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ABSTRACT ONLY

MODELING SUPERMASSIVE BLACK HOLES IN HYDRODYNAMICAL SIMULATIONS OF GALAXY FORMATION

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Supermassive black holes are ubiquitously observed in the centres of galaxies, and they play a critical role in current theories for galaxy formation, where they are supposed to suppress star formation in large galaxies by injecting energy into the gas. We hence want to simulate the growth of these black holes and the associated co-evolution with the galaxy when studying numerical models of galaxy formation. In reality, it is believed that the black holes experience dynamical friction against the background of dark matter and stars, and possibly also through gas-dynamical processes, making them spiral in to the centres of galaxies on a reasonably short timescale. Only when they are positioned there, they can efficiently influence the whole galaxy and grow rapidly. After galaxy mergers, the remnant (merged) black hole will return to the centre through these friction processes, after being kicked out through asymmetric emission of gravitational waves. To properly estimate how long the growth/feedback may be weak/interrupted after a merger (because the centre is not yet found again), and how many free floating massive black holes there may be, the orbit of the black holes needs to be followed reasonably accurately. This, however, is not readily possible, as the masses of dark matter and star particles in N-body simulation are very much larger than in reality and similar to the mass of the black hole. As a result, two-body scattering effects will try to 'heat-up' the central black hole particle and prevent it from experiencing proper dynamical friction, or in other words, the black hole will not return to the centre of the potential by itself under these conditions. Current simulation models therefore usually employ non-physical tricks to 'glue' the black hole particle to the potential minimum, for example by searching for the smallest black hole potential value among neighbours around the black hole, and then simply positioning the black hole particle to this minimum. This is for example done by the Illustris and Gigagalaxy projects. While this prevents that the central black hole particle is lost, it also prevents that the above questions can be studied, and potentially one also introduces severe inaccuracies in the efficiency with which black holes can grow. In this work, we use a semi-analytical treatment in the Arepo code, where numerical heating is reduced by excluding the interaction with neighbour particles around the black hole and is replaced by an effective dynamical friction term. We then calibrate the decay timescales and run a set of cosmological simulations in order to study the effects of our implementation on the black hole demographics and the galaxy properties.

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This work is to be presented as an oral presentation.