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Measuring the physical imprints of gas flows in galaxies. I. Accretion rate histories

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Abstract

Galaxies are expected to accrete pristine gas from their surroundings to sustain their star formation over cosmic timescales. This mechanism is well established in models and simulations, but evidence from observations is mostly indirect. These gas inflows leave distinct traces in the chemical composition of newborn stars and alter the distribution of stellar abundances compared to what would be expected from a closed-box model of chemical evolution. Aims: The goal of this work is to measure the amount of pristine gas that galaxies accrete during their lifetime, using information on the ages and abundances of their stellar populations and a chemical evolution model. We also aim to determine the efficiency of star formation over time. Methods: We derived star formation histories and metallicity histories for a sample of 8523 galaxies from the MaNGA survey. We use the former to predict the evolution of the metallicity in a closed-box scenario, and estimate for each epoch the gas accretion rate required to match these predictions with the measured stellar metallicity. Results: Using only chemical parameters, we find that the history of gas accretion depends on the mass of galaxies. More massive galaxies accrete more gas and at higher redshifts than less massive galaxies, which accrete their gas over longer periods. We also find that galaxies with a higher star formation rate at z = 0 have a more persistent accretion history for a given mass. We characterize the individual accretion histories in terms of two parameters: the total accreted gas mass and the 80 of the accretion history, a measure of when most of the accretion occurred. As expected, there is a strong correlation between the integrated star formation history and the total accreted gas mass, such that more massive galaxies accreted more gas during their lifetime. Currently star-forming galaxies lie above this correlation, so they tend to accrete more gas than average. The relationship between 80, the current stellar mass, and the current specific star formation rate is split such that star-forming galaxies (as now observed) may be found in a population with persistent gas accretion regardless of their stellar mass. The star formation efficiency shows similar correlations: early-type galaxies and higher-mass galaxies had a higher efficiency in the past, and it declined such that they are less efficient in the present. Our analysis of individual galaxies shows that compactness affects the peak star formation efficiency that galaxies reach, and that the slope of the efficiency history of galaxies with current star formation is flat.

Conclusions: We show throughout the article that we can obtain information about the processes that regulate the chemical composition of the interstellar medium during the lifetime of a galaxy from the properties of stellar populations. Our results support the hypothesis that a steady and substantial supply of pristine gas is required for persistent star formation in galaxies. Once they lose access to this gas supply, star formation comes to a halt.

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