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# Formation of galactic nuclei with multiple supermassive black holes at high redshifts

Girish Kulkarni, Abraham Loeb

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We examine the formation of groups of multiple supermassive black holes (SMBHs) in gas-poor galactic nuclei due to the high merger rate of galaxies at high redshifts. We calculate the relative likelihood of binary, triple, and quadruple SMBH systems, by considering the timescales for relevant processes and combining merger trees with N-body simulations for the dynamics of stars and SMBHs in galactic nuclei. Typical haloes today with mass $M_0\approx 10^{14}$ M$_\odot$ have an average mass $M_{z=6}=5\times 10^{11}$ M$_\odot$ at $z\sim 6$, while rare haloes with current mass $M_0 \gtrsim 10^{15}$ M$_\odot$ have an average mass $M_{z=6}=5\times 10^{12}$ M$_\odot$ at that redshift. These cluster-size haloes are expected to host single galaxies at $z\sim 6$. We expect about 30% galaxies within haloes with present-day mass $M_0\approx 10^{14}$ M$_\odot$ to contain more than two SMBHs at redshifts $2\lesssim z\lesssim 6$. For larger present-day haloes, with $M_0 \gtrsim 10^{15}$ M$_\odot$, this fraction is almost 60%. The existence of multiple SMBHs at high redshifts can potentially explain the mass deficiencies observed in the cores of massive elliptical galaxies, which are up to 5 times the mass of their central BHs. Multiple SMBHs would also lead to an enhanced rate of tidal disruption of stars, modified gravitational wave signals compared to isolated BH binaries, and slingshot ejection of SMBHs from galaxies at high speeds in excess of 2000 km s$^{-1}$.

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