Modeling the physico-chemistry of the diffuse interstellar medium (ISM)

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Observations of the local ISM performed in absorption and emission over the past 50 years have revealed the abundances, the kinematic signatures, and the statistical distributions of many atoms and molecules in the diffuse gas. These chemical and spectral properties are usually studied with state-of-the-art 1D astrochemical models leading to plausible local physical conditions along the lines of sight. The implementation of partly out-of-equilibrium chemistry in 3D numerical simulations [1,2] leads, however, to different interpretations.

Extensive parametric studies of numerical simulations of the multiphase turbulent ISM were recently performed in the framework of the MIST project (Molecules, magnetic fields, and Intermittency in coSmic Turbulence) [3,4]. These show that a single simulation of the multiphase ISM naturally explains several observational constraints, including the distribution of the thermal pressure, the statistical distribution of H_2 and of its excited levels and the distribution of CH^+ and of its line profiles. The H-to-H_2 transition is found to be sensitive to the mass and volume distributions of the warm and cold neutral phases (WNM and CNM) in space, while the distribution of CH^+ is sensitive to the rate of mass transfer between these two phases.

All these comparisons suggest that many chemical and kinematic features observed in the diffuse ISM are in fact tracers of global physical conditions at galactic scales. The underlying physical processes involved in the production of each species reveals the probabilistic evolution of the neutral diffuse ISM towards star formation.

References

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