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Metallicity gradients in intermediate-redshift absorption-selected galaxies

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Abstract. Metallicity gradients are most frequently investigated directly from galaxies observed in emission. We have shown that galaxies detected via strong quasar absorption lines also exhibits a metallicity gradient in the outskirts and circumgalactic medium out to ~ 40 kpc distance. We infer a metallicity gradient of -0.022 dex kpc^{-1} for absorption-selected systems at redshifts $0.1 \lesssim z \lesssim 3$. Applying this metallicity gradient and a flattening of the gradient beyond 12 kpc, we demonstrate that absorption-selected galaxies obey the same mass-metallicity relation (MZR) as observed for luminosity-selected galaxies.

Strong absorption lines in quasar spectra arise when the lines of sight to distant quasars intersect intervening galaxies. Associated metal absorption lines from the strongest hydrogen absorption lines, the damped Lyman-α absorbers (DLAs), allow us to trace accurate metallicities of galaxies back to redshifts $z > 5$. This has revealed metallicities around 0.1–100% solar values with a gradual increase in metallicity with increasing cosmic time as expected when DLAs get progressively enriched by star-formation processes. DLAs have metallicity distributions roughly similar to that of Milky Way halo stars, but with a 2–3 decade range in metallicities at all redshifts.

In order to understand the connection between the DLAs and the host galaxies and how the metallicities vary with radial distances, we first need to detect the host galaxy in emission. This search has evolved rapidly in the past decade (e.g. Fynbo *et al.* 2010), and we now have a sufficiently large sample of absorber-galaxy pairs out to redshifts $z > 2$, where we can compare galaxy metallicities in emission and absorption.

Based on the established galaxy mass-metallicity relation (MZR) and its evolution with redshift Møller *et al.* (2013) predicted a similar relation for absorption-selected galaxies by connecting the absorption metallicity to the host galaxy stellar masses. This prediction was verified in Christensen *et al.* (2014). Based on the differences between the predicted versus the measured stellar masses, we can indirectly infer a metallicity gradient. Expanding this sample to include 19 DLA and sub-DLA systems at $0.1 < z < 3$, Rhodin *et al.* (2018) derive an average metallicity gradient $\langle \Gamma \rangle = -0.022 \pm 0.001$ dex kpc^{-1}, and propose a truncation with a flattening of the gradient at larger radii ($r \gtrsim 12$ kpc). In turn, this gradient implies that absorption selected galaxies obey the MZR of luminosity selected galaxies at these redshifts.

References

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