Formation of Silicates at Cryogenic Temperatures in the Presence of Carbon Molecules and Others

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The re-formation of dust grains in the interstellar medium (ISM) is expected to contribute to the existence of the observed populations. Interstellar grains are otherwise subjected to various destruction mechanisms altogether faster than their condensation in stellar outflows and subsequent injection into the ISM. The re-formation is thought to proceed through the accretion of atoms and/or molecules found in the interstellar gas phase, and chemical reactions that incorporate the accreted species into the grain.

As accretion is favored by higher gas-phase densities and lower temperatures, its efficiency increases from the cold regions of the diffuse ISM, where temperatures of ≈100 K prevail, to the heart of dense molecular clouds, where the temperature approaches 10 K. Taking into account the fact that interstellar dust comprises essentially carbonaceous grains and silicate particles, two issues arise in the re-formation scheme. First, one must explain how such specific materials are re-formed while the interstellar gas phase contains many different species. Second, one must determine what chemical reactions make the re-formation possible at temperatures as low as 10 K.

We have already reported experiments on the growth of silicates through the accretion of atoms and molecules cooled to cryogenic temperatures as they were initially isolated in Ne ice. These atoms and molecules, precursors of silicate matter, were silicon oxides and relevant metal atoms. The experiments have shown the formation of amorphous silicate matter at temperatures as low as 13 K during the annealing and evaporation of the doped Ne matrices (Rouillé et al. 2013, Krasnokutski et al. 2014, Rouillé et al. 2014).

In new experiments, Ne matrices were doped with the silicate precursors, to which carbon atoms and molecules (C_n, $n = 1$–10) were added. The matrices contained also significant amounts of H_2O, CO, CO_2, and C_3O molecules. We have observed that amorphous silicate matter is formed during the annealing and evaporation of the Ne ice despite the presence of the carbon molecules, the H_2O molecules, and the other species. The experiments will be presented and their relevance to the re-formation of silicate grains in the ISM will be discussed.

References

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