The chemical evolution of galaxies from high to low redshift

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Abstract

In this talk, I will discuss how the chemical evolution of various types of galaxies has proceeded over cosmic time, with a particular emphasis on the insights given by the Munich semi-analytic model (SAM) of galaxy formation. The chemical properties of the gas and stars in galaxies provide crucial information on how these galaxies have evolved in general. We can combine our theoretical knowledge of their varied star formation histories with that of metal production in the hearts of stars and supernovæ to explain the often puzzling chemical compositions observed at both high and low redshift. For example, using the Munich SAM built on the MILLENNIUM simulation of hierarchical dark-matter structure formation, we have found that the chemical properties in a) the ISM of local star-forming galaxies, b) the photospheres of G dwarfs in the solar neighbourhood, and c) the stellar populations in nearby elliptical galaxies can all be *simultaneously* reproduced without requiring a variable IMF or strong, interaction-induced starbursts at high redshift (Yates et al. 2013). I will further present how the iron abundances in the hot gas surrounding galaxy clusters can also be well explained by the same model, given certain considerations regarding the metal enrichment and pristine infall occurring at redshifts above 3 (Yates, Thomas & Henriques, in prep.).

Additionally, I will present the leading theoretical perspective on the evolution of the mass-metallicity relation (MZR) out to high redshift. The shape and evolution of the MZR, as well as of the mass-SFR-metallicity relation (or FMR), is still hotly debated, and no clear consensus has been formed. I will show the latest results on this topic from the new Munich SAM, which includes a detailed galactic chemical enrichment scheme, a sophisticated treatment of H_2 formation, and improved modelling of the cycling of baryonic material throughout galaxies. I will also explain how gradual dilution in quiescent, post-merger systems above redshift 1 drives the positive correlation between SFR and metallicity seen in massive galaxies by redshift 0 (Yates et al. 2012; Yates & Kauffmann 2014). This work will be supplemented by our team's up-coming *observations* of the metal content in the star-forming gas surrounding gamma-ray bursts (GRBs) detected around redshift 2.5. This data will provide a unique insight into the low-mass, high-redshift region of the MZR and FMR, and help us further explain how galactic chemical evolution has proceeded over cosmic time.