Dust dynamics in the interstellar medium

Tom Hendrix[1] and Rony Keppens[1]

[1]*Centre for mathematical Plasma-Astrophysics, KU Leuven, Belgium*

Dust particles have a large (and often unknown) variety of sizes and compositions, therefore including the effect of dust in the analysis of the dynamics of dust containing systems causes a significant increase in the complexity of numerical and analytical analysis. This often results in assuming either strong coupling between dust and gas fluids or a single dust grain size in the calculations. In this way, the importance of the size distribution and different compositions of dust grain is ignored. Including these in full dynamical simulations is an important step for understanding the effect of dust on the dynamics of astrophysical fluids on the one hand, and on the other hand is of importance in confronting simulations with observations of dust emission.

To study the effect of dust on the dynamics of astrophysical fluids, we use the multi-fluid gas+dust MPI-AMRVAC[1] code, which allows including a dynamical size distribution and different dust compositions. This is done by allowing for multiple dust fluids in a single simulation, each having different dust grain properties. We will elaborate on how dust tends to alter the formation of one of the most frequently encountered instabilities in astrophysical fluid dynamics, the Kelvin-Helmholtz instability (KHI). From both 2D and 3D simulations we infer how these instabilities can increase the local dust density by several orders of magnitude[2]. Also, a clear dependency on dust sizes is seen, with larger dust particles displaying significantly more clumping than smaller ones. We connect our finding of the dusty KHI to observations of molecular clouds and see how the KHI may explain some of the features in these observations. To do so, we have coupled the output of the MPI-AMRVAC code with the SKIRT radiative transfer code[3] which allows us to compare observations and simulations directly.

Ultimately we take the lessons learned from studying dusty instabilities and apply these to the dynamics of dust formation in binary Wolf-Rayet star systems, where colliding wind interactions give rise to dusty spiral patterns observed at infrared wavelengths.

[1]`https://gitorious.org/amrvac`; Keppens, R. et al. 2012, JCP, 231, 718

[2]Hendrix T. and Keppens R. 2014, A&A, 562, A114

[3]Baes, M., Verstappen, J., De Looze, I., et al. 2011, ApJS, 196, 22