Report from the Workshop
"Physical and chemical processes of astrophysical interest"
held in Saint Florent, France (Haute-Corse)
June 11-14, 2019

Participants: C. Alcaraz, M. Alexander, L. Biennier, C. Bop, N. Bouhafs, E. Bron, S. Carles, E. Dartois, B. Desrousseaux, A. Faure$^{(*)}$, C. Favre, R. Georges, G. Guillon, P. Gratier, M. Hochlaf, E. Josselin, V. Kokoouline, F. Lique$^{(*)}$, J.C. Loison, J. Loreau, M.A. Martin, O. Poch, O. Roncero, T. Stoecklin, X. Urbain, A. Zanchet
$^{(*)}$ alexandre.faure@univ-grenoble-alpes.fr, francois.lique@univ-lehavre.fr

Scientific organizing commitee: A. Faure, F. Lique, O. Roncero

The ionic composition of astrophysical environments has always attracted close attention. Indeed, despite their low fractional abundance ($\sim 10^{-4} - 10^{-8}$ in the interstellar medium), both atomic and molecular ions play a crucial role in the chemical and thermal balance of the gas, its ionization state and its coupling with the ambient magnetic field. Among the more than 200 molecules detected in the interstellar gas, about two dozens are cations (from CH^+ to C_{60}^+ and very recently HeH^+) and half a dozen are anions (from CN^- to C_8H^-). In interstellar ices, OCN^- and NH_4^+ have been tentatively identified. While the kinetics of simple protonation reactions is well understood, a variety of ion-neutral, ion-ion and ion-electron reactions remain poorly characterized. The excitation of molecular ions also poses a severe theoretical challenge because these species are often reactive with the dominant colliders (H, H_2 and free electrons). In addition, the laboratory rotational spectra of many molecular ions are unknown, which precludes their identification in space.

The fifth Workshop "Processus physico-chimiques d'intérêt Astrophysique" was held in St Florent, France (Haute-Corse), June 11-14 2019, and was devoted to the *chemistry and excitation of ions*. Following the success of the previous editions, the aim of this new workshop was once again to bring together experts from both the laboratory astrophysics and observational communities to discuss the current status and the new challenges of interpreting the growing amount of observational data on molecular ions. The scientific program has consisted of 23 invited talks and many informal discussions. The spectroscopy, collisional excitation and gas/solid-phase reactivity of ions were discussed together with their current and future observations. We have identified the following (obviously non-exhaustive) list of topics to be addressed in future experimental, theoretical and modelling studies:

- Laboratory spectroscopy of the protonated forms of abundant species (with support from theory)
- Kinetics of reactions proceeding by tunnelling through a barrier (e.g. isotope exchange reactions)
- Kinetics and state-selectivity of ion-neutral reactions, including radiative associations
- Laboratory spectroscopy of salts and their counterions in ices
- Inelastic and reactive scattering of polyatomic reactive ions
- Dissociative recombination of large polyatomic molecular ions with determination of their product branching ratios (e.g. via statistical theories)
- Composite theoretical schemes for the derivation of accurate spectroscopic data of medium-sized and large molecular species
- Search for robust tracers of the ionization fraction in various astronomical objects (via statistical approaches such as random forests)
- Search for new chemical pathways for the formation of anions