Dynamical effects of the radiative stellar feedback on the HI-to-H_2 transition.

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A key question in astrophysics is the question of the available mass of molecular gas to form stars and of the role of radiative feedback in star forming regions on the parent clouds. Radiative feedback and the transition between atomic and molecular gas both occur in Photo-dissociation regions (PDRs). Several numerical models and analytical theories have been developed to characterize the physics of these regions, most of them at stationary state [1]. Herschel and ALMA observations changed our understanding of the structure of PDRs by highlighting the role of dynamics due to photo-evaporation that compresses the gas at the edge of molecular clouds, making possible a "hot" chemistry leading to the formation of molecules closer to the ionization front than expected [2, 3, 4]. All our theories and data interpretation must be revisited.

Recently [6], thanks to the new Hydro-dynamical PDR code HYDRA [5], we studied the impact of the gas dynamics on the H/H_2 transition and on H_2 line intensities. We showed that, considering the ionization front propagation induced by photo-evaporation, the width of the atomic region is considerably reduced compared to static models. The H/H_2 transition is crucial as it controls the fraction of molecular gas, which constitutes the mass reservoir for star formation, as evidenced by the Schmidt-Kennicutt law. The atomic region may even disappear if the ionization front velocity exceeds a threshold value, leading the H/H_2 transition and the ionization front to merge. We provide analytical expressions to determine the total HI column density. Finally, we compare our results to observations of PDRs illuminated by O-stars, for which we conclude that the dynamical effects can be strong, especially in low excitation PDRs such as the Horsehead. In preparation to the JWST H_2 observations, we have thus implemented the full H_2 excitation and line intensity computation in the HYDRA code. With the H/H_2 transition closer to the edge of the cloud, some H_2 is found in a hotter and more illuminated region resulting in an increase of the H_2 emission lines, in particular for pure rotational lines. In addition, we studied the vibrational emission lines detected by the IGRINS spectrograph (170 lines up to v = 14, J = 1) in 6 typical PDRs (among them the Horsehead and the Orion Bar) [7], in order to determine if evidence of dynamical effects can be found in these observations. We will show the key role of the most recent H_2 collision rates determined by the LUPM group to explain these unique observations.

References:

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