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Assessing the redshift evolution of massive black holes and their hosts

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Motivated by recent observational results that focus on high redshift black holes, we explore the effect of scatter and observational biases on the ability to recover the intrinsic properties of the black hole population at high redshift. We find that scatter and selection biases can hide the intrinsic correlations between black holes and their hosts, with 'observable' subsamples of the whole population suggesting, on average, positive evolution even when the underlying population is characterized by no- or negative evolution. We create theoretical mass functions of black holes convolving the mass function of dark matter halos with standard relationships linking black holes with their hosts. Under these assumptions, we find that the local MBH - sigma correlation is unable to fit the z = 6 black hole mass function proposed by Willott et al. (2010), overestimating the number density of all but the most massive black holes. Positive evolution or including scatter in the MBH - sigma correlation makes the discrepancy worse, as it further increases the number density of observable black holes. We notice that if the MBH - sigma correlation at z = 6 is steeper than today, then the mass function becomes shallower. This helps reproducing the mass function of z = 6 black holes proposed by Willott et al. (2010). Alternatively, it is possible that very few halos (of order 1/1000) host an active massive black hole at z = 6, or that most AGN are obscured, hindering their detection in optical surveys. Current measurements of the high redshift black hole mass function might be underestimating the density of low mass black holes if the active fraction or luminosity are a function of host or black hole mass. Finally, we discuss physical scenarios that can possibly lead to a steeper MBH - sigma relation at high redshift.

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