Abstract

Our current understanding of structure formation in the universe leads us to believe that galaxies are formed hierarchically out of dark matter halos, which have been created from initial density fluctuations at the beginning of time. Once such a galaxy forms it will start to grow, due to subsequent merger events with smaller structures (among other reasons), and will eventually build larger galaxies like our own Milky Way. Since mergers are recurring events in hierarchical structure formation, we expect the black holes that can be found in the centers of such massive galaxies to suffer from dynamical friction. This should eventually lead to a black hole binary formation, followed by subsequent hardening and coalescence via gravitational wave emission. Numerous studies have extensively investigated this process, analytically as well as numerically, for the supermassive black hole case. Nowadays, thanks to the recent LIGO discovery of "GW190521", we know that intermediate mass black holes (intermediate mass black holes) with masses between ~$10^2 M_\odot$ and ~$10^6 M_\odot$ exist. Additionally, recent and novel observations of dwarf galaxies (dwarf galaxies) suggest that intermediate mass black holes live close to the central vicinities of their host galaxies. The orbital decay for intermediate mass black holes has however not been investigated with the same thoroughness, even though intermediate mass black holes could possibly be the most abundant source for the next generation Laser Interferometer Space Antenna (LISA). Moreover, the sensitivity curve of LISA peaks at black hole masses that are within the intermediate mass black holes regime; for this reason, LISA is able to detect the binary from the very early-phase of the in-spiral up to its gravitational wave emission. Consequently, the modeling and parameter extraction from those waveforms will be exquisite in the intermediate mass black hole case and could be used for many astrophysical applications such as testing general relativity or the cosmological model.

As a PhD graduate student, I study the mechanism responsible for the gravitational decay of small structures within larger systems. This decay mechanism can range from dwarf galaxy satellites within dark matter halos of more massive galaxies to massive black holes in the nuclei of galaxies as well as nuclear star clusters or globular clusters in host galaxies. Throughout many decades, there have been various attempts to determine the underlying physics and timescale of this drag mechanism, ranging from the local dynamical friction approach of Chandrasekhar [1], to controversial scenarios in which the orbital decay is driven by induced global halo modes [e.g. 2]. It is indisputable that such drag mechanism plays a key role in the dynamics of astrophysical systems; as a consequence, to fully comprehend current and future observations, it is of exceeding importance to better understand its processes. Considering that next-generation gravitational wave detectors, like LISA, will be able to first probe intermediate mass black holes with a very high signal-to-noise ratio at extremely high redshifts, they will thus allow us to explore the

very first galaxies in the universe. The unique conditions in those dwarf galaxies provide a superb laboratory for various dark matter theories; Fuzzy dark matter, Self-Interacting dark matter, and also between the interplay of baryons and dark matter.