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Fuzzy dark matter meets galaxy formation with IllustrisTNG

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Ultra-light dark matter models, which feature particles whose masses are so light that their behavior can be treated as a collective wave rather than individual particles, are an intriguing alternative to "standard"cold dark matter. They feature a rich and unique phenomenology on astrophysical scales, with implications for small-scale tensions. The most well-studied member of this family is commonly called fuzzy dark matter, where dark matter is composed of scalar particles with a mass of $\sim 10^{-22}\,\mathrm{eV}$. Although strong constraints have been placed on this particular model, it remains an important benchmark to understand structure formation in more general wave dark matter scenarios, and because of computational limitations encountered in numerical simulations of wave dark matter.

While simulation efforts for fuzzy dark matter have thus far mainly focused on understanding its properties in a dark matter-only context, i. e. without including baryonic matter, the coupling of both matter components has hardly been studied and remains poorly-understood. In particular, it is unclear to what extent the presence and gravitational influence of baryonic matter modifies the conclusions obtained in this manner, and in turn, how strongly the unique behavior of fuzzy dark matter affects important baryonic processes and astronomical observables, such as star and galaxy formation.

In this talk, I will present numerical simulations of cosmic structure formation with fuzzy dark matter, and highlight the unique signatures of fuzzy and other ultra-light dark matter models. In particular, I will focus on new cosmological fuzzy dark matter simulations including baryons, using the IllustrisTNG galaxy formation model, which provide invaluable data in a more realistic scenario.

Primary author: MAY, Simon (Perimeter Institute)

Presenter: MAY, Simon (Perimeter Institute)

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