Radiation feedback in dusty clouds with two-fluid

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Abstract & Conclusions: We have investigated the impact of photoionization and radiation pressure on a dusty star-forming cloud by one-dimensional radiation two-fluid (gas and dust) hydrodynamic simulations, which include absorption and re-emission of photons by dust. We find that, when dust-to-gas mass ratio is low, radiation pressure creates dust-free gas-rich regions. This state has been predicted by Inoue (2002). For a high dust-to-gas mass ratio, a dust-free gas-rich region is not created and a dust-gas-free region (a vacuum region) is created. This difference seems to be caused by the amount of dust and the optical depth of dust within an expanding shell. First, when there is not enough dust to drag gas, the gas is left behind by dust. Second, when the optical depth of dust is not large enough and radiation pressure gradient force is not much stronger than thermal pressure gradient force, dust-free gas flows back to a vacuum region and the dust-free gas-rich region is created.

Methods: In our simulations, we place a radiation source at the centre of a spherically symmetric gas distribution. We solve the radiation transfer equation including following processes: chemical reactions, heating-cooling processes of gas, and radiation pressure. The species we include in our simulations are H, He, electrons, and dust. Since it is difficult to calculate the differential velocity between dust and gas, we use a first order approximation described by Laibe & Price 2014.

Results: To study radiation feedback in star-forming clouds, we model each cloud as a Bonnor-Ebert sphere. We present density and dust-to-gas mass ratio profiles of each cloud at $t = 0.18$ Myr in Fig. 1. The difference between Cloud 1 and 2 is the initial condition of dust-to-gas mass ratio. To investigate the effect of two-fluid treatment, we perform simulations with one-fluid and two-fluid. Simulations in which we solve hydrodynamics with two-fluid are labelled “two-fluid”. Simulations in which we solve hydrodynamics with one-fluid are labelled “one-fluid”. Our results show that the dust-free gas-rich region is created in Cloud 1 inside 12 pc. On the other hand, a dust-free gas-rich region is not created and simulation results with one-fluid and two-fluid are indistinguishable in Cloud 2.

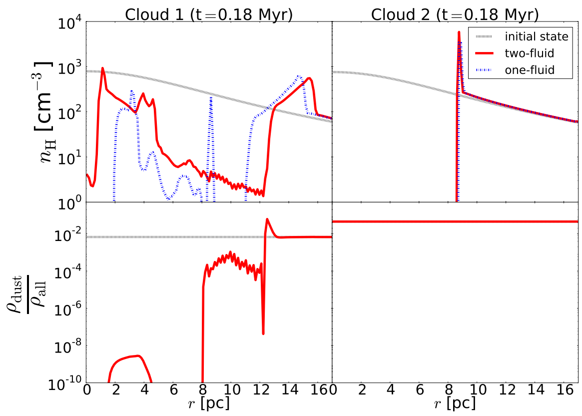

Figure 1: Density (top) and dust-to-gas mass ratio (bottom) profiles at t=0.18 My.