Dust destruction in supernova remnants and in the ISM

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Supernova remnants (SNRs) are pivotal players in the galactic dust cycle - producing dust in their ejecta while simultaneously destroying it through powerful shocks. Understanding how much dust survives these environments is critical for explaining dust enrichment in galaxies across cosmic time. This is particularly relevant for high-redshift galaxies, where SNe are thought to dominate dust production due to the short lifetimes of massive stars and the limited contribution from evolved stars. However, the survival fraction of dust grains remains highly uncertain, with predictions ranging from near-complete destruction to substantial preservation.

In this talk, I will present recent results from dust destruction simulations in both clumpy supernova ejecta and the turbulent, magnetized ISM. Using our dust post-processing code *Paperboats*, we analyze high-resolution MHD simulations to study dust grain evolution across a wide range of physical conditions. Our model includes an unprecedented number of physical processes, making it uniquely comprehensive in the field. Notably, grain-grain collisions - often neglected in previous studies - are found to play a critical role in dust destruction, both in SNRs and in the ISM. This expanded physical treatment allows for significantly improved estimates of dust survival rates. In addition, we generate synthetic dust density maps from our simulations, providing a novel tool for connecting theoretical predictions with observational data.

We find that dust destruction in SNRs depends sensitively on the density contrast between ejecta clumps and the surrounding gas. In addition to dust-specific factors such as grain size and composition, the magnetic field strength and orientation influence destruction by shaping shock dynamics and grain trajectories. Accurate estimates of dust survival therefore require detailed knowledge of grain properties, clump structures, magnetic fields, and the ejecta evolution. Furthermore, grain-grain collisions act synergistically with sputtering to enhance overall destruction. In a turbulent, magnetized ISM, dust destruction by forward shocks is significantly reduced compared to a homogeneous medium. However, the total dust mass destroyed under these conditions still far exceeds the amount expected to form in SNR ejecta.

Whether we aim to model dust destruction in the subgrid physics of galaxy simulations, interpret observations of SNRs, or gain a deeper understanding of the dust lifecycle, it is essential to accurately determine how dust responds to shocks under a range of astrophysical conditions. This work contributes to a more unified and predictive framework for dust evolution. The insights are critical for interpreting current and future observations and for developing consistent models of cosmic dust evolution across diverse astrophysical environments.