New Evidence for High Spins Among the Most Massive Black Holes at $z \sim 2-4$

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Abstract

The spins of growing super-massive black holes (a_*) dictate the radiative efficiencies of the accretion process, and hold evidence regarding their past growth. This is particularly relevant for the most massive BHs observed at high redshifts, which must grow efficiently in order to match BH seeding scenarios. Theoretical models broadly predict that the most massive BHs may either "spin-down" to $a_* \sim 0$ or alternatively "spin-up" to the maximal allowed value, $a_* \simeq 1$. Our current ability to observationally test the relevance of these two scenarios at high redshifts is, however, highly limited. I will present new constraints on the radiative efficiencies (and therefore, BH spins) of a large sample of luminous un-obscured AGN at $z \sim 2-4$, powered by some of the most massive black holes known. The analysis relies on estimates of BH masses, bolometric luminosities and accretion rates, based on the virial approach and on simple scaling laws emerging from accretion disk models. Most of the extremely massive BHs in the sample (i.e., $M_{\rm BH} > 3 \times 10^9\,M_{\odot}$) show very high BH spins, with typical values well above $a_* \sim 0.7$. This strongly supports a "spin-up" scenario, which is driven by either prolonged accretion or a series of anisotropically oriented accretion episodes. Since their high masses require efficient growth, it is argued that the most probable scenario for the SMBHs under study is that of an almost continuous sequence of randomly yet not isotropically oriented accretion episodes. I will also discuss the potential to constrain the spins of SMBHs at yet higher redshifts, and possible implications for the (in-)completeness of high-redshift AGN surveys.