The Role of Heterogeneous Condensation on Dust Formation in Protoplanetary Disc

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The process of dust condensation in protoplanetary disc may be different from that in outflow of evolved stars because of much longer cooling time and higher total pressure. Condensation temperatures and grain size distributions are expected to be lower in rapid cooling and low pressure conditions.

Magnesium silicates and metallic iron are the most abundant dusts that form in O>C environments, although metallic iron is not observed by infrared spectroscopy. Previous dust formation models assume *a priori* that silicates and metal condense independently through homogeneous condensation. This assumption is, however, not guaranteed. In the present study, we investigate the role of heterogeneous condensation of Fe on previously condensed silicate and discuss the change of phases appeared and the grain size distribution.

The model is based on the kinetic condensation model by Yamamoto and Hasegawa (1987). The difference from their model is that we assume heterogeneous condensation of Fe on silicate when the supersaturation ratio of Fe gas reached 5, which is the number that we have obtained in our condensation experiments. The results are shown in the difference in final products. The assemblage of final products is divided into two cases in the space of total pressure and cooling time; (1) secondary Fo and Fe with Fo core (+/- En and SiO2), and (2) Fe with Fo core and SiO2. The grain size distribution is also obtained. The average (or typical) size increases with increasing cooling time, and the size distribution is generally less than an order.

The present work shows an important result that forsterite always condenses prior to Fe due to smaller surface tension, which prevents the reaction between forsterite and gas that is expected in an “equilibrium” model. This finally results in condensation of SiO2. The phases formed in young discs will be a mixture of Fo, En, SiO2, Fe on Fo, and Fe on En. This explains the infrared spectra that are well fitted by mixtures of several phases with size distribution. The abundant formation of grains with Fo core and Fe mantle may explain the spectra of some discs that show solely PAH, where most silicate components are coated by thick metal to show no silicate feature.