance from the galactic plane ($z \approx 4\,$kpc), reached maximum light at 9^m in May 1903. It was discovered 5 years later on a Harvard plate (Leavitt 1908). No outburst spectrum is known. A photographic outburst light curve is given by Walker (1923); additional photometric data were published by Sakharov (1954) and Kinman *et al.* (1965). The light curve, shown in Fig. 1, presents 10-day means, based on all published data, and unpublished data taken from Emily Hughes Boyce's notebook, Harvard College Observatory Plate Collection.

Hughes Boyce (1942) discovered a 275^d periodicity during minimum light. From the fragmentary light curve in Fig. 1, including three more recent 'oscillation' maxima, a period of 277 days is found. If one assumes that the nova reached $M_{pg} = -6$ at maximum, the typical value for a slow nova, the mean absolute magnitude at minimum, $M_{pg} = +2$, together with the observed amplitude of about 2^m and a relatively long mean period, suggests a very late-type (typically M6e) semi-regular variable.

Spectra were published by Williams (1983) and Shara *et al.* (1986). Williams' spectrum, taken not later than 1982, shows a fairly flat continuum with very weak Hα, Hβ and He II 468.6 nm emission lines.

Shara *et al.*'s spectrum taken in 1986 or earlier has a fairly red continuum with relatively strong emission lines of the Balmer series, He II 468.6 nm, He I 587.6 nm and He I 667.8 nm, [O III] 500.7, 495.9 nm, and [O I] 630.0, 636.4 nm. Na I 589.3, 589.6 nm may be present in absorption.

A spectrum obtained by the present authors in August 1986 (Fig. 2a) shows a strong blue continuum, weak Balmer lines with indications of blueshifted absorption components at $v = -2000\,\mathrm{km\,s^{-1}}$, He II 468.6 nm, He I 587.6, He I 667.8 nm, and the auroral line [O I] 557.7 nm. He II is much stronger than Hβ.

By early 1988, a drastic change had occurred (Fig. 2b). The flux in the blue had decreased by almost an order of magnitude and the continuum became very flat; a rich emission line spectrum had appeared, dominated by [O I] 630.0, 636.4 nm and [O I] 557.7 nm. It also shows a moderately strong Balmer series and all major lines of He I up to high series members. He I 587.6 is clearly stronger than He I 667.8 nm. He II is now much weaker than Hβ.

Interpretation

Unfortunately, no photometric data are available for comparison with the spectroscopic observations. The light curve, in spite of its incompleteness, suggests the existence of 'high states' (average 13^m) which gradually change to 'low states' (about 17^m) within less than 10 years. The observed 277 day 'oscillations' are superimposed on these long-term variations. We postulate that the changes in spectral appearance are due to a 'small outburst' cycle with a time scale of about 10 years.

The weak emission lines in Fig. 2a indicate that no well-developed gaseous envelope is present. The continuum is comparatively strong, but permits no conclusion concerning its origin.

The apparently red continuum in the spectrum taken some years later by Shara *et al.* could be an artefact due to incomplete reduction. If it is real, a red source has appeared, possibly the star responsible for the light oscillations. In the spectrum of 1988 the star must have disappeared again (minimum of its oscillation cycle?). The relatively strong forbidden lines, including those of [O III], in Shara *et al.*'s spectrum indicate a tenuous nebula of relatively high temperature.

Later in 1986 we observed a strong blue source, whose high temperature is derived from the large ratio He II to Hβ. It is surrounded by a 'stellar' envelope with electron densities higher than $N_e \approx 10^7\,\mathrm{cm^{-3}}$, as indicated by the small ratio of the He I diffuse triplet to diffuse singlet line

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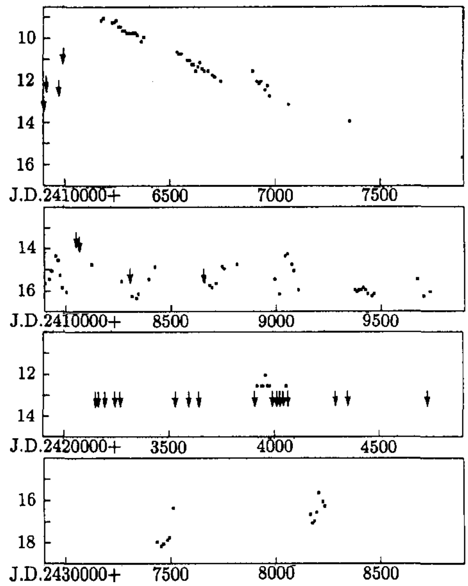

Fig. 1. Light curve of X Ser.

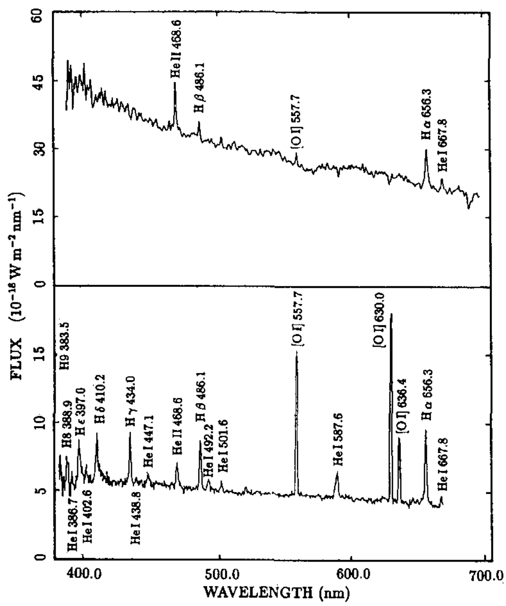

Fig. 2. Spectra of X Ser, a) 1986 b) 1988.

strengths (Schmid 1989). A small and relatively cool lower density nebula, which is responsible for the weak auroral [O I] line, is part of the system.

The final scene so far is (the reappearance of?) an extended, cool nebulosity, as witnessed by the very strong [O I] lines. The 'stellar' envelope has a lower density than before, apparent from the reversal of the He I line ratio. The temperature of the central source has decreased as indicated by the decrease in the He II line strength. The broad wings of the Balmer and helium lines suggest velocities approaching $\pm 2000\,\mathrm{km\,s^{-1}}$. The extremely low Balmer and helium decrements are hard to explain, unless we see different parts of the shell in different lines.

The hypothetical 'small outburst' gains credibility through the presence of blueshifted absorption lines during the hottest phase and the presence of high velocity gas observed later in the envelope. In general, the very unusual slow nova X Ser appears more like a low-excitation planetary nebula (in the making?) with an active nucleus rather than a classical nova.

To support the above speculations through quantitative analysis, well-calibrated spectra covering time intervals shorter than the 'oscillation' time scale and longer than that of the 'small outburst', as well as photometric patrol observations are needed. Infrared data would help to determine the existence and nature of the red source.

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