JWST ERS Program ID1288:

Radiative feedback from massive stars as traced by multiband imaging and spectroscopic mosaics.

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Massive stars disrupt their natal molecular cloud material by dissociating molecules, ionizing atoms and molecules, and heating the gas and dust (Fig. 1a,b). These processes drive the evolution of interstellar matter in our Galaxy and throughout the Universe from the era of vigorous star formation at redshifts of 1-3, to the present day. Much of this interaction occurs in Photo-Dissociation Regions (PDRs, Fig. 1c) 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. It also provides a unique tool to rigorously study the physical and chemical processes that are relevant for most of the mass in inter- and circumstellar media including diffuse clouds, protoplanetary disk - and molecular cloud surfaces, globules, planetary nebulae, and starburst galaxies. The global PDR emission results from an intricate combination of physical, chemical and dynamical processes. Hence, it is essential to spatially resolve a PDR with high spectral resolution and large wavelength coverage to fully understand the underlying processes. This is of paramount importance to interpret more distant star-forming regions. JWST will resolve and directly observe, for the first time, the response of PDR gas to the penetrating far-ultraviolet (FUV) photons in its key zones: the ionization front and the H I/H_2 photodissociation front, at unprecedented spectral and spatial detail over the full 1-28 μm range.

The primary goals of this ERS program are:

- Obtain the first spatially resolved, high spectral resolution observations of a PDR with well-defined UV illumination in a typical massive star-forming region using NIRCam, NIRSpec and MIRI
- Provide template data and science-enabling products for PDRs
- Guide the preparation of Cycle 2 proposals on star-forming regions in our Galaxy and beyond

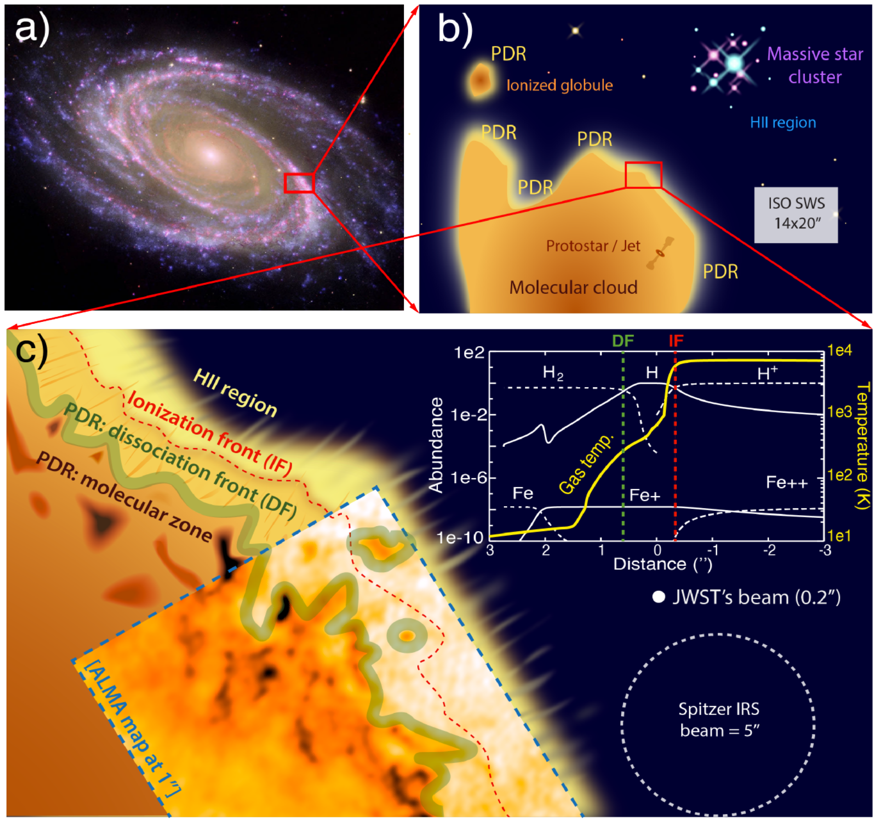

Figure 1: Zooming into a PDR. a) Multi-wavelength view of a Galaxy (M81): UV tracing massive stars (blue), optical light tracing H II regions (green), and PAH emission tracing PDRs (red). b) Sketch of a typical massive star-forming region (at a distance of 2 kpc). c) Zoom in on the PDR, showing the complex transition from the molecular cloud to the PDR dissociation front, the ionization front and the ionized gas flow. Inserted is the ALMA molecular gas data of the Orion Bar, at a resolution of 1" (dashed lines; Goicoechea et al., Nature, 2016). The inset shows a model of the structure of the PDR. The scale length for FUV photon penetration corresponds to a few arcsec. The beam sizes of ISO-SWS, Spitzer-IRS and JWST-MIRI are indicated. JWST will resolve the 4 key regions.

The Team

The philosophy of this ERS program has been, from the start, to be open to everyone with the objective to gather together the international community. Today, this has materialized into a large international and interdisciplinary team of 140 scientists from 18 countries. Figure 3 shows the detailed demographics. If you're interested in joining the team, register at **https://jwst-ism.org**.

The project is managed by three co-PIs (the PI team: O. Berné, E. Habart, E. Peeters) who will be responsible for overall coordination and for the distribution of the deliverables i.e. Data Products (DPs) and Science Enabling Products (SEPs). Both for coordination and delivery of DPs and SEPs, the PIs will be assisted by the core team (consisting of A. Abergel, E. Bergin, J. Bernard-Salas, E. Bron, J. Cami, S. Cazaux, E. Dartois, A. Fuente, J. Goicoechea, K. Gordon, Y. Okada, T. Onaka, M. Robberto, A. Tielens, S. Vicente, M. Wolfire).

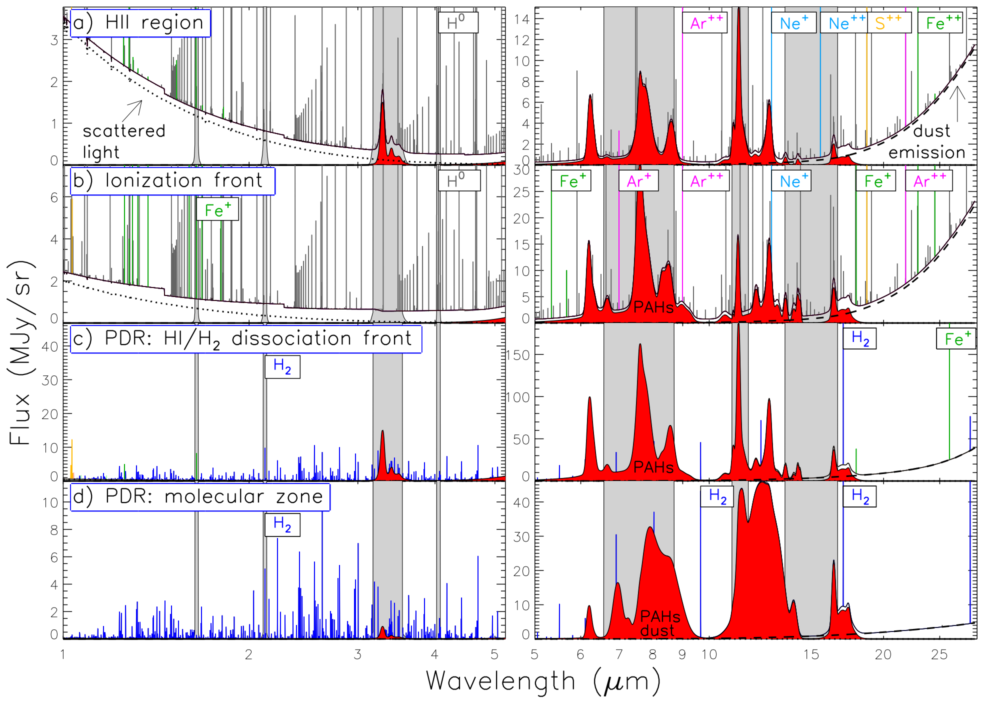

Figure 2: Model IR spectra of the 4 key regions within the interface of an H II region around a massive star (or cluster) and the natal molecular cloud (Fig. 1) illustrating the spectral richness that JWST will observe. Dust scattered light and continuum emission are shown in dotted and dashed lines. Ionic, atomic and molecular gas lines, PAHs and small dust bands are shown in colors. The band-passes of the photometric filters selected in this ERS program are shown in gray. Spectra have been calculated with the Meudon PDR code (Le Petit et al., ApJS, 2006), Cloudy (Ferland et al., PASP, 1998), DustEM (Compiégne et al., A&A, 2011) and PAHTAT (Pilleri et al., A&A, 2012).

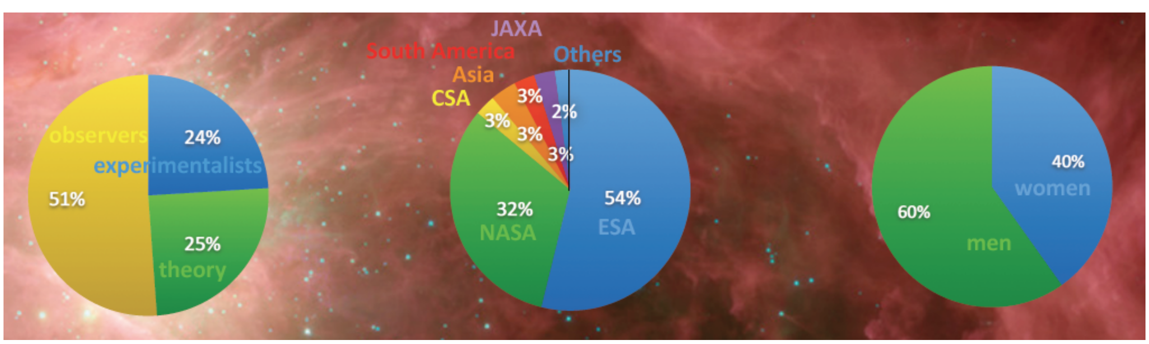

Figure 3: Detailed demographics of the ERS-PDR team.

The Observations

The current target (depending on JWST's launch date and thus the ERS window) is the archetypical nearby (d=414 pc) PDR, the Orion Bar. The observing modes are:

- **NIRSpec IFU moscaic:** 1–5.3 μm spectral map covering ~27"x3" at a spectral resolution of ~2700 and an angular resolution of 0.1"-0.2". The field of view (FOV) is positioned perpendicular to the PDR front to best trace the key zones in the PDR.

- **MIRI IFU mosaic:** 5-28.5 μm spectral map covering $\sim$27"x3" (similar as NIRSpec) at a spectral resolution of $\sim$1550–3250 and an angular resolution of 0.2" at 5 μm.
- **NIRCam imaging:** single pointing with the full array in bright mode for a 9.7 arcmin^2 FOV at an angular resolution of 0.1"–0.2" in the narrow and medium band filters 162M, 164N (probing [FeII] 1.64μm), 210M, 212N (probing H_2 1-0 S(1)), 300M, 335M (probing 3.3μm PAH band), and 405N, 410M (probing Brα), and the broadband filters 150W, and 444W.
- **MIRI imaging & NIRCAM parallel:** 3x3 mosaic with the SUB128 array for a $\sim$40"x40" FOV in the broad-band filters centered at 7.7, 11.3, 15, and 25.5 μm at an angular resolution of 0.2" at 5 μm.

The Science-Enabling Products

The program will provide the following products to the community:

- **P1 Enhanced data products:** i) maps of integrated lines/bands from IFU spectroscopy cubes; and ii) template spectra (H II region, ionization front, dissociation front, molecular zone) directly extracted from the observations or blind signal separation methods
- **P2 Products facilitating data reduction and manipulation:** i) spectral order stitching and stitched cubes; ii) cross-correlation of spectra & images; iii) pyPAHFIT to decompose the spectra into gas lines, dust features (aromatic/PAHs, aliphatics, fullerenes, silicates, ices), and dust continuum components (of all pixels in IFU maps); and iv) list of all the lines/bands present in the data
- **P3 Data-interpretation tools:** i) H_2 fitting tool for maps of T_{ex}, N_{H_2} and R_{otp}; ii) PDR model fitting tool for maps to search in massive grids of complete models and derive physical parameters from observations of any number of lines; iii) PAHdb Spectral Analysis Tool to decompose the PAH emission into contributing sub-populations (charge, size, composition, structure) using theoretical/laboratory IR cross section spectra from the NASA Ames PAH IR Spectroscopic Database; and iv) ionized gas lines diagnostic diagrams of key species for conversion of the lines intensities into physical conditions and extinction based on multi-level models or Cloudy.

Community Oriented Program

Telecons open to the community will be organized on a regular basis to disseminate data reduction, analysis techniques and recipes, best practices to design JWST proposals, and provided SEPs. We will organize the workshop "Galactic and extragalactic PDRs with JWST".

Join the team: https://jwst-ism.org