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Galaxy Evolution in the context of radial metallicity gradients

Patricia B. Tissera

Physics Department, Universidad Andres Bello, 700 Fernandez Concha, Santiago, Chile.
email: patricia.tissera@unab.cl

Abstract. The chemical abundances of the gas-phase and stellar components of disc galaxies are relevant to understand their formation and evolution. It has been shown that an inside-out disc formation yields negative chemical profiles. However, a large spread in metallicity gradients, including positive ones, has been reported by recent and more precise observations, suggesting the action of other physics processes such as gas outflows and inflows, radial migration, and mergers and interactions. Cosmological simulations that includes chemical models provide a tools to tackle the origin of the metallicity profiles and the action of those processes that might affect them as a function of time. I present a summary of the current state-of-knowledge from a numerical point of view and discuss the main results from the analysis of the EAGLE simulations.

Keywords. galaxies:formation, galaxies:evolution

1. Introduction

The distribution of chemical elements in the interstellar medium (ISM) and the stellar populations (SPs) of galaxies is the result of action of different physical processes such as star formation, stellar nucleosynthesis, gas accretion, galaxy interactions and mergers, secular evolution, migration. In spite of the complexity posed by the variety of involved temporal and spatial scales, chemical radial gradients are observed. In the Local Universe, galaxies with well-defined discs show a correlation between metallicity gradients of HII regions and stellar mass. These correlations store information on the processes that took place in the formation history of galaxies. In the Local Universe, IFU surveys, such as CALIFA, MaNGA and SAMI, have collected a large database of metallicity gradients in disc galaxies of different stellar masses. These new estimates report a larger variety of metallicity gradients at a given stellar mass. Radial oxygen gradients in the star-forming galaxies have been also detected across cosmic times. These data contribute key information to constraint galaxy formation models.

2. Summary

Disc metallicity gradients: inside out formation. Cosmological hydrodynamical simulations are powerful tool to study the chemical evolution of galaxies (Taylor & Kobayashi 2017). Tissera *et al.* (2016, 2017) analysed the radial oxygen gradients in cosmological simulations, finding that if the discs formed inside out then, negative metallicity gradients are detected in the gas-phase, in agreement with previous results (Pilkington *et al.* 2012).

Disc metallicity gradients: feedback and mergers. Observations report the existence of inverted (positive) metallicity gradients in galaxies generally associated to interactions and mergers. Numerical simulations are able to reproduce this inversion of the metallicity gradients as a results of both mergers and interactions and strong feedback that removes enriched material preferentially from the inner regions (Tissera *et al.* 2019).

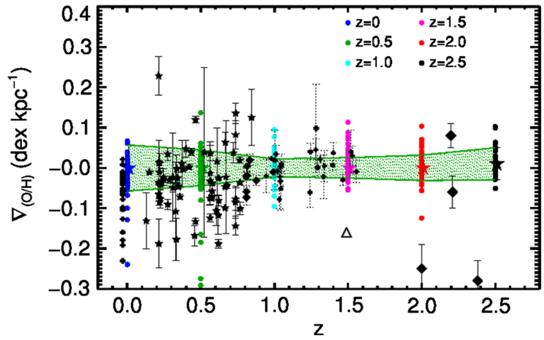

Figure 1. Oxygen gas-phase abundance gradients in discs selected from the EAGLE project (L25R756RECL) as a function of redshift. The shaded area shows the 25 and 75 percentiles. A compilation of available observations at different redshifts are shown for comparison (black symbols).

Both mechanisms can act together, contributing to regulate the transformation of gas into stars, which is a crucial process to shape metallicity gradients.

Disc metallicity gradients: redshift evolution. The available observational data of metallicity gradients across time show a large dispersion with no clear trend. Results from hydrodynamical simulations are consistent with no evolution when enhanced stellar feedback is adopted (e.g. Gibson *et al.* 2013 and Ma *et al.* 2018) while weaker stellar feedback shows a slight trend with redshift (e.g. Tissera *et al.* 2017). As shown in Figure 1, the metallicity gradients obtained from the EAGLE project (Schaye *et al.* 2015) are consistent with the observed large dispersion and show no clear evolution in time (Tissera *et al.* in prep).

The distribution of chemical abundances in the ISM and SPs reflect the complex history of assembly and star formation history of galaxies and provides a challenging opportunity to understand galaxy formation.

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