Dust Entrainment in External Photoevaporative Winds: Theory and Observation

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The environment in which circumstellar discs evolve plays a crucial role in their evolution, and the eventual formation of planets. Stars commonly form in stellar clusters, so most discs and planets form in environments with at least some external radiation, which irradiates the gas and dust in these discs. An important, but under-studied aspect of this is what sizes of dust get entrained in the disc wind. This affects the amount and position of planet-forming solids, as well as having a feedback-loop effect by shielding the disc from further UV radiation. We hence need to understand the grain sizes and amounts that are entrained in winds to understand gas and dust mass loss rates from these discs.

We have developed a particle solver to track the entrainment of dust in multi-dimensional simulations of photo-evaporating discs. This code was benchmarked against Weidenschilling (1977) and we validated an existing analytic estimate in 1D by Facchini et al. (2016). However, we found the situation more complex for 2D axisymmetric models, with significant angular variation in entrained dust sizes between the midplane and above the disc surface. From the disc surface, only sub-micron dust was entrained, while up to 100μm dust grains could be entrained from near the midplane of the disc outer edge. Interestingly, however, as the opacity to UV radiation is dominated by smaller dust (on the order of 0.1μm), our models predict that the shielding should be uniform in all directions, even if the dust size distribution is not. This has implications for the structure of gas mass loss and observational characteristics of proplyds. For example, HST has observed dark lanes emanating from the outer edge of silhouette discs in Orion (e.g. Ricci et al. (2008)), but not from above the discs, consistent with the outcomes of our models.

Here, we present synthetic observations of these evaporated disc models at various wavelengths, including IR, optical and mm and discuss what can be learned from them. We will focus on recovering dust grain sizes from optical and IR images, as well as what can be learned about the dust composition and disc structure from spectra and mm images.