Chemical Evolution of Galaxies: Theories and Observations

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Metallicities, elemental abundances, and isotopic ratios can be measured for stars and the interstellar medium (ISM), and are the key to constraining physical processes during galaxy formation and evolution. During the Big Bang only light elements such as hydrogen and helium were produced. Carbon and heavier elements are created inside stars. Alpha elements are mainly produced from core-collapse supernovae, while the majority of iron-peak elements are from Type Ia supernovae – binary systems. Neutron-capture elements are produced by asymptotic giant branch stars, electron-capture supernovae, magneto-rotational supernovae, collapsars, and/or neutron-star mergers. Integrating the production and recycling of elements, chemical evolution models can predict the time evolution of chemical compositions of stars and the ISM. I will discuss three types of theoretical models: so-called one-zone models, semi-analytic models to include large-scale structure formation of the universe, and the most advanced, chemodynamical simulations. The last model can predict the spatial distribution of elements within a galaxy, often measured as a radial metallicity gradient, as well as the scaling relations of galaxies in the universe. Nowadays, a vast amount of observational data is available for these quantities from galaxy surveys with multi-object spectroscopy (MOS) and integral field unit (IFU). In addition, the Gaia satellite provided detailed kinematics of the Milky Way, the Atacama Large Millimeter Array (ALMA) added chemodynamical information of the ISM, and most recently the James Webb Space Telescope (JWST) is surprising us with the amazing quality of data from nearby to distant galaxies. I will also show some comparison between theoretical predictions and these observational data in this lecture.