TYPE IA SUPERNOVA DIVERSITY: STUDIES OF SN 2007QD, SN 2008Q AND SN 2011FE

ABSTRACT

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Type Ia supernovae (SN Ia) have proven to be incredibly useful as distance indicators and nuclear astrophysics, but there remain many unanswered questions as to their nature.

We examine three particular SN Ia at depth in an attempt to provide constraints on both their theory and their application to cosmology.

We first present SN 2007qd, which was one of the lowest-luminosity SN Ia ever discovered, and appears to belong to the SN 2002cx-like subclass of peculiar SN Ia. We observe and analyze the photospheric-phase spectra and photometry for this event and determine that, despite its extreme nature, it still appears to be a thermonuclear event rather than a core-collapse SN Ic. We also discover a possible relation between the luminosity and the low expansion velocities (2000~7000 km/s) of similar events, and determine that they constitute a well-defined group of SN Ia. From the explosion kinematics and the content of the spectra, we argue that SN 2007qd was likely caused by a pure deflagration of a carbon and oxygen white dwarf.

We then consider SN 2008Q, a SN Ia that exploded in the same early-type host galaxy as the peculiar SN 2000cx. This provided a chance for a direct comparison of two SN Ia at the same distance, extinction and host environment. We combine photometry from the ultraviolet through to the mid-infrared (MIR) and create a picture of how this SN evolved bolometrically over a span of two years. We discover that SN 2008Q was particularly bright in the ultraviolet, and characterize the possible existence of a class of SN Ia with similar UV excess. We identify intrinsic differences between SN 2008Q and SN 2000cx, and discuss what this means for the variation in explosion and nebular physics in SN Ia events.

We present next the mid-infrared and optical decay of SN 2011fe. This SN Ia exploded in the nearby galaxy M101, allowing observations of high signal-to-noise during the later phases. We examine this SN with Spitzer/IRAC MIR photometry, and discover that the decay rates in each of these channels behave similarly to certain optical channels. We use spectra taken with the Large Binocular Telescope to identify which atomic transitions are responsible for the decay in optical passbands, and generalize their contributions to the MIR photometric filters. From these observations, we find a correlation between the difference in the MIR filters and the early light curve width.

Lastly, we summarize these findings and discuss them in the framework of building a model for SN Ia explosions, identifying new routes for further research.