Topological models to infer multi-phase ISM properties

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Spectroscopic observations of very high redshift (z~7) galaxies have become routinely available (e.g., [1]), with an increasing number of tracers arising from different ISM phases, enabling numerous diagnostics that had been so far limited to local galaxy survey studies. Considering the complex distribution of matter and phases in the ISM, the challenge is then to infer reliable and meaningful diagnostics (e.g., star formation rate, AGN fraction, molecular gas content...) from the integrated emission-line spectrum. The latter contains a wealth of constraints about chemical abundances, physical conditions, and energetic sources in the galaxy, that may be relevant, e.g., for cosmological evolution of galaxies or to examine specific processes such as escape of ionizing photons and the nature and influence of compact objects in low-metallicity environments (e.g., [2]). However, the integrated spectrum reflects 1) a combination of many interstellar components with different properties (ionization parameters, abundances, column density, incident radiation field...) that need to be disentangled, and 2) a combination of different tracers with different emission conditions (e.g., critical density, excitation temperature...). We have undergone several projects over recent years to infer physical parameters from IR and optical spectra of nearby galaxies. Our studies focusing on low-metallicity dwarf galaxies from the Dwarf Galaxy Survey ([3]) pioneered the multi-phase models of the ISM in external galaxies. We modeled simultaneously the ionized and neutral (atomic and molecular) gas with the photoionization and photodissociation code Cloudy ([4]) while considering increasingly complex arrangements of regions with different characteristics. As this complexity increases, however, it becomes important to implement a statistically robust method to identify solutions and their confidence intervals. Previous efforts to model galaxies with multiple sectors and phases have mostly relied on χ^2 methods, with severe limitations. We have thus designed a new statistical framework to evaluate solutions in a multi-dimensional grid and to quantify confidence intervals in a multi-sector/phase approach. The tool we present is quite general, being agnostic to the steps before the model grid creation.

References

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[2] Lebouteiller et al. A&A, 602, 45 (2017)
[3] Madden et al. PASP, 125, 928 (2013)
[4] Ferland et al. RMxAA, 53 (2017)