

## Outbursts of Classical Symbiotics: Multi-Wavelength Observations of the 2000-2001 Outburst of Z Andromedae

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The outbursts of classical symbiotic systems (SS) could be due to accretion or thermonuclear instabilities, expansion of a white-dwarf (WD) photosphere in response to a change in accretion rate, or a combination of these mechanisms. Since most classical SS are thought to be burning accreted material on the surface of a WD, they are closely related to the supersoft X-ray sources, and the causes of the outbursts may be similar. Furthermore, the mass loss during outbursts could play a role in determining whether SS can become Type Ia supernovae. We present here the first results from a program of multi-wavelength monitoring of SS in outburst designed to address the above issues.

The prototypical SS Z and was observed at radio through X-ray wavelengths during its 2000-2001 outburst. On the rise to maximum, the optical flux moved through two plateaus (observations began during the first plateau), and the *U*-band flux, which may reflect both nebular emission plus direct emission from the hot component, has a different pattern of variation than the *BVR* fluxes. On longer time scales, the *U*-band and far-UV (FUV) fluxes are correlated. Significant variations may also be present on time scales as short as days (Fig. 1a), although the 28-minute oscillation that persisted through a smaller outburst (Sokoloki & Bildsten 1999, ApJ, 517, 919) disappeared near optical maximum.

In the radio, our first observation revealed Z And to be fainter than usual (Seaquist & Taylor 1990, ApJ, 349, 313). The flux therefore dropped very early in the outburst, probably indicating that the thermal radio nebula shrank as the ionizing flux from the WD was blocked by an optically thick shell. Z And was not resolved at 5 GHz with the MERLIN interferometer near the peak of the optical outburst. Once the source had brightened again 4 months later, however, spatial structure was marginally detected by the VLA, at 15 GHz (Fig. 1b).

P-Cygni profiles are apparent in the FUV spectra, and they evolve on a time scale of weeks (Fig. 1c). The first *FUSE* observation shows a large amount of cool gas (e.g., singly and doubly ionized C, Fe, and Si), which only partially covers the source of FUV emission. Multiple line features evolve from absorption to emission as the outburst progresses, and there is evidence for hot gas moving at 100s of km/s, as well as for significant collisional excitation.

X-ray observations were made at three epochs during the outburst. The spectra from the first two observations could not be fit with simple supersoft black-body models. Emission is detected above 1 keV in both, and out to 10 keV in the data from XMM (Fig. 1d). The high energy emission provides evidence for shock heating of the red giant wind as the outburst ejecta collide with it.

## Light Curves

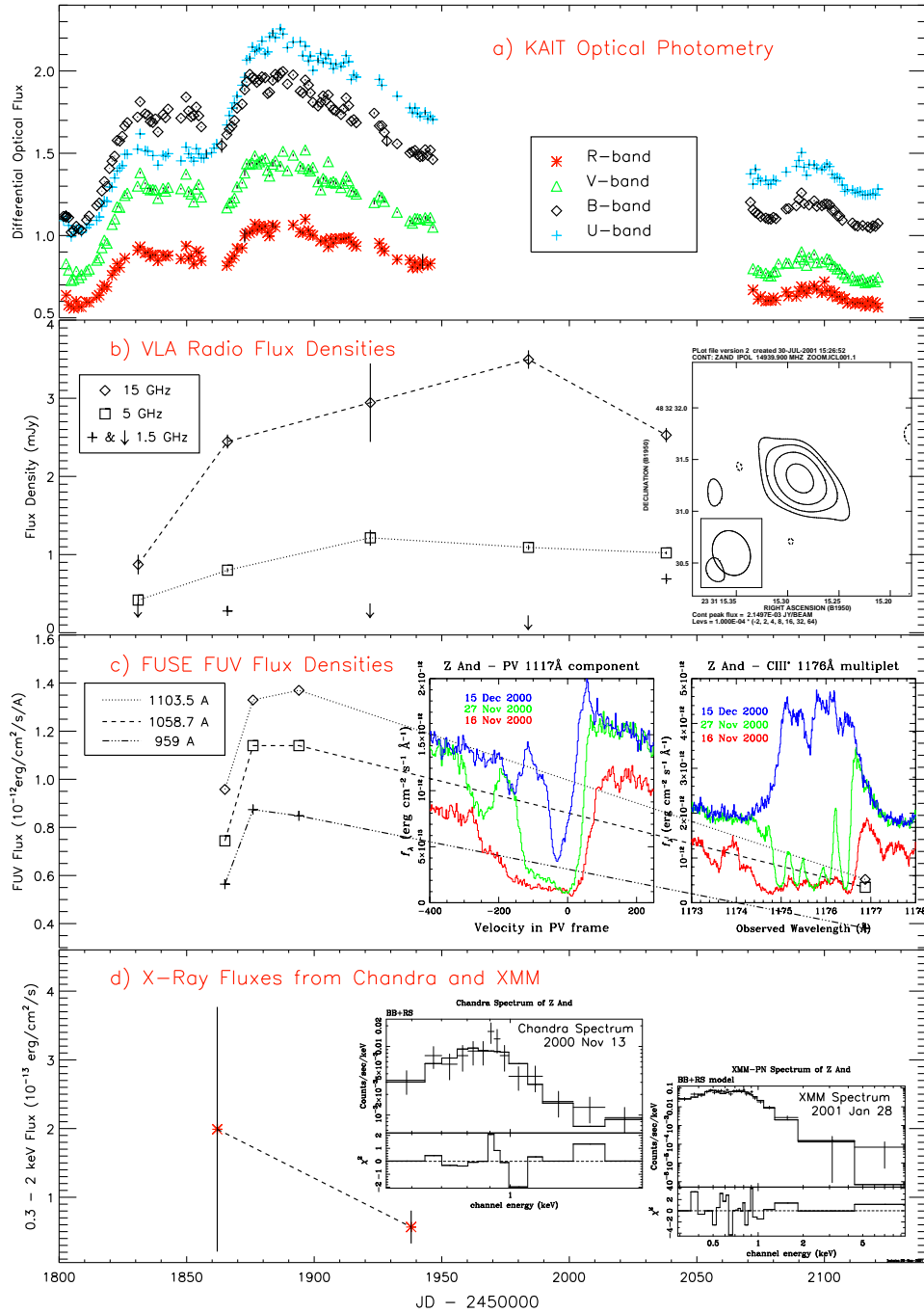


Figure 1. a)  $U$ ,  $B$ ,  $V$ , and  $R$  light curves from the 0.8-m Katzman Automatic Imaging Telescope (KAIT), at Lick Observatory. The light curves have been offset for clarity. b) VLA radio fluxes at 15 GHz, 5 GHz, and 1.5 GHz. 15 GHz fluxes from the Ryle telescope confirm the general trends seen in the VLA data. In the 2001 May 8 observation, we find some evidence that the radio extent of Z And is resolved at 15 GHz (inset). c) FUV fluxes at three relatively line-free regions of the continuum. Inset: changes in the P-Cygni profiles of the P V lines, and the evolution from absorption to emission of the C III complex at 1175-1176 Å. d) Absorbed 0.3 - 2 keV X-ray fluxes. For spectral fits,  $N_H$  was set to  $5 \times 10^{21}$  cm $^{-2}$  (determined from *FUSE* data) and abundances were set to solar. Fit parameters are  $kT_{BB} = 81$  (80) eV and  $kT_{RS} = 0.8$  (0.7) keV for the Chandra (XMM) data.