Searching for Imprints of Circumstellar Material in the Ultraviolet Spectra of Type Ia Supernovae

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Type Ia supernovae (SNe Ia) are thermonuclear explosions that have high and relatively standard peak luminosities. It is accepted that SNe Ia originate in white dwarf (WD) binary systems, however, the companion star is still unclear. Two possible progenitor models are the single- (SD) and double-degenerate (DD) scenarios, where the companion in the DD scenario is another WD, while the companion in the SD scenario is a more normal star such as a red giant.

Here, we test these models by searching for indications of circumstellar material (CSM) in *Hubble Space Telescope* UV spectra of 8 SNe Ia. Imprinted on these UV spectra are narrow absorption lines from ISM and/or CSM. If these features vary in strength over time, the material is likely CSM, ionizing and recombining after the SN explosion. Such material is most easily explained in a SD progenitor system. Using a total of 46 spectra from 8 SNe Ia, we do not detect any variability in Mg I, Mg II, and Fe II lines, placing new, strong constraints on the progenitor systems of these SNe Ia.

We detect the Mg II λ2800 doublet and Mg I λ2853 in all spectra, although SNe 1992A, 2011ek, and 2011iv only show absorption from the Milky Way. We also detect Fe II in some observations from each SN. Measuring the EW of each feature at each epoch, we look for any variability. In our best measurements to date, we do not detect any significant change in any of the absorption features, consistent with studies of optical features for SN 2011fe (Patat et al., 2013) and SN 2014J (Welty et al., 2014; Goobar et al., 2014, Foley et al., 2014). We therefore do not detect a large amount of CSM along our line of sight.

References:
Patat et al., 2013, A&A, 549, 62.
Welty et al., 2014, ApJ, 792, 2.
Goobar et al., 2014, ApJL, 784 12.
Foley et al., 2014, MNRAS, 433, 2887.

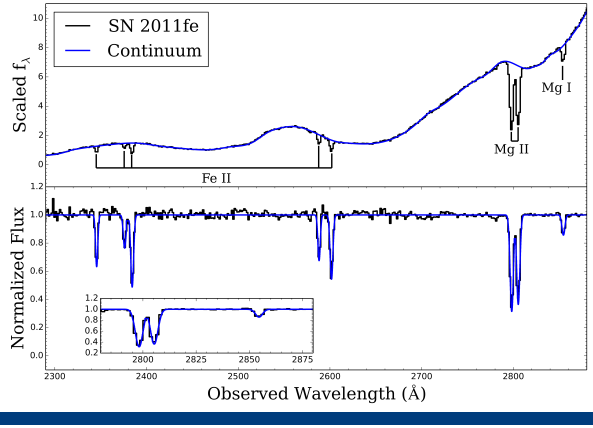

Fig. 1: (*Top*) Maximum-brightness spectrum of SN 2011fe. The blue curve is a 3rd-order interpolated fit to the data including Gaussian profiles for the Fe II λλ 2344, 2374, 2383, 2587, 2600; Mg II λλ2796, 2803; and Mg I λ2853 absorption features. (*Bottom*) Normalized maximum-brightness spectrum of SN 2011fe. The inset is a zoom-in showing the region near the Mg I and Mg II features.

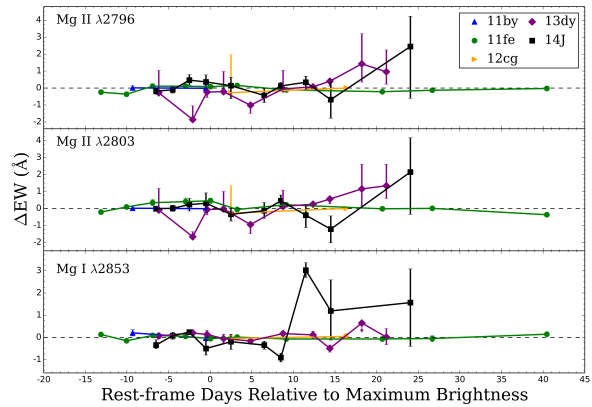

Fig. 2: Deviations in the EW from the average measurement of the Mg II doublet and Mg I, respectively. We do not detect any absorption at the redshift of the host galaxy for the three SNe not listed. When a feature is not detected, we plot the 3-σ upper limit as a downward arrow. The measurements are all consistent with zero variability.

Support for presenting this poster comes from the University of Illinois Department of Astronomy, the University of Illinois Office of Undergraduate Research, and the National Radio Astronomy Observatory.