Influence of grain growth on ices spectroscopic profiles

Modelling for dense cores and disks

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Interstellar dust grain growth in dense clouds and protoplanetary disks, even moderate, affects the observed interstellar ice profiles as soon as a significant fraction of dust grains is in the size range close to the wave vector at the considered wavelength. The continuum baseline correction made prior to analysing ice profiles influences the subsequent analysis and hence the estimated ice composition, typically obtained by band fitting using thin film ice mixture spectra. We explore the effect of grain growth on the spectroscopic profiles of ice mantle constituents, focusing particularly on carbon dioxide, with the aim of understanding how it can affect interstellar ice mantle spectral analysis and interpretation. Using the Discrete Dipole Approximation for Scattering and Absorption of Light, the mass absorption coefficients of several distributions of grains – composed of ellipsoidal silicate cores with water and carbon dioxide ice mantles – are calculated. A few models also include amorphous carbon in the core and pure carbon monoxide in the ice mantle. We explore the evolution of the size distribution starting in the dense core phase in order to simulate the first steps of grain growth up to three microns in size. The resulting mass absorption coefficients are injected into RADMC-3D radiative transfer models of spherical dense core and protoplanetary disk templates to retrieve the observable spectral energy distributions. Calculations are performed using the full scattering capabilities of the radiative transfer code. We then focus on the particularly relevant calculated profile of the carbon dioxide ice band at 4.27 μm. The carbon dioxide antisymmetric stretching mode profile is a meaningful indicator of grain growth. The observed profile toward dense cores with the Infrared space observatory and Akari satellites already showed profiles possibly indicative of moderate grain growth. The observation of true protoplanetary disks at high inclination with the JWST should present distorted profiles that will allow constraints to be placed on the extent of dust growth. The more evolved the dust size distribution, the more the extraction of the ice mantle composition will require both understanding and taking into account grain growth.

References

[1] 'Spectroscopic evidence of grain ice mantle growth in YSOs. I. CO ice modeling and limiting cases', Dartois, E. 2006, Astronomy & Astrophysics, 445, 959. doi:10.1051/0004-6361:20053239

[2] 'A Survey of H_2O, CO_2, and CO Ice Features toward Background Stars and low-mass Young Stellar Objects Using AKARI', Noble, J. A., Fraser, H. J., Aikawa, Y., et al. 2013, Astrophysical Journal, 775, 85. doi:10.1088/0004-637X/775/2/85

[3] 'Influence of grain growth on CO2 ice spectroscopic profiles. Modelling for dense cores and disks' Dartois, E., Noble J. A., Ysard N., Demyk K., Chabot M., submitted to Astronomy & Astrophysics