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Re-evaluating the Mass–Metallicity Relation with Self-Consistent Photoionization Models

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The galaxy mass–metallicity relation is essential for chemical evolution studies, yet its dependence on star formation rate (the so-called fundamental metallicity relation) remains contentious due to different metallicity calibrations. We present a photoionization model–based metallicity calibration that yields self-consistent metallicity and ionization parameter estimates for MaNGA galaxies from multiple optical line ratios. The calibration achieves close agreement with direct-method abundances, with a median offset of only 0.09 dex. Applying this calibration, we find no statistically significant dependence of metallicity on star formation rate, either for spatially-resolved regions or integrated galaxies, at nearly all stellar masses. On the other hand, the total stellar mass of a galaxy has a much stronger influence on the spatially-resolved mass-metallicity relation. As a result, apparent trends between metallicity and SFR are consistent with being induced by the star-formation main sequence rather than reflecting a fundamental three-parameter relation.

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