Research internship for Master 2 Nuclei, Atoms and Collisions

2018-2019

Molecular growth inside of clusters of hydrocarbons induced by ion collision: application to planetary atmospheres

From the last decades, it appears that we are living in a molecular universe with the observation of about 200 molecules in space from the simplest H_2 to fullerenes made up of 60 to 70 carbon atoms. The understanding of the growth mechanism of such complex molecules is of prime importance for the physical chemistry of different astrophysical environment, including the planetary atmospheres such as the one of Titan a moon of Saturn. For instance, in the case of fullerene, two approaches are considered. On the one hand, in the "*bottom-up*" one, the typical football carbon cage is made up starting from small carbon molecules. On the other hand, in the "*top-down*" perspective, a large carbonaceous matter (grains) is physically processed by stellar radiation (photons, electrons, ions). Therefore, in order to understand the rich molecular inventory, laboratory astrophysics is required to study cold chemical reactions and to simulate the interaction of radiation with the molecular species present in space. Among the radiations, ions show a peculiar interest due their relatively high mass. Thus, in addition to the interaction with the molecular electronic cloud, atomic projectiles could also interact with molecular nuclei in binary collisions.

Recently, we have shown that a rich molecular growth could be induced inside of molecular clusters by the collision of an ion. Such growth processes have been observed in clusters of polycyclic aromatic hydrocarbons (PAH) [1] and in clusters of fullerenes [2].

In the present internship, we propose to extend these studies to small linear hydrocarbons in order to look for the formation of the primary aromatic rings which are the building blocks of PAH and fullerenes. These studies aim to address more specifically the physical chemistry of planetary atmospheres where small hydrocarbons are present. For instance, the typical haze observed on Titan is due to the formation of aerosols.

The trainee will become familiar with the experimental methods to generate molecular clusters and to study their interaction with ion beams. The experiment will be performed using both the beams delivered by ARIBE, the low-energy ion beam facility of GANIL and an independent ion source. She/he will strongly interact with the team PhD student and further continuation in thesis is foreseen.

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[1] R. Delaunay et al., *J. Phys. Chem. Lett.* **6** (2015) 1536-1542.
[2] R. Delaunay et al., *Carbon* **129** (2018) 766-774.