Understanding PDRs through multiline diagnostics

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Far-ultraviolet photons (FUV; E < 13.6 eV) from OB-type massive stars regulate, or at least influence, the heating, ionization, and chemistry of much of the neutral ISM in galaxies. These environments are broadly known as "photodissociation regions" (PDRs). The interaction between FUV photons and interstellar matter triggers a plethora of gas/PAH/grain microphysical processes. Throughout the last decades, more and more sophisticated observations of PDR environments have generated a good deal of theoretical, laboratory, and numerical models to understand these processes.

PDR line tracers are the smoking gun of the radiative feedback from massive stars. These feedback processes take place at very different spatial scales: from hundreds of AU at the bright rims of FUV-illuminated molecular clouds, to kpc-scales in spatially unresolved starburst galaxies. Improving our understanding of these environments, determining their physical conditions, and quantifying their energy budget and chemical composition requires a multi-wavelength spectroscopic approach.

Last years have seen rapid progress in specific techniques involving spectral-imaging: ***i.*** Increased angular resolution in interferometric mosaics, providing astonishing sub-arcsecond resolution images of the extended ISM emission, **ii.** Broader instantaneous bandwidth of heterodyne spectrometers, allowing us to map many molecular lines simultaneously or to carry out deep spectral line surveys in reasonable observatory times, and **iii.** Development of multi-pixel receivers, able to acquire square-degree, velocity-resolved (sub-km s^{-1}) images of the ISM in the emission from abundant molecules, and also in the brighter atomic cooling lines [OI]63um and [CII]158um at higher FIR/THz frequencies.

As a consequence, current research in PDRs is not only about the detailed study of small fields in a few nearby prototypical PDRs such as the iconic Orion Bar or the Horsehead Nebula (from which we have learnt so much). It increasingly covers the global study, at pc-scales, of stellar feedback in the ISM of the Milky Way and of nearby galaxies (cloud dynamics and evolution, star-formation regulation, properties of the "CO-dark" molecular gas, etc.). Recent developments go as far as trying to understand the "PDR emission" from high redshift galaxies.

New models of dynamical PDRs and new MHD simulations including PDR processes are being developed to interpret these new observations. IRAM telescopes, their forefront instrumentation, and the variety of available observational techniques have clearly played a pivotal role in improving our understanding of the ISM and its underlying processes.