The dust mass in Cassiopeia A from a spatially resolved Herschel analysis

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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 from massive stars. Theoretical models predict that core-collapse supernovae (CCSN) 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 CCSN remnants (e.g., SN 1987A, Crab Nebula) that confirm this scenario.

We revisit the dust mass produced in Cassiopeia A (Cas A), a ∼330-year old O-rich Galactic supernova remnant (SNR) embedded in a dense interstellar foreground and background. We present the first spatially resolved analysis of Cas A based on Spitzer and Herschel infrared and submillimetre data at a common resolution of ∼0.6 arcmin for this 5 arcmin diameter remnant following a careful removal of contaminating line emission and synchrotron radiation. We fit the dust continuum from 17 to 500 micron with a four-component interstellar medium (ISM) and supernova (SN) dust model. We run different sets of SED models with varying dust composition ($MgSiO_3$, $Mg_{2.4}SiO_{4.4}$, $Mg_{0.7}SiO_{2.7}$, Al_2O_3, $CaAl_{12}O_{19}$, various types of amorphous carbon) for the warm and cold SN dust components.

We find a concentration of cold dust in the unshocked ejecta of Cas A and derive a mass of 0.3-0.5 Msun of silicate grains freshly produced in the SNR. Silicates are thought to dominate the dust composition in this O-rich remnant, with a possible contribution from carbon grains. For a mixture of 50% of silicate-type grains and 50% of carbonaceous grains, we derive a total SN dust mass between 0.4 M_{sun} and 0.6 M_{sun}. We can exclude $Mg_{0.7}SiO_{2.7}$, $CaAl_{12}O_{19}$ and Al_2O_3 as dominant dust species based on the elemental yields predicted for a core-collapse supernova with a 30 $M_{\odot}$ progenitor and the amounts required to match the observed SED. These dust masses estimates are higher than from most previous studies of Cas A and support the scenario of supernova dominated dust production at high redshifts. Our resolved analysis shows that 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 furthermore derive an interstellar extinction map which towards Cas A gives average values of A_V = 6-8 mag, up to a maximum of A_V = 15 mag.