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Revised analysis of the supersoft X-ray phase, helium enrichment, and turnoff time in the 2000 outburst of the recurrent nova CI Aquilae

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Revised analysis of the supersoft X-ray phase, helium enrichment, and turn-off time in the 2000 outburst of the recurrent nova CI Aquilae

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Abstract. The recurrent nova CI Aquilae entered the final decline phase a bit before May of 2001, showing the slowest evolution among the recurrent novae. Based on the optically thick wind mass-loss theory of the thermonuclear runaway model, we have estimated the turn-off time of the CI Aql 2000 outburst in March of 2001, after a supersoft X-ray source (SSS) phase lasts 150 days from December of 2000 until May of 2001. Fitting our theoretical light curves with both the 1917 and 2000 outbursts, we also obtained the WD mass to be $M_{\mathrm{WD}} = 1.2 \pm 0.05\ M_\odot$, helium enrichment of ejecta, He/H~ 0.5 by number, the mass of the hydrogen-rich envelope on the WD of $\Delta M \sim 6 \times 10^{-6} M_\odot$ at the optical maximum, which is indicating an average mass accretion rate of $\dot{M}_{\mathrm{acc}} \sim 0.8 \times 10^{-7} M_\odot\ \mathrm{yr}^{-1}$ during the quiescent phase between the 1917 and 2000 outbursts.

1. Light Curve Analysis of CI Aql and Turn-off Time

The second recorded outburst of CI Aquilae was discovered in 2000 April by Takamizawa since the first recorded outburst in 1917. After optical brightness reached its maximum, $m_V \sim 9$, in early May of 2000, it rapidly decreased to $m_V \sim 13$ in about 50 days. A plateau phase follows; the brightness leveled off at $m_V \sim 13.5$. Once it rapidly decayed to $m_V \sim 14.5$ at the end of November of 2000, it stayed at $m_V \sim 14.5$ until March of 2001. CI Aql has entered the final decline phase toward its quiescent level from May of 2001 as shown in Fig. 1

We have modeled the system consisting of a massive white dwarf (WD) and a lobe-filling main-sequence (MS) star. Irradiation effects of the accretion disk (ACDK) and the MS companion by the WD are included into the light curve calculation. The numerical method has been described in Hachisu & Kato (2001b). 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 including those for the ACDK are shown in Fig. 1 (see also Hachisu & Kato 2001a).

After the paper of Hachisu & Kato (2001a) has been published, we have new data on the final decay phase of the 2000 outburst (Schaefer 2001, private communication) and, now, are able to determine the turn-off time, the helium
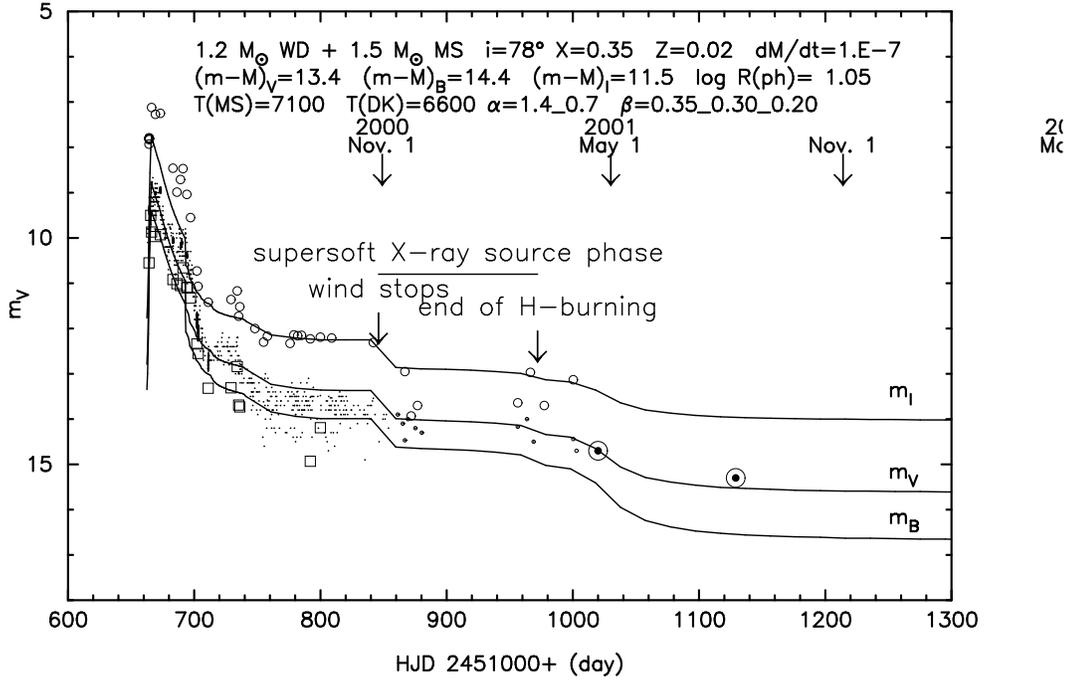
Figure 1.   Calculated V, B, and I_c light curves plotted against time (HJD 2,451,000+) together with the observations. Small dots indicate observational V and visual magnitudes including late phase $\odot$ marks (Schaefer 2001, private communication), while open squares represent observational B magnitudes and open circles indicate observational I_c magnitudes (all taken from the VSNET archives except $\odot$'s). Calculated light curves are plotted for the model consisting of a $1.2M_\odot$ WD and $1.5M_\odot$ MS. The hydrogen content of the WD envelope is about $X = 0.35$ in mass weight. Each light curve connects the brightness at the binary phase 0.35 (roughly the brightest in a binary phase). The apparent distance modulus of $(m - M)_V = 13.4$ is obtained by fitting.

content of the envelope, and the duration of luminous supersoft X-ray phase as shown in Fig. 1. We have also revised the physical parameters: the unheated surface temperatures are $T_{\rm ph,MS} = 7100$ K of the MS companion, $T_{\rm ph,disk} = 6600$ K of the disk rim, the apparent distance modulus $(m - M)_V = 13.4$, the color excess $E(B - V) = 1.0$, the absorption $A_V = 3.1$, and the distance to CI Aql $d = 1.1$ kpc.

References

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