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Mapping multi-phase mixing of metals in Star Forming Galaxies, a pioneering spatially-resolved UV + Optical study

Metals are fundamental components of galaxy evolution, they regulate the cooling of gas and the transport of momentum, enhancing/quenching star formation. Despite this essential role, we have a poor understanding of how metals are distributed among different gas phases through a galaxy. Chemical inhomogeneities have been detected in the ionized gas of numerous star-forming galaxies (SFGs) via spatially resolved studies, with large implications for the flow of metals within and around galaxies. Recent HR hydrodynamical simulations have opened crucial questions on mixing timescales and the presence of localized enrichment between the two gas phases. In this talk I present the first spatially-resolved multi-phase gas abundance study of a metal poor high-z local analogue, targeting 10 star-forming (SF) regions (ranging between 1 – 15 Myr) with HST-COS and co-spatial optical VLT-MUSE observations. We obtained neutral gas abundances for 13 different ions sampling 8 elements (N, O, S, P, Ni, C, Fe and Si) by analyzing UV spectroscopic data and compared them with the ionized gas abundances (O, N, Fe and S) measured along the same sightlines with the optical IFU data. Determining whether metal abundance offsets exist between the two phases, both globally and locally across a range of HII region properties, enables an exceptionally detailed sampling of chemical mixing scenarios and enrichment mechanisms experienced in SFGs. By exploring metal distribution as a function of age, radius and gas phase, we have pinned down the mixing timescales between the neutral and ionized gas phases. The findings of this remarkable study are applicable to both nearby and high-z SFGs, expanding the potential of multi-phase analysis to the high redshift universe in the era of JWST. As follow-up to this study, spatially resolved analysis in the UV regime is essential to account for the multiple thermal, dynamical and chemical enrichment processes intervening in the evolution of the interstellar medium (ISM). Future UV facilities such as Habitable Worlds (HWO) and UVEX will play a fundamental role in this endeavor.