Experimental and theoretical needs for the JWST Early Release Science Program on radiative feedback from massive stars (PDRs4ALL) II. an experimental perspective

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Massive stars disrupt their natal molecular clouds by dissociating molecules, ionizing atoms and molecules, and heating the gas and dust. These processes drive the evolution of interstellar matter in our Galaxy and throughout the Universe, from the era of vigorous star formation at z=1-3 to the present day. Much of this interaction occurs in Photo-Dissociation Regions (PDRs) where far-ultraviolet photons from these stars create a largely neutral, but warm region of gas and dust. PDR emission dominates the IR spectra of star-forming galaxies and provides a unique tool to study the physical and chemical processes that are relevant for inter- and circumstellar media, including diffuse clouds, molecular cloud and protoplanetary disk surfaces, and starburst galaxies.

The ERS program ID1288 is dedicated to provide template data and data processing and analysis tools for studying PDRs. To this end, it has observed the Orion Bar, the proto-typical PDR situated in the nearby Orion Nebula, using NIRSpec IFU, MIRI IFU (TBD), and NIRCAM and MIRI imaging. These observations, for the first time, spatially resolve and perform a tomography of the PDR, revealing the individual IR spectral signatures from the key zones and sub-regions within the ionised gas, the PDR, and the molecular cloud.

In this talk, we present an overview of laboratory work crucial for maximising the scientific return of this program. Experimental techniques to investigate important species in PDRs, such as Polycyclic Aromatic Hydrocarbons (PAHs), will be presented. These can provide essential data on spectral fingerprints, photo-induced ionisation, fragmentation, isomerisation, and more. They can also provide insight into the molecular physics at play, from (non-)radiative processes and lifetimes to anharmonic behaviour. This is well-illustrated by the strong anharmonicity in PAHs reported recently, which greatly affects reaction rates and astronomical models, and the recent insights into isomerisation, such as formation and destruction of species with 5-membered rings. Advanced techniques, such as IRMPD spectroscopy, IR-UV double resonance spectroscopy, zero-electron kinetic-energy spectroscopy, ultrafast spectroscopy, ion-storage ring experiments, and combinations thereof, have opened the way towards studies going beyond the small and symmetric species, i.e., large and isomeric species. Moreover, the experimental advances and insights gained in the molecular physics involved are widely applicable, with possible impact on research fields complementary to and other than astrochemistry.