25. Optical and ultraviolet spectral observations of nova LMC 1991

G. J. Schwarz and S. Starrfield

Arizona State University

P. H. Hauschildt

University of Georgia, Athens

S. N. Shore

Indiana University South Bend

Nova LMC 1991 (hereafter LMC 91) was discovered on 18 April 1991 (Liller 1991) at \( m_v = 12 \). LMC 91 was the brightest nova ever seen in the LMC with \( m_v^{max} \sim 9 \) on 24 April. LMC 91 was also one of the fastest CO type novae on record with \( t_2 \) and \( t_3 \) times of \( 4.5 \pm 0.5 \) and \( 6 \pm 1 \) days respectively.

Optical (Williams et al. 1994) and ultraviolet spectra were obtained of LMC 91 while the nova was still optically thick. A grid of spherically symmetric, non-LTE, line-blanketed, expanding synthetic spectra were calculated with the model atmosphere code PHOENIX. The model atmospheres were characterized by: 1) a reference radius, 2) a model temperature, 3) the density parameter, \( N \), \( (\rho(r) \propto r^{-N}) \), 4) the maximum expansion velocity, and 5) the abundances. The fits to the observations were then iteratively improved by changing the parameters of the model atmospheres.

A metallicity of 0.1 solar (except for CNO) consistently gave the best fits during all of the optical thick phases including the earliest “fireball” phase (Gehrz 1988). In particular, synthetic spectral fits to optical Fe II emission lines and the UV pseudo-continuum at \( V_{max} \) were significantly improved with the low metal abundance. This metal abundance is also significantly lower than the canonical LMC value of 1/3 that we used to successfully model LMC 1988 #1 (Schwarz et al. 1997b). The brightness and low metallicity of LMC 91 seems to confirm recent hydrodynamic calculations that metallicity is inversely correlated with luminosity if mixing occurs during a thermonuclear runaway (Starrfield et al. 1997). In addition, we found evidence of carbon and oxygen enhancements of order 10 times solar from fits to C I and O I near-IR emission lines. This is consistent with the predictions of theoretical calculations (Starrfield et al. 1997) and elemental abundance determinations for other CO type novae (Schwarz et al. 1997a and references therein).

In Figure 1, we show the early visual lightcurve of LMC 1991. The synthetic V band magnitudes calculated from the best fits to the observed spectra are consistent with the observed lightcurve. In Figure 1, we also show the bolometric flux (calculated by integrating the flux of the best fitting model spectrum from 200Å to 10µm) as a function of time. The last two points are derived from syn-
Figure 1. Top panel: Early visual lightcurve of LMC 1991 with photoelectric V (squares) and visual estimates (dots) from IAU circulars and PHOENIX V band magnitudes (dots). Bottom panel: The bolometric flux of the best fitting model spectra.

Theoretical spectral fits to spectra that are dominated by many strong semi-forbidden lines. These lines are not in the model atmospheres and thus our fits are lower limits only. Assuming a distance of 52 kpc to the LMC, the peak bolometric luminosity is $\sim 3 \times 10^{39}$ ergs s$^{-1}$. This luminosity is 20 times the Eddington luminosity of a 1 M$_{\odot}$ white dwarf (X = 0.7 and electron scattering opacity) and shows conclusively that novae can be super-Eddington for a substantial period of time.

References

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