Near Infrared Spectroscopy of Type Ia Supernovae Using SpeX

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The tremendous brightness and apparent homogeneity of Type Ia Supernovae (SNe Ia) make them excellent probes of the universe at great distances. Type Ia supernova observations provide high quality data for estimates of the Hubble constant, analysis of the matter density of the Universe, and possibly demonstrate a positive value for the Cosmological Constant. The observed characteristics of SNe Ia strongly suggest that these events are the thermonuclear explosions of Carbon/Oxygen White Dwarf stars. Although the general physical scenario for SNe Ia is widely accepted, the details of the explosion and the progenitor remain under discussion.

Our program compares the spectra obtained at the IRTF to detailed models. The NIR between 0.8μ and 2.5μ is optimal for examining certain products of the SNe Ia explosion that may be blended or obscured in other spectral regions. The expansion velocities of explosion products in the supernova ejecta are found by measuring the Doppler shift of the absorption minimum in the spectra. By comparing these velocities with our models, we can trace the explosion dynamics as well as the propagation of the deflagration burning front through the white dwarf star. Other spectral features are sensitive to progenitor composition. We will establish significant new constraints for type Ia supernova physics.

The model spectra in the Figure 1 are generic and were not intended to match the observed spectra. The models were calculated in order to permit definitive identification of the major spectral features. The differences in slope between data and models are due to different zero points for the flux rates. We are working to resolve this problem. We want to publish the data very soon with line identifications since there are few NIR spectra of SNe Ia in the literature. More detailed physical analysis will follow is a series of papers. There will be a great deal to say about this data.

Figure 2 shows the MgII absorption feature near 1.05μ ($\lambda_{rest} = 1.0926\mu$) for the SN2001en (-3) spectrum. Magnesium is a product of explosive carbon burning, but not oxygen burning. That makes magnesium an excellent diagnostic tool for defining the region of transition between carbon and oxygen burning during the explosion. This transition is a key aspect of explosion models for SNe Ia. Such absorption features are a few thousand kilometers per second in width and are easily resolved with the SpeX instrument data.

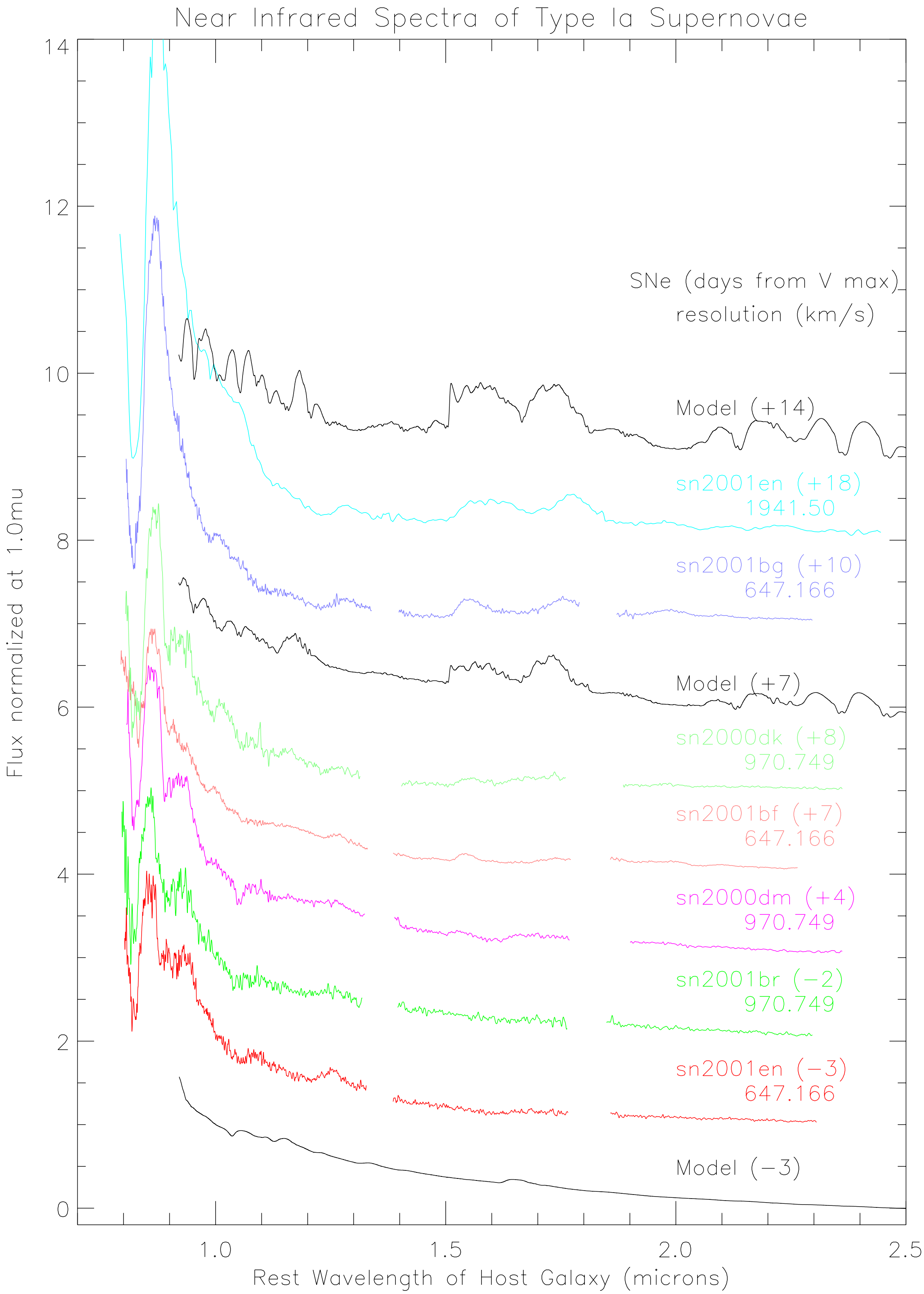

Fig. 1.— NIR spectra obtained at the IRTF and synthetic spectra for normal bright type Ia. These are not the final reductions.

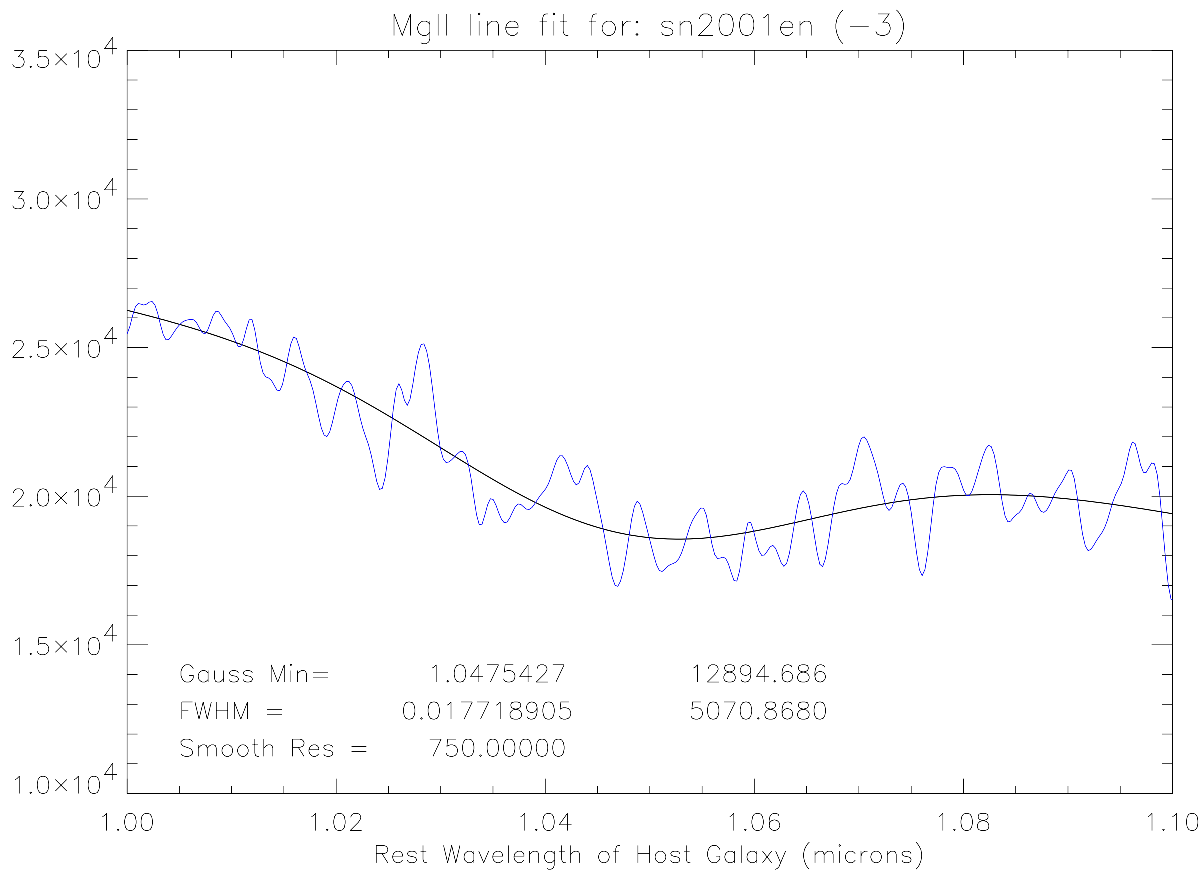

Fig. 2.— Gaussian fit to the MgII line (rest wavelength 1.0926μ) for the SN2001en (-3) spectrum. The expansion velocity is found to be $\sim 12900 km/s$ and the line width $\sim 5000 km/s$. The resolution of the spectrum is $\sim 600 km/s$.