Warm molecular Hydrogen spectroscopy in the Horsehead Nebula with JWST

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H_2 is the most abundant molecule in the interstellar medium. Due to its excited form in irradiated regions, it makes it a useful tool to study photodissociation regions (PDR), where radiative feedback from massive stars on stellar formation is dominant. The James Webb Space Telescope (JWST), with its high spatial resolution and good spectral resolution, provides unique access to the analysis of the spatial morphology of H_2 and thus to the spatial variation of physical parameters throughout the PDR.

In this contribution, I will present the detection of hundreds of H_2 lines in the Horsehead Nebula with JWST spectro-imaging acquired with the GTO program "Physics and chemistry of PDR fronts" using both the NIRSpec and MIRI-MRS instruments. I will show how to use H_2 lines to constrain the Horsehead geometry by estimating attenuation from foreground matter. This study reveals that the Horsehead is observed in extinction with A_V increasing from the edge of the PDR to the second and third H_2 filaments. The analysis of H_2 excitation unveiled very few variations of the observed temperature derived from H_2 rotational lines throughout the PDR. This result is in disagreement with static PDR models where the gas temperature is expected to drop rapidly inside the PDR. The quite constant temperature could be explained by the complex geometry where the Horsehead Nebula is irradiated from its backside. The thermal pressure estimated at the very edge of the PDR is higher than what is expected in the HII region, revealing an overpressure at the interface. This is in agreement with the gas and dust in photoevaporation seen in imaging data. As static PDR models fail to reproduce H_2 excitation and we observe a high overpressure at the edge, I will highlight the importance of thermochemical dynamical modeling to constrain the impact of photoevaporation on the physics and chemistry of the Horsehead Nebula.