V2487 Ophiuchi: A strong candidate for a recurrent nova and a progenitor of Type Ia supernova

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**Abstract.** The light curve of the 1998 outburst of V2487 Ophiuchi (Nova Oph 1998) shows a very rapid decline ($t_3 \sim 9$ days) and a mid-plateau phase from 10 to 30 days after the optical maximum, which are characteristics common to the U Sco subclass of the recurrent novae. We have numerically reproduced light curves of the 1998 outburst based on a thermonuclear runaway model with optically thick winds. The results show that the mass of the white dwarf (WD) is as massive as $1.35 \pm 0.01 M_\odot$; the envelope mass of the WD at the optical maximum is $\sim 6 \times 10^{-6} M_\odot$; the hydrogen content of the WD envelope is as low as $X \sim 0.1$ by mass weight. The mass transfer rate in quiescence is roughly estimated to be $\sim 1.5 \times 10^{-7} M_\odot$ yr$^{-1}$ and, therefore, that the recurrence period of nova outbursts is about 40 yr. Since the WD mass may be now growing at a rate of $\sim 2 \times 10^{-8} M_\odot$ yr$^{-1}$, V2487 Oph is a strong candidate for a progenitor of a Type Ia supernova.

1. **Light Curve Analysis and a Very Massive White Dwarf**

The outburst of V2487 Ophiuchi (Nova Oph 1998) was discovered at $m_V \sim 9.5$ by Takamizawa on 1998 June 15.561 UT. The early optical decline rate of 0.37 mag day$^{-1}$ makes this nova one of the fastest ever seen (see Fig. 1, from the VSNET archives). The rapid decline stopped about 10 days after maximum and then the decline rate lessened to $\sim 0.05$ mag day$^{-1}$, that is, the brightness stayed at $m_V \sim 14$ from 10 to 30 days after maximum. We call this period mid-plateau phase. Then the optical brightness again declined so fast from $m_V \sim 14$ to $m_V \sim 16$ in about 10 days. The brightness stayed again at $m_V \sim 16$ at least until 70 days after maximum (HJD 2,451,050), which is not shown in Fig.1 but from observational points reported in the AAVSO archives.

We have modeled the system consisting of a very massive WD and a lobe-filling main-sequence (MS) star. Irradiation effects of the accretion disk (ACDK)
Figure 1. Calculated V light curves are plotted against time (HJD 2,450,000+) together with the observational points of the 1998 outburst (all taken from the VSNET archives). Each line indicates the light curve of $M_{\text{WD}} = 1.35 M_\odot$ connecting the V light at the binary phase 0.5 (the phase at which the WD component is in front of the MS companion seen from the Earth) for various hydrogen contents of the WD envelope, i.e., $X = 0.70$ (dashed line), $X = 0.50$ (dash-dotted line), $X = 0.35$ (dotted line), and $X = 0.10$ (thick solid line).

and the MS companion by the WD are included into the light curve calculation. The numerical method has been described in Hachisu & Kato (2001). We are able to reproduce the light curve by adopting model parameters similar to those of U Sco (Hachisu et al. 2000). The model parameters are shown in Fig. 1.

The very rapid decline and the ensuing mid-plateau phases are common features among the U Sco subclass of recurrent novae. If V2487 Oph belongs to the U Sco subclass, its orbital period should be between $\sim 0.3$ and $\sim 3$ days. The numerical results strongly indicate that this nova is a recurrent nova. Adding V2487 Oph to the member of the recurrent novae would provide us valuable information on recurrent novae and SN Ia progenitors.

References