Impact of dust evolution on B-field diffusion in molecular cloud

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Dust grains in molecular clouds affect the gas ionization degree and the coupling between gas and magnetic fields by adsorbing ions and electrons in the gas phase. The degree of the coupling (so-called ambipolar diffusion) can be measured by the drift velocity $v_{\rm drift}$ between ions that perceive electromagnetic forces and neutral gas particles that do not.

Recently, Pineda et al. (2021) obtained the important results that the drift velocity between ions and neutrals is $\sim$ 100 ms^{-1} in a filamentary molecular cloud by the NH_3 and N_2H^+ line observations. This data provides important information to pin down the strength of the magnetic field, the ionization degree of the gas, and the dust size distribution (i.e., possible dust size evolution) in the molecular cloud.

In this study, we investigated whether the dust size distribution should vary in molecular clouds from the MRN size distribution in order to explain the observed drift velocity. To this end, we combined a dust size evolution code that takes into account accretion and coagulation with an ionization chemistry calculation code that determine the strength of ambipolar diffusion from the dust size distribution. Then, we calculated the expected drift velocity and compared it with the observed value.

We found that the presence of micron-size dust grain is essential for the drift velocity values to be consistent with observations at the cloud core scale. However, the dust growth to micron-size within the core requires 3-10 free fall time. The cloud core is unlikely to be maintained for such a long time because the core undergoes spherical gravitational collapse within 1-2 free-fall time.

On the other hand, we found that the dust can grow to 1 μm in size during the formation of cores from filamentary molecular clouds. This is because filament fragmentation requires a relatively long timescale (1–3 $t_{\rm ff}$) and filaments can exhibit trans/super-sonic turbulence which accelerates the dust coagulation.

These results suggest a scenario that the dust grains grow somewhere in the evolution from molecular clouds to cores, thereby enabling ion-neutral drift within the cores. In the presentation, we will also discuss the consistency between our results and estimated values for cosmic ray intensity and magnetic field strength.