Laboratory Studies on Gas-Phase Condensation and Spectral Properties of Subnanometer and Nanometer-Sized Carbonaceous Matter

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Carbonaceous grains represent a major component of cosmic dust. In order to understand their formation pathways, as well as their structural, compositional, and spectral properties in different astrophysical environments, dedicated laboratory experiments combined with structural analyses are necessary.

Nanometer- and subnanometer-sized carbonaceous grains were prepared in the laboratory by gas-phase condensation reactions such as laser pyrolysis of gaseous hydrocarbons and laser ablation of graphite in quenching gas atmospheres. Two formation pathways with different precursors have been analyzed by studying the by-products and the structure of the final condensates. In a low-temperature (LT) condensation (below 1700 K), polycyclic aromatic hydrocarbons (PAHs) are found to be precursors and building blocks for condensing carbonaceous grains. Therefore, these condensates consist of a mixture of PAHs and grains. In the high-temperature condensation (above 3500 K), carbon chains, fullerene snatches and fullerenes are precursors for grain formation. Consequently, condensation products in cool and hot astrophysical environments, such as cool and hot AGB or Wolf Rayet stars, should be different.

The laboratory experiments demonstrated that a big variety of PAHs are produced in LT gas-phase condensation reactions. In the interstellar radiation field, a part of the condensed molecules such as smaller and less compact ones are likely destroyed. A mixture of remaining large PAHs and a few freshly produced smaller ones eventually contribute to the observed spectral signatures of cosmic carbonaceous matter such as the interstellar UV bump, the UIR bands and the extended red emission. We will demonstrate that a mixture of PAH molecules and clusters have similar spectral properties in the UV/vis spectral range as carbon soot grains.

Keywords: carbonaceous dust; laboratory astrophysics; circumstellar dust, interstellar dust