

Probing the early phases of the evolution of supermassive black holes in proto-spheroidal galaxies at $z > 1.5$

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We show how the wide samples of far-infrared (FIR) galaxies observed in the X-rays and of X-ray/optically selected active galactic nuclei (AGNs) followed-up in the FIR, along with AGN and stellar luminosity functions at redshift $z > 1.5$, can be used to constrain the different stages in the coevolution of supermassive black holes and host galaxies. We illustrate a simple model that accounts for the observations and that can be summarized as follows: the star formation in the host galaxy proceeds at an almost constant rate, over a timescale of 0.5-1 Gyr, within a heavily dust-enshrouded medium; part of the interstellar medium loses angular momentum and reaches the circum-nuclear regions at a rate proportional to the star formation and is temporarily stored into a massive reservoir/proto-torus around the central black hole (BH); the latter grows by accretion in a self-regulated regime with radiative power that can slightly exceed the Eddington limit (particularly at the highest redshifts). The AGN begins its life as a faint and obscured nucleus and then evolves into an obscured QSO visible mostly in the X-ray or in mid-IR bands. For massive BHs the ensuing energy feedback at its maximum exceeds the stellar one and removes the interstellar gas, thus stopping the star formation and the fueling of the reservoir. Afterwards, if the reservoir has retained enough gas, a short phase of supply-limited accretion follows in which the QSOs are visible even in the optical band.

The formation of a reservoir in the circumnuclear region of the proto-spheroidal galaxy is a key prediction of the model and represents the characteristic feature observable during the early stages of the black hole growth. We discuss how a sub-arcsecond mid-/far-infrared interferometer from space can help to constrain the properties and the specific evolution of the reservoir when coupled with strong gravitational lensing, as provided by the large samples of strongly lensed galaxies currently discovered in wide area sub-mm/mm surveys.