Title :

Unveiling physical and microphysical process in Photo-Dominated Regions with H_2 ro-vibrational lines from IGRINS observations

Authors *:*

A. Piluso, V. Maillard, E. Bron, F. Le Petit, K. F. Kaplan, P. Palud, R. Meshaka, E. Habart, J. Le Bourlot, and E. Roueff

Abstract :

Observations of H_2 emission lines serve as a powerful diagnostic tool for investigating the physical processes within star-forming regions, particularly the radiative feedback from young stars on their surroundings. Until recently, observing H_2 emission, apart from a few ground-accessible lines, necessitated space-based spectrometers like ISO, Spitzer, and now JWST. The James Webb Telescope enables for the first time the detection of dozens of ro-vibrational lines (up to v = 6 for the Orion Bar). In parallel, new ground-based instruments with high spectral resolution, such as IGRINS (Immersion Grating Infrared Spectrometer with R = 45,000), have been developed allowing us to detect an even broader range of ro-vibrational lines, covering all vibrational levels of H_2 starting from v = 1 to v = 13 and a large range of ro-vibrational lines (up to J=10).

Five emblematic photodissociation regions (PDRs) were observed with IGRINS, including the Orion Bar, the Horsehead Nebula, and S140. These observations are remarkable in that they provide access to highly excited H_2 levels, at an unprecedented level of detail. However, the data have yet to be fully exploited, despite their potential to shed light on longstanding questions regarding H_2 physics in PDRs.

In this work, I will present how we constrained the physical conditions in these observed PDRs using both the IGRINS data and the latest version of the Meudon PDR code. For the inversion procedure to constraint the physical parameters, we employed a new Bayesian method called *Beetroots*, which allows us to derive uncertainties on the predicted physical parameters, such as the gas thermal pressure and the intensity of the UV radiation field.

Furthermore, I will show how these observations, combined to comprehensive numerical models such as the Meudon PDR code, provide on one hand new insights into key microphysical processes, including the nascent excitation of H_2 formed on grains and collisional rate coefficients for vibrationally excited levels, but also on the other hand allow us to understand by which physical processes the many H_2 ro-vibrational levels are populated.