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# Probing the link between dense environment and fast SMBH growth at high redshift

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The large-scale environment is one of the key drivers of galaxy evolution, but the link with SMBH growth, especially at high redshift, is so far poorly understood. Massive SMBHs are thought to form in the peaks of the dark matter distribution of the early Universe, and dense and gas-rich regions at later cosmic times can provide the conditions for efficient SMBH growth. This scenario can be tested observationally with a two-fold approach by searching for overdensities of galaxies around luminous QSOs as close as possible to the epoch of SMBH formation, and investigating the AGN content of the density peaks of the high-redshift Universe, e.g. protoclusters. I will discuss some on-going activities that follow such lines of research. In particular, I will present the results of recent Chandra observations of two extremely gas-rich protoclusters at z=4, namely DRC and SPT2349, identified as strong overdensities of dusty star-forming galaxies (DSFGs). By comparing the AGN incidence in those structures with the AGN population in a sample of DSFGs in the field environment matched in L_FIR and stellar mass, we found a significant enhancement of AGN in high-redshift protoclusters. Interestingly, both protoclusters host in their central regions a luminous (Lbol~1e47 erg/s) and heavily obscured (NH~1e24 cm-2) AGN, with space densities higher by 3-5 orders of magnitude than what is found in the field environment. These objects represent a key phase of fast and efficient SMBH growth that will likely produce strong feedback, allowing the accreting SMBHs to reveal themselves as luminous optical QSOs at later cosmic times. I will also show preliminary results of an on-going work aimed to probe the large-scale (up to 8 Mpc) environment of a sample of 15 z>~6 QSOs using dedicated optical/IR observations with LBT and CFHT. The aim of this project is to obtain the first statistically robust view of the typical environmental properties of massive SMBHs at cosmic dawn by selecting Lyman-break galaxy (LBG) candidates at the same redshift of the central QSOs. Some of the targets have been already observed, and all of these appear to be surrounded by a number of LBGs in excess of the expectations from blank fields. These results support the existence of tight links between dense and gas-rich regions of the Universe, the formation of SMBHs, and their rapid growth at high redshift.

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