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Bends of the river(s) of galaxy formation (PNCG)

Over the last decade, new instruments and techniques have pushed back the limits of precision and distance in the observations of galaxies and their contents. Gaia, ALMA, NOEMA, JWST and Euclid, to name a few, have revealed complex features in stellar populations, disk kinematics, gas distributions etc.; all signatures of complex and far from monotonous formation histories of our Galaxy, its neighbors, and those in the distant Universe. Many results now question the universality of the physics of galaxy and star formation, and call for the existence of different regimes across cosmic times. In this talk, I will present the picture which has recently emerged from galaxy and cosmological simulations. I will explain what defines the different regimes found along galaxy evolution, and what triggers the transitions between them. I will conclude by showing what are the distinct observable signatures these regimes leave and how to use them to reconstruct the formation history of galaxies.