Title: The origin of scatter in galaxy scaling relations

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Abstract:
Observations show that star-forming galaxies reside on a tight three-dimensional plane between mass (M_{star}), gas-phase metallicity and star formation rate (SFR), and that galaxies lie on a scaling relation between M_{star} and dark matter halo mass, with a scatter of roughly only a factor of two. In order to investigate the physics encoded in these galaxy scaling relations, we used a multi-dimensional analysis of the properties of ~10,000 simulated galaxies in the EAGLE simulation. In my talk, I will show that (due to galaxy assembly bias) halo binding energy, and not halo mass, is the most fundamental halo property that determines the stellar and black hole mass of a galaxy. As a consequence, galaxies move through M_{star}-SFR space on median long-timescale tracks depending on halo mass and formation time (with galaxies in early forming halos on a fast-track with higher SFRs and vice versa). At high masses this effect is mitigated by mergers and because galaxies on the fast-track grow a black hole relatively efficiently, affecting their SFR earlier, reducing differences between galaxies on fast and slow tracks.
These results have interesting consequences for scaling relations with chemical enrichment. We predict that fundamental three dimensional planes exist between stellar mass, SFR and α-enhancement (both in gas and in stars). The three dimensional relation for gas-phase α-enhancement has less scatter than the fundamental metallicity relation at z=0. However, it evolves at $z > 1$ due to lagging iron yields. At fixed mass, galaxies with higher SFRs have star formation histories shifted toward late times, are more α-enhanced and this α-enhancement increases with redshift as observed. I will conclude my talk with the implications of these results for the interpretation of (emission line) observations and propose observables that can test the latest hydrodynamical simulations of galaxy formation.

Related publications/submissions:

Matthee, Jorryt; Schaye, Joop; Crain, Robert A.; Schaller, Matthieu; Bower, Richard; Theuns, Tom; `The origin of scatter in the stellar mass-halo mass relation of central galaxies in the EAGLE simulation', 2017, MNRAS, 465, 238

Matthee, Jorryt; Schaye, Joop; `Star-forming galaxies are predicted to lie on a fundamental plane of mass, star formation rate and α-enhancement', submitted to MNRAS, arXiv:1802.06786

Matthee, Jorryt; Schaye, Joop; `The origin of scatter in the star formation rate - stellar mass relation in EAGLE', in preparation (will be submitted/on arXiv before the conference)