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STRAWBERRY: Finding haloes in the gravitational potential

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Dark matter haloes are the end product of cosmological structure formation. Produced through the gravitational collapse of initial density perturbations, these objects are considered to be self gravitating and virialised. Nonetheless, standard methods, used to both detect and analyse these structures in simulations, produce objects that are not virialised requiring the inclusion of an additional external pressure to ensure their stability. The need for this term has been shown to simply be a selection artefact, and only arises due to the inclusion of newly accreted particles that are not yet bound to haloes.
Recently, it has been proposed that a more physical description of dark matter haloes could simplify observations and models that rely upon this definition, most notably the halo mass function, the halo profile and the halo model for the non-linear two-point correlation function. However, due to the relatively large computational cost of current methods to perform this binding check, these studies have been limited to studying only small samples of haloes.
In this work, we present a novel, physically motivated approach based on the boosted gravitational potential. In practice, after directly reconstructing the effective local potential landscape felt by particles inside and surrounding a halo, the question of binding simply becomes: does a certain particle have a sufficient energy to escape this potential? As a result, this computationally inexpensive technique allows the production of large catalogues of virialised haloes, paving the way for future large sample studies of these objects and their properties.

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