PHD position in Laboratory Astrophysics
(open in September 2021)

Title : The rôle of radicals in the growth of the molecular complexity on interstellar dust grains

Supervisor : prof F. Dulieu (LERMA, University of Cergy-Pontoise & Paris Observatory, France)

Scientific context

One of the major questions in modern physics is how life emerged on Earth and whether it is a general characteristic of our Universe. At the bottom line, life is an extreme complication of chemistry. Thus, the Noble prize winner C. De Duve wrote that life is "a cosmic imperative" as "*The general conclusion is that the building blocks of life form naturally in our galaxy and, most likely, also elsewhere in the cosmos. The chemical seeds of life are universal*".

The question we aim to help answering with this project is: Is De Duve's last sentence really true?

We have now the instruments to tackle this problem and to understand how the blocks of life form, where and when in our Galaxy. In a few words, we can now determine how molecular complexity grows up in space, at its first stages.

In addition to its own interest, understanding molecular complexity in space helps to understand the link between the primitive nebula, the young Solar System and its small bodies, in which today we detect complex molecules and even amino acids (as in comets and meteorites), as well as the unexpected molecular oxygen unveiled by the in situ measurements of the Rosetta mission (Bieler et al. 2015). Where these molecules come from? How and where did they form? What do they tell us about the stars and planets formation processes? And at last, but not the least, atoms and molecules are the remote thermometers and barometers, as their observed line spectra can and are used to extract a mine of precious and often unique information.

Our specific goal is to understand how molecules diffuse, meet and mate on grains in order to assess what COMs are formed on them and how. In this project, we focus on the grain surface chemistry and, specifically, on the role of radicals in the formation of some test COMs. This is a crucial first step to assert the degree of molecular complexity achievable in the de Duve's cosmic bricks.

Methods

Our team owns two state-of-the-art experimental set-ups (FORMOLISM and VENUS), which have been very productive the last years. Radicals are produced in plasma sources (up to 4 at the same time), and are aimed at the substrate UHV chamber, through a triple stage differential pumping. New molecules produced at low-temperature on interstellar analogues are detected by quadrupole mass spectroscopy, Fourier transform infrared spectroscopy or resonance enhanced multiphoton ionization. (http://lerma.obspm.fr/spip.php?article48). FORMOLISM has been adapted to the study of PAH (movable coronene oven and possibility to go to "high" temperatures (750K)). VENUS is more devoted to the study of ice and complex molecules. The overlap is large, and depending on the study, each apparatus propose both advantages and defaults.

The general idea for a new generation of chemical compounds is to favor experimental conditions where radical-radical reactions can take place. There are two ways to undergo such conditions. The first one is to achieve radical beams, (for example beam made of CH_3, OH or HCO...), and to merge them on the surface. It is an important technological move. The second way is directly in line with our current expertise and consist in producing in-situ various amount of radicals, and to compare their products (see Nguyen PHD thesis 2018 https://cylerma.cyu.fr/version-francaise/publications/theses-soutenues)

Application

Applicant must have a master degree in Science, especially in Astrophysics, Physics or Chemistry at the beginning of the contract. An experience (Internship, master diploma...) in experimental physics would be an effective positive aspect of the application. Applicant must have excellent communication skills in English (oral and written).

Applications should be constituted of a detailed CV and a letter of motivation. The candidate should furthermore arrange for a recommendation letter from a professor familiar with the applicant to be sent to Prof. Dulieu. A remote interview will be organized for shortlisted applicants.

The offer will close later, as soon as one eligible and selected candidate accepts the job.

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