On the Structure of Supernova Dust Aggregates

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Abstract:

Recently the James Webb Space Telescope has observed dust in galaxies out to $z \simeq 8$, and galaxies with considerable metalicity out to $z \simeq 14$. Yet the source of this high redshift dust is not well understood, as the two main dust producers we observe locally become problematic. At these extreme redshifts, Asymptotic Giant Branch stars have not yet had enough time to evolve to a state where they experience a large outflow of material where dust can form. Additionally, dust produced in supernova remnants needs to survive the supernova reverse shock in order to enter into the ISM, but estimates for reverse shock dust destruction remain uncertain and range anywhere from 0-99%.

One key to this problem may be dust aggregates. So far, simulations of reverse shock dust destruction treat dust as single particle grains, since the structure of dust aggregates formed in such an environment has not been directly studied.

To better understand the structure of dust aggregates formed in a supernova remnant we have performed Discrete Element Method simulations of dust coagulation with our code DECCO (Discrete Element Cosmic COllision). In these simulations, we randomly place single grains in a volume with periodic boundary conditions. These grains are then given a thermal velocity in a random direction and the simulation plays out. The simulation ends either when all grains are in a single aggregate, or a certain amount of time has elapsed.

By studying the structures of the final aggregates, this information can inform reverse shock dust destruction simulations and help paint a better picture of how much dust is destroyed.