Hydrodynamic Simulations of Dust Destruction in Supernova Remnants

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Dust plays a significant role in the composition and evolution of the universe and has long since been believed to be mainly formed in the atmosphere of asymptotic giant branch (AGB) stars. However, recent observations of high redshift galaxies (z>6) have revealed dust masses of the order of 10^8 M_{sun} (Bertoldi et al. 2003). As such systems are far too young for dust enrichment by AGB stars, alternative dust factories need to be considered. One such possible dust factory that could explain the presence of large amounts of dust in the early universe is the core collapse supernova (CCSN) which is estimated to produce up to 0.7 M_{sun} of dust (Matsuura et al. 2011). How much of the so produced dust survives has been the subject of many studies, such as Jones (1994) and Nozawa et al. (2007), who found a grain lifetime of 400 to 600 million years for silicate and carbon grains and a complete destruction of grains with a radius below 10^{-4} μm for all grain species respectively.

In this study, we aim to investigate through (magneto)hydrodynamic (MHD) simulations how much of the dust produced during a CCSN explosion can survive the reverse shocks in the supernova remnant (SNR). To determine whether CCSNe could be the dominate producers of dust in the early universe, we will consider various grain radii, heating, sputtering, grain-grain collisions and the effect of magnetic fields to estimate the lifetime of dust grains in such a volatile environment.

Our simulations are performed using the grid-based MHD codes PLUTO (Mignone et al. 2012) and ENZO (Bryan et al. 2014). We insert a cloud of gas populated with tracer particles into an ambient medium representing the SNR and analyse their evolution as shocks impact the gas cloud. Grain distributions are then assigned to each tracer particle retrospectively and sputtering effects as well as grain-grain collisions are considered during post-processing.

We present our preliminary results for purely hydrodynamic simulations in 1D and 2D, including the time evolution of one dimensional density profiles and two-dimensional density maps as well as initial 2D tests featuring external tracer particles.