ISM in 3D: methods and astrophysical consequences

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Determining distances is a longstanding issue in astrophysics, limiting our ability to build an accurate and reliable three-dimensional picture of our Galaxy. Because interstellar gas and dust are often optically thin and generally consist of diffuse emissions, our knowledge of the 3D structure of the interstellar medium (ISM) is even more uncertain than the spatial distribution of stars.

Numerous strategies have been developed to circumvent those difficulties utilising a variety of observations. The observation of gas line emission (CO rotational emission, HI hyperfine emission, ...) has proven fruitful to separate ISM components according to their kinematic properties, and to estimate cloud distances based on assumptions on the Galactic dynamics. Several ambitious surveys were recently published (e.g. the HI4PI all-sky 21cm survey) or are still being conducted (e.g. the Mopra Southern Galactic Plane CO Survey) which increase by orders of magnitude the amount of data available to study the 3D structure of the ISM, and make statistical, automated methods unavoidable. But presently, the best potential to progress on our knowledge of the 3D ISM comes from the recent large stellar surveys like SDSS, Pan-starrs and, even more importantly, Gaia and its spectroscopic follow-up surveys, which trace the distribution of interstellar dust extinction. Analysing these large (>1 billion stars) and heterogeneous (magnitudes, parallaxes, spectra, ...) data sets raises numerous challenges both in terms of methods and physical knowledge of the ISM (e.g. the extinction curve and its variations).

In this presentation, I will review the methods that were developed to deal with the wealth of available data and the recent advances in the characterisation of the ISM 3D structure, with an emphasis on scales from giant molecular clouds to Galactic scales.