W15b Three-body encounters close to supermassive black holes: on the origin of the S-stars and the merger rate of black hole binaries

Trani, A. Alessandro (The University of Tokyo); Spera, Mario (University of Innsbruck); Fujii, Michiko (The University of Tokyo)

The environment close to supermassive black holes (SMBHs) has stellar densities that can reach $\sim 10^7\,M_\odot/pc^3$. An example is the SMBH in our galaxy, which features a density cusp composed of old and young stars and even compact remnants. Moreover, a high number of binaries is expected to be present close to SMBHs in galactic nuclei, due to either dynamical friction or star formation. These binaries can efficiently interact dynamically with other stars, undergoing close encounters that can trigger tidal disruptions and mergers. We investigate the outcome of 3-body encounters between binary and single stars in orbit about a SMBH, by means of high-accuracy, regularized N-body simulations. The encounters are modeled as 4-body systems of a SMBH, a binary and a single star. We find that 3-body encounters can ionize the binaries so that their member are scattered into highly eccentric orbits about the SMBH. This mechanism can explain the origin of S-stars, the $\sim$30 stars on eccentric orbits around the SMBH in our galaxy. In addition, stellar mass black holes can be kicked onto orbits that end in a gravitational-wave driven inspiral with the SMBH in less than a Hubble time. These events are expected to be observable in the LISA band. Finally, we show how the surviving binaries undergo a systematic increase in the eccentricity, which leads to increased merger rate by gravitational waves. These mergers can contribute significantly to the rate of binary black hole mergers detected by aLIGO.