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Panchromatic Observations of SN 2011dh Point to a Compact Progenitor Star

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We report the discovery and detailed monitoring of X-ray emission associated with the Type IIb SN 2011dh using data from the Swift and Chandra satellites, placing it among the best studied X-ray supernovae to date. We further present millimeter and radio data obtained with the SMA, CARMA, and EVLA during the first three weeks after explosion. Combining these observations with early optical photometry, we show that the panchromatic dataset is well-described by non-thermal synchrotron emission (radio/mm) with inverse Compton scattering (X-ray) of a thermal population of optical photons. In this scenario, the shock partition fractions deviate from equipartition by a factor, (e_e/e_B) ~ 30. We derive the properties of the shockwave and the circumstellar environment and find a shock velocity, v~0.1c, and a progenitor mass loss rate of ~6e-5 M_sun/yr. These properties are consistent with the sub-class of Type IIb SNe characterized by compact progenitors (Type cIIb) and dissimilar from those with extended progenitors (Type eIIb). Furthermore, we consider the early optical emission in the context of a cooling envelope model to estimate a progenitor radius of ~1e+11 cm, in line with the expectations for a Type cIIb SN. Together, these diagnostics are difficult to reconcile with the extended radius of the putative yellow supergiant progenitor star identified in archival HST observations, unless the stellar density profile is unusual. Finally, we searched for the high energy shock breakout pulse using X-ray and gamma-ray observations obtained during the purported explosion date range. Based on the compact radius of the progenitor, we estimate that the breakout pulse was detectable with current instruments but likely missed due to their limited temporal/spatial coverage. [Abridged]

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