The James Webb Space Telescope Captures the Dusty SN 2013ej

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Motivation — studying dusty CCSNe

Core-collapse supernovae (CCSNe) are special astrophysical laboratories that have long been considered contributors to the cosmic dust budget. These dust grains are fundamental building blocks of several objects of the Universe. However, the contribution of different sources is partially understood. The role of SNe is not entirely known and could be significant, especially at high redshift. Studying CCSNe gives valuable insight into the environments where dust formation may occur.

The SN 2013ej & methods

Recently, observations from the *James Webb Space Telescope* (JWST) confirm that CCSNe form a considerable amount of dust. We present the late-time dust evolution of the well-studied SN 2013ej using high-quality data from the **JWST** (GO-2666, GO-1783, and GO-2107) and the **Keck** telescopes. The JWST provides mid-infrared (IR) data, while Keck traces the asymmetries in optical line profiles induced by dust grains in the SN ejecta. Previously, the SN 2013ej showed signs of ongoing interaction with the circumstellar matter (CSM) and the presence of warm dust.

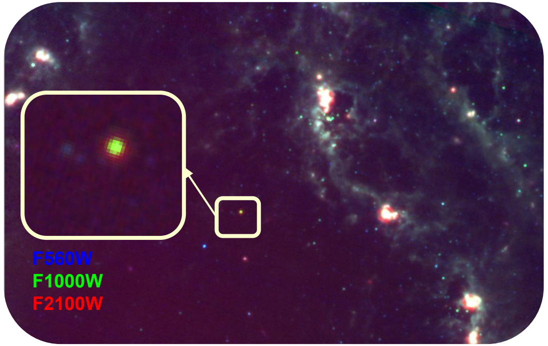
We investigate the late-time evolution and possible origins of dust grains in the environment of the dusty SN (e.g., dust in the SN ejecta or the cold dense shell, CSM dust). We apply analytical and numerical dust models to analyze the photometric and spectroscopic data.

Main Takeaways

The mid-IR models uncovered a **significant amount of dust** in the environment of the SN, **even in** these **later phases**.

Optical spectra could reveal **a large amount of cold dust** in the vicinity of CCSNe that **is hidden** at mid-IR wavelengths.

By studying the dust parameters in well-studied SNe like SN 2013ej, we can improve our understanding of the dust formation efficiency in other CCSNe.



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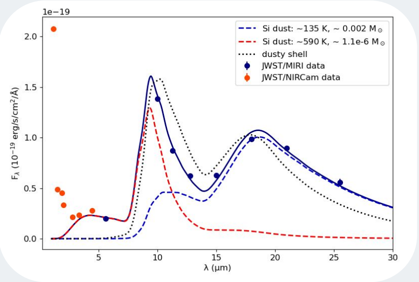

Figure 1: We present the JWST data with the most probable two-component model from our Bayesian analysis, assuming a spherically symmetric dust-containing region (Zsíros et al. in prep.). The dashed blue line represents the warm, while the red line shows the hot dust component. The model describes a **~135 K, ~0.002 $M_\odot$** silicate-rich dust in the environment of the SN. The NIRCam data are most likely to be affected by line emission.

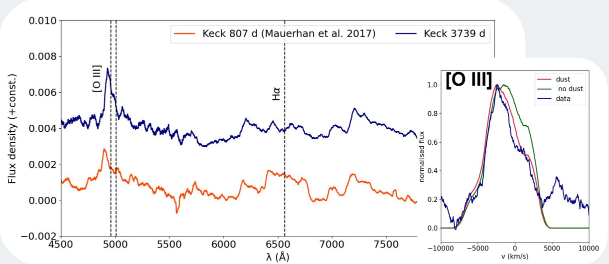

Figure 2: The late-time Keck/LRIS spectrum of the SN (Zsíros et al. in prep.) reveals emission line asymmetries indicating the presence of a significant amount of dust. (The Keck 807-day data is from Mauerhan, J. C. et al. 2017, ApJ, 834, 118). We modeled the **[O III]** emission line using the **DAMOCLES** radiative transfer code (Bevan, A. & Barlow, M. J. 2016, MNRAS, 456, 1269; Bevan, A. 2018, MNRAS, 480, 4659). We also found that the [O III] emission line can be described by a dusty shell comparable in size to that resulting from fitting the mid-IR emission of the SN (represented with a dotted line on Fig. 1).

Figure 3 shows a collection of numerous literature dust values for CCSNe (data adopted from Roger Wesson's homepage: https://nebulousresearch.org/dustmasses/). The blue stars mark the dust mass obtained from this work. The dashed line represents a sigmoid function (adopted from Wesson, R. et al. 2015, MNRAS, 446, 2089) to describe dust mass evolution.