X11a Understanding Galaxy Evolution through Machine Learning

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Galaxy evolution is a complicated process that encompasses many physical properties in/around a galaxy (e.g., stellar mass, gas mass, star formation rates, star formation histories, environment). It is still challenging to describe the entangled processes from just the fundamental theory entirely. The studies using observed data have given us the many galaxy scaling laws (e.g., star formation main sequence, Tully-Fisher relation, Faber-Jackson relation, Kennicutt-Schmidt). However, current galaxy surveys provide hundreds of physical quantities for up to hundreds of millions of galaxies, and characterizing the intricate nature through simple scaling laws is undesirable. There is a need for sophisticated multivariate analysis to simultaneously incorporate all these features if we want to build a unified picture of galaxy evolution. We have identified a universal two dimensional manifold (galaxy manifold) from a 12-dimensional space of luminosities measured at 11 wavelengths from far ultraviolet to infrared and cosmic age using the latest machine learning (manifold learning) techniques. The manifold explains the traditional evolutionary features (star formation rates and stellar mass) continuously, allowing us to parametrize the manifold to derive fundamental equations of galaxy evolution. The discovered galaxy manifold from nearby Universe will enable us to explore the evolution across cosmic time, up to its formation.