30 Years of Photodissociation Regions:
A symposium to honor David Hollenbach's lifetime in science
Asilomar, CA, USA - June 28th to July 3rd, 2015

Chemical probes of turbulence in the diffuse medium: the TDR model

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Because it is predominantly heated by the UV radiation field, the diffuse interstellar medium (ISM) has long been thought to behave like a photo-dissociation region (PDR). Yet, for the last 30 years, absorption spectroscopy has revealed a gas with a chemical richness that was unexpected from the sole predictions of PDR-type models. This problem has recently been deepened by the observations of large abundances of small hydrides using the Herschel/HIFI instrument. Since their production pathways are blocked by highly endo-energetic reactions, it has been proposed that several of these species are nothing else but a signature of another powerful energy source, such as the dissipation of magnetized turbulence (Godard 2009).

Among all the molecules, CH^+ and SH^+ are a unique couple (Godard 2012) because the energies involved in their formation are large ($\Delta E/k \sim$ 4640 K and 9860 K respectively). Their presence in the cold diffuse ISM is therefore much more than a chemical riddle : it is rooted in the physics of the diffuse ISM, the intermittency of the turbulent cascade and the rate of its dissipation, and it connects with the broader issues of star formation and galaxy evolution.

The informations inferred from the absorption spectra are analysed (Godard 2014) in the framework of the TDR (Turbulent Dissipation Regions) model which follows the dynamical and chemical evolutions of the gas in intermittent regions of turbulent dissipation. By comparing the predictions of the TDR model with multiwavelength observations of seven atomic and molecular species (C^+, CH^+, SH^+, H, H_2, HCO^+ and CO) we are able, for the first time, to measure five essential properties of the interstellar turbulence: (1) the dissipation rate ($\sim 10^{-24}$ erg cm^{-3} s^{-1}), (2) how it varies across the Galactic disk, (3) the size of the dissipative structures ($\sim$ 100 AU), (4) their lifetime ($\sim$ a few hundred years), and (5) the dominant dissipative process (viscous friction or ion-neutral friction).

REFERENCES

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