# ON THE POSTOUTBURST FAR ULTRAVIOLET DECLINES OF WZ SAGITTAE AND V1500 CYGNI

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In an earlier paper [1], we demonstrated that the declining ultraviolet flux, observed long after optical quiescence was reached in three dwarf novae, most likely represents the cooling of a white dwarf whose outer layers have been heated by the accretion event. If the observed change in temperature is due to the cooling of the white dwarf surface layers following the intense heating produced in the outburst, then a thermal timescale of the heated portion of the white dwarf is implied, which could yield a rough estimate of the depth of heating into the white dwarf envelope. The thermal timescale is essentially given by the ratio of the internal energy in the affected layers to their luminosity, L.

We have constructed white dwarf models to represent U Gem, VW Hyi and WZ Sge, using the Henyey-type stellar evolution (with accretion and diffusion) described by Sion et al. [2] and Sion and Starrfield [3]. Our envelope models utilize Cox and Stewart opacities and and have very fine mass zoning in the outer layers. The physical parameters of our models are listed in Table 2. As a first approximation to the determination of the mass and depth of the outburst-heated region, we assume that the observed cooling timescale represents the cooling timescale of the heated white dwarf surface layers. We locate by integration the mass zone in our model where the product of the envelope luminosity and the observed cooling timescale, $\tau_k$, equals the product $c_v$ T dM where $c_v$ is the specific heat at constant volume, T is the zone temperature amd dM the zone mass. If indeed the observed flux decline and Lyman $\alpha$ profile variations result from cooling of the outburst- heated white dwarf surface layers, then the observed cooling timescale allows us an order of magnitude estimate of the depth and mass of the affected layers that underwent heating due to the outburst. On the assumption that the quiescent cooloing timescale can be taken as the appropriate thermal timescale of the heated white dwarf outer layers, we find the heated mass as listed in Table 2.

We obtained two IUE low resolution SWP spectra of V1500 Cyg (June 29, 1988, 280 min exposure; and May 15, 1989, 265 min exposure) 13-14 years post-outburst when the visual magnitude of the system was about V=17. Our spectra show virtually no flux shortward of 1500Å but a very weak continuum at longer wavelengths.

The effective temperature of the white dwarf at the present time can be constrained by the range of the photometric variations (0.5 to 1 magnitude) reported by Kaluzny and Chlebowski [4], if we assume that they are caused by the varying aspect of the heated facing hemisphere of the M4V compaion. R.F. Webbink has provided us with two methods of constraining of the cooling evolution of the white dwarf. If we adopt the observed value for the B magnitude range and assume that the variation in V has roughly the sane amplitude, then the optical variation at V can be converted to a brightness temperature at V for the facing hemisphere of the M4V companion. The temperature difference with respact to the non-irradiated side implies a luminosity of $5.9\times10^{-2}L_\odot$ for the white dwarf, which corresponds to a white dwarf effective temperature of only 37,000 K, a rough lower limit. If we take the mean absolute visual magnitude $M_V$=+5.75, corrected for visual absorbtion by Cohen [5], and subtract -0.1 to correct for the inclination being less than 90 degrees, then the brightness temperature of the facing hemisphere implies $L_{wd}=5L_\odot$ with $T_{eff}$(WD)=110,000 K. This value of the white dwarf temperature at 14 years post-outburst is close to the roughly 2 solar luminosities at 14 years post-outburst indicated by the 1.25 solar mass hydrodynamic simulation of Prialnik [6]. Therefore the white dwarf has cooled by roughly 70-80,000 K since 1978 when the presumed white dwarf central ionizing source was estimated to be 180,000 K, based upon the ejecta emission. Since this object is the first known magnetic (AM Her) nova, it is extremely important to know whether the post-outburst behavior and cooling of this massive, magnetic white dwarf differs from the cooling behavior of a post nova, non-magnetic degenerate.

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[4] Kaluzny, J. and Chlebowski, T. 1989, Ap. J., 332, 227.
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TABLE 1

| Object | WZ SGE | V1500 Cyg |
|---|---|---|
| Orbital P (min) | 82 | 201 |
| Mass WD ($M_\odot$) | 1.1 | 1.4 |
| Outburst Date | Dec. 1978 | Aug. 1975 |
| Outburst V mag | 7.8 | 1.8 |
| Quiescent mag | 15 | 21.5 |
| Outburst Amp (mag) | 7.2 | 19.7 |
| Time to Opt. Quiescence | ˜126 days | >14 yrs (still at V=17) |
| Time to UV Quiescence | ˜8 yrs | >14 yrs |
| $T_{EFF}$ at Quiescence | 13500K WD | 13600 K Black Body |

TABLE 2

| | WZ Sge | U Gem | VW Hyi |
|---|---|---|---|
| $M/M_\odot$ | 1.1 | 0.8 | 0.6 |
| $T_{eff}$ | 13,500 | 40,000 | 20,000 |
| $L/L_\odot$ | $1.03\times10^{-3}$ | $5.33\times10^{-2}$ | $2.41\times10^{-2}$ |
| Observed Cooling Timescale (days postoutburst) | 2,920 | 108 | 20 |
| Heated Layer Mass (stellar masses) | $3.23\times10^{-9}$ | $4.32\times10^{-9}$ | $9.1\times10^{-10}$ |
| Heated Layer Mass (grams) | 6.4E$\times10^{24}$ | $6.9\times10^{24}$ | $1.1\times10^{24}$ |
| Temperature at Base of Heated Layer | $1.78\times 10^{6}$ | $2.1\times10^{6}$ | $1.03\times10^{6}$ |