Interstellar PAHs: a challenge for molecular physicists

Christine Joblin[1]

[1] *IRAP (Institut de Recherche en Astrophysique et Planétologie), Université de Toulouse; CNRS; 9 Av. Colonel Roche, BP 44346, Toulouse 31028 Cedex 4, France*
christine.joblin@irap.omp.eu

Polycyclic aromatic hydrocarbons (PAHs) have been proposed 30 years ago to be a ubiquitous component of cosmic matter [1-3]. Interstellar PAHs absorb ultraviolet (UV) photons from stars and reemit this energy in the so-called Aromatic Infrared Bands (AIBs). They play a key role in the heating of the gas by photoelectric effect, the ionisation balance and the chemistry. Astronomers consider PAHs as the smallest in size dust particles and they use the AIB spectrum as a diagnostic in regions of star formation from the small scales of protoplanetary disks to the large scales of galaxies. However, although the large carbonaceous molecule, fullerene $C_{60,}$ and its cation were detected in cosmic environments ([4] and references therein), not a single individual PAH species has been identified so far. PAHs represent a large class of species and their identification has to be guided by a better understanding on where interstellar PAHs come from and how they evolve due to processing by UV photons and shocks, and to interactions with electrons, gas and dust. In addition, the photophysics/chemistry of PAHs in space involves long timescales due to the extreme isolation conditions that prevail in these environments. The study of these processes has stimulated the development of dedicated laboratory setups such as cryogenic ion traps and of theoretical simulations at the forefront of molecular physics.

In my presentation, I will describe how our understanding of the interstellar PAH population is progressing thanks to a synergy between laboratory astrophysicists and molecular physicists. I will illustrate how recent studies on the relaxation of energized PAHs [5] and on the anharmonicity on the IR emission features [6] can help us retrieve the key physical parameters that are needed to model observations. These studies have been extended to related systems such as PAH clusters or PAH-metal complexes [7-9], which are also likely to be found in cosmic environments. Finally, I will briefly describe some perspectives in the framework of the starting ERC Synergy project Nanocosmos [10].

[1] A. Léger, J. L. Puget, *Identification of the 'unidentified' IR emission features of interstellar dust?*, Astron. & Astrophys. **137**, L5 (1984)

[2] L. J. Allamandola, A. G. G. M. Tielens, J. R. Barker, *Polycyclic aromatic hydrocarbons and the unidentified infrared emission bands - Auto exhaust along the Milky Way*, Astrophys. J. **290**, L25 (1985)

[3] *PAHs and the Universe: A Symposium to Celebrate the 25th Anniversary of the PAH Hypothesis*, C. Joblin and A.G.G.M. Tielens eds, EAS Publications Series, vol. 46, (2011)

[4] O. Berné, G. Mulas, C. Joblin, *Interstellar* C_{60}^{+}, Astron. & Astrophys. **550**, id.L4, 5 (2013)

[5] S. Martin, J. Bernard, R. Brédy, B. Concina, C. Joblin, M. Ji, C. Ortega and L. Chen, *Observation of fast radiative cooling of Anthracene in a compact electrostatic storage ring*, Phys. Rev. Lett. **110**, id. 063003 (2013)

[6] O. Pirali, M. Vervloet, G. Mulas, G. Malloci, C. Joblin, *High resolution absorption spectroscopy of thermally excited naphthalene in the infrared and far infrared spectral régions. Measurements and calculations of anharmonic parameters and vibrational interactions*, Phys. Chem. Chem. Phys. **11**, 3443 (2009)

[7] A. Simon, M. Rapacioli, M. Lanza, B. Joalland and F. Spiegelman, *Molecular dynamics simulations on [FePAH]$^+$ π-complexes of astrophysical interest: anharmonic infrared spectroscopy*, Phys. Chem. Chem. Phys. **13**, 3359 (2011)

[8] A. Simon and C. Joblin, *Photodissociation of [$Fe_x(C_{24}H_{12})_y$]$^+$ complexes in the PIRENEA set-up : iron-PAH clusters as good candidates for interstellar very small grains*, J. Phys. Chem. A **113**, 4878 (2009)

[9] M. Rapacioli, A. Simon, L. Dontot, F. Spiegelman, *Extensions of DFTB to investigate molecular complexes and clusters*, Phys. Status Solidi B **249**, 245 (2012)

[10] http://www.icmm.csic.es/nanocosmos/