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Resolved dust analysis of two iconic Galactic supernova remnants: Cassiopeia A and the Crab Nebula

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The large reservoirs of dust observed in some high redshift galaxies have been hypothesised to originate from dust produced by supernovae (SN). Theoretical models predict that core-collapse SN can be efficient dust producers (0.1-1 $M_\odot$) potentially responsible for most of the dust production in the early Universe. Observational evidence for this dust production efficiency is however currently limited to only a few remnants (e.g., SN 1987A, Crab Nebula) that confirm this scenario.

We revisit the dust mass produced in Cassiopeia A (Cas A), a $\sim$ 330-year old O-rich Galactic supernova remnant (SNR) embedded in a dense interstellar foreground and background. We present the first spatially resolved analysis based on Spitzer and Herschel infrared and submillimetre data at a common resolution of $\sim 0.6'$ for this $5'$ diameter remnant following a careful removal of contaminating line emission and synchrotron radiation. We find a concentration of cold dust in the unshocked ejecta of Cas A and derive a mass of 0.3-0.6$M_\odot$ of silicate grains (+a minor contribution from carbon grains) freshly produced in the SNR. The cold SN dust component is mainly distributed interior to the reverse shock of Cas A, suggesting that part of the newly formed dust has already been destroyed by the reverse shock. We derive an interstellar+SN dust extinction map which towards Cas A gives average values of $A_V = 6-8$ mag, up to a maximum of $A_V = 15$ mag. We have modelled the mid-infrared to radio emission from the Crab Nebula with a broken power law synchrotron spectrum, and a warm+cold SN dust component. Dust grains in the Crab Nebula are distributed predominantly along dense filaments, mostly in the southern half of the remnant, and account for 0.02 to 0.17 $M_\odot$ of 40K carbon dust with the somewhat lower dust mass compared to previous Herschel-based estimates being due to a re-analysis of the synchrotron component contribution and SN dust temperatures using the latest Herschel SPIRE calibrations. In addition, we require an extra model component in the millimetre wavelength domain, which accounts for 25 to 35% of the emission at 1 to 3 mm. We discuss possible origins for this excess emission in the centre of the Crab Nebula; including spinning dust grains, a secondary synchrotron component, magnetic Fe-bearing dust particles and free-free emission from a hot plasma.

In conclusion, these updated dust mass estimates for Cas A and the Crab Nebula support the scenario of supernova dominated dust production at high redshifts.

Consider for a poster?

Primary author: DE LOOZE, Ilse (Universiteit Gent - University College London)

Presenter: DE LOOZE, Ilse (Universiteit Gent - University College London)

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