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Physics and chemistry of UV illuminated gas: the Horsehead case

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Abstract. Molecular lines are used to trace the physical conditions of the gas in different environments, from high-z galaxies to proto-planetary disks. To fully benefit from the diagnostic power of the molecular lines, the formation and destruction paths of the molecules must be quantitatively understood. This is challenging because the physical conditions are extreme and the dynamic plays an important role. In this context the PDR of the Horsehead mane is a particularly interesting case because the geometry is simple (almost 1D, viewed edge-on; Abergel *et al.* 2003), the density profile is well constrained and we are making several efforts to constrain the thermal profile. The combination of small distance to Earth (at 400 pc, $1''$ corresponds to 0.002 pc), low illumination ($\chi = 60$) and high density ($n_{\rm H} \sim 10^5$ cm^{-3}) implies that all the interesting physical and chemical processes can be probed in a field-of-view of less than $50''$ (with typical spatial scales ranging between $1''$ and $10''$). Hence, the Horsehead PDR is a good source to benchmark the physics and chemistry of UV illuminated neutral gas.

In our recent work on the ISM physics and chemistry in the Horsehead we have shown the importance of the interplay between the solid and gas phase chemistry in the formation of (complex) organic molecules, like H_2CO, CH_3OH and CH_3CN, which reveal that photo-desorption of ices is an efficient mechanism to release molecules into the gas phase (Guzmán *et al.* 2011, Gratier *et al.* in prep, Guzman *et al.* in prep). We have also provided new diagnostics of the UV illuminated matter. For example, we detected CF^+ and resolved its hyperfine structure (Guzman *et al.* 2012b). We propose that CF^+, which is observable from the ground, can be used as a proxy of C^+ (Guzman *et al.* 2012). Finally, we reported the first detection of the small hydrocarbon C_3H^+, which sheds light on the formation pathways of other observed small hydrocarbons, like C_3H and C_3H_2 (Pety *et al.* 2012). Part of these results were possible thanks to a complete an unbiased line survey at 1, 2 and 3 mm performed with the IRAM-30m telescope (Horsehead WHISPER), where approximately 30 species (plus their isotopologues) are detected.

Keywords. astrochemistry, ISM: clouds, ISM: molecules

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