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Hydrodynamic Simulations of Dust Destruction in Supernova Remnants

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Sub-millimetre observations of galaxies at redshift z>6 have revealed dust masses of up to 10^8 solar masses (e.g. Bertoldi and Cox, 2002). As such systems are thought too young for significant dust enrichment by asymptotic giant branch (AGB) stars to have occurred, core-collapse supernovae (CCSNe) have been suggested as possible alternative dust producers (Nozawa et al. 2003, Dwek et al. 2007). This is supported by recent Herschel far-IR and sub-millimetre observations of young CCSN remnants that are estimated to show between 0.25-0.8 solar masses of cool dust in SN 1987A, Cassiopeia A and the Crab Nebula (Barlow et al. 2010, Matsuura et al., 2011, De Looze et al. 2017).

Once formed, the dust particles can be subjected to various erosion processes such as sputtering and grain-grain collisions (the latter subject to a separate contribution by F. Kirchschlager) due to the reverse shock generated by interactions between ejecta and circumstellar material. This can result either in the complete destruction of the grains or in a size reduction. Whether significant quantities of dust can survive these conditions long enough to be incorporated into the interstellar medium (ISM) has been the subject of multiple recent studies (Nozawa et al. 2006, 2007, Silvia et al. 2010, 2012, Bocchio et al. 2016). The predicted dust survival rates vary greatly and models tend to adopt ISM-like grain size distributions dominated by small particles. However, recent determinations of ejecta dust size distributions (e.g. Wesson et al. 2015, Bevan et al. 2017) have indicated that larger (~1 micrometer radius) particles may dominate.

In this study, I investigate the survival rates of dust produced in CCSNRs through (magneto)hydrodynamic (MHD) shock simulations carried out with the publicly available AMR codes ENZO (Bryan et al. 2014) and AstroBEAR (Cunningham et al. 2009). The MHD models feature a cloud of dense gas (clump) embedded in a less dense ambient medium through which a shock propagates. As the shock travels through the computational domain, it collides with the clump and accelerates, compresses and heats the gas contained within. Following Silvia et al., 2010, we introduce parcels of dust in post-processing using a code developed at UCL. Each dust parcel contains a realistic dust grain size distribution and is advected alongside the gas flow. Sputtering effects (based on Tielens et al., 1994) then lead to a redistribution of grain sizes in the dust parcels.
I present preliminary results featuring purely hydrodynamic simulations in 2D with realistic dust grain radii distributions and sputtering rates.

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