

The impact of AGN winds on the early evolution of massive galaxies

The advent of JWST is revealing a surprisingly abundant population of massive galaxies less than 2 billion years after the Big Bang, some of which are already quenched. These observations challenge standard models of galaxy formation, suggesting that both the assembly of stellar mass and the onset of quenching may occur significantly earlier and more rapidly than previously predicted. Feedback from AGN winds, powered by actively accreting supermassive black holes, is among the leading candidates for driving this evolution at early epochs. However, modelling this multi-scale process remains challenging in cosmological simulations, where AGN feedback in this regime is typically implemented as isotropic thermal energy injection. A more physically grounded treatment of AGN feedback is thus essential to assess its role at early epochs. To this end, we implemented Mistral, a physically motivated subgrid prescription for modelling AGN-driven winds within the Arepo cosmological code, informed by observations of broad absorption line winds.

Coupling this subgrid model to cosmological zoom-in simulations, I will present the new Black Dawn suite, which targets the 50 most massive galaxies at $z = 3$ from the 100 cMpc IllustrisTNG volume. Each system is resimulated with Mistral, with the standard TNG AGN feedback model, and without black holes, enabling a controlled comparison of the impact of AGN winds on early galaxy assembly and quenching. These simulations demonstrate that AGN winds can drive rapid gas depletion and compact stellar growth, and that they are required to suppress star formation efficiently enough to produce massive quiescent galaxies as early as $z = 6$. While the large-scale environment modulates the degree and persistence of quiescence, AGN winds are the dominant factor, as galaxies remain star-forming in their absence. Our simulated galaxies are broadly consistent with recently discovered high-redshift quiescent and post-starburst galaxies, which supports a scenario in which AGN winds are a key ingredient in galaxy formation models to reproduce the early assembly and shutdown of massive galaxies from cosmic dawn to cosmic noon.