Super-massive black holes in the early Universe

The study of the accreting super-massive black holes (SMBHs) population in the very early phases of the Universe is a crucial topic in the context of the present-day astrophysics and is part of the science goals of the most relevant telescopes of the next decade at all wavelength (eRosita, LSST, Euclid, SKA, WFIRST, Athena). SMBHs, with masses in the range of 10^6 - 10^9 solar masses, are observed in the center of all the galaxies and are thought an important element in their evolution. While we know the recipe to make out a black-hole with typical mass of 1-10 solar masses, understanding a physical mechanism to seed SMBH is much more difficult. From an observational point of view the most important piece of information in this context is the **SMBH mass function**, in particular when evaluated at **high redshift (z>4)**.

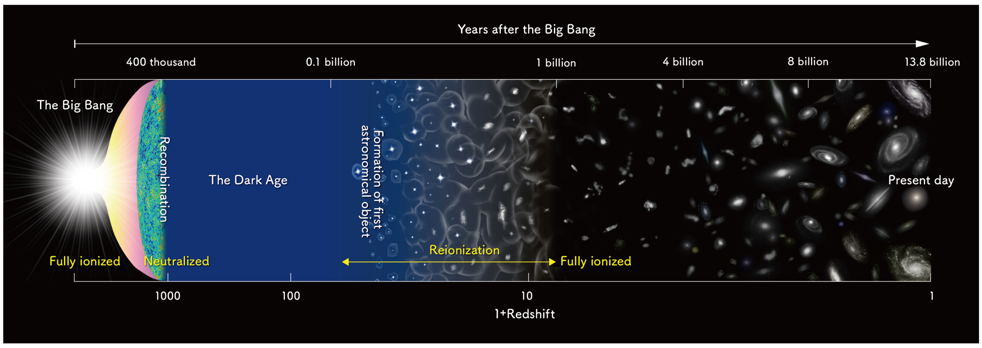

Fig.1 - Universe timeline. The research project discussed here focuses on QSO in the first 1.5 Gyr since the Big Bang, close or within the re-ionization epoch [credits: NAOJ].

At the Brera Observatory we are working in this field following 2 different and complementary approaches.

- First, we are working on the selection of high redshift QSOs exploiting large photometric catalogs, in the optical and IR wavelengths like the PanStarrs, DHS, VIKING and VHS surveys and using the classical drop-out technique. This method will select very high-z QSO candidates **up to z∼8**.
- In addition, we are focusing on the radio-loud QSO population and in particular on the class of **blazars** that can provide an independent estimate of the supermassive black-hole mass function in high redshift radio-loud AGN without the bias due to absorption along the line-of-sight. Indeed, since blazars are radio-loud AGN whose relativistic jet is pointing towards the observer (Urry & Padovani 1995), the obscuration is negligible and does not affect the selection. The space density of the entire population of radio-loud AGN can then be inferred indirectly from the observed number of blazars (see e.g. *Ghisellini et al. 2013, MNRAS, 432, 2818* for details).

During the last years we have obtained several observing nights at the major optical telescopes available to date (e.g. TNG, NTT and LBT). Thanks to these observing runs we have built up the largest statistically complete radio selected sample of blazars (the CLASS sample) that we have then used to estimate, **for the first time, the space density of these sources at redshift between 4 and 5.5** (*Caccianiga et al. 2019, MNRAS, 484, 204*). In addition we are studying in more details newly discovered high-z blazars (*Belladitta et al. 2019, in prep.*) and the X-ray properties of the entire CLASS sample of high-z blazars (*Ighina et al. 2019 in prep.*).

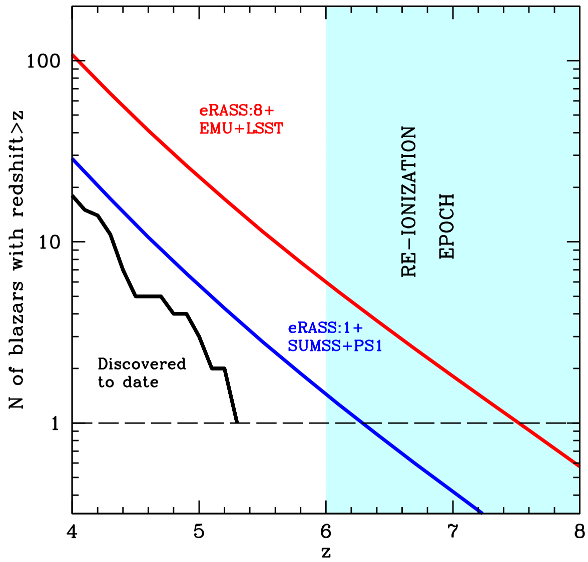

Fig.2 - Predicted number of high-z blazars that will be selected by combining the new wide-angle surveys that are going to be carried out in the optical (LSST), X-rays (eRASS from the eROSITA telescope) and in the radio (EMU).

In order to push our research towards higher redshifts (See Fig. 2) and to increase the numbers of selected sources, we are collaborating with the team of some of the most important facilities that will be available in the next few years. Specifically, our group is officially in the collaboration of the **Large Synoptic Survey Telescope (LSST)** that, starting from the 2021, will provide the deepest wide angle survey in the optical band. At the same time, we have recently submitted a proposal to have priority access to the X-ray data from the **eROSITA** telescope that is expected to be launched in the 2019. This telescope will carry out the deepest all-sky survey at X-ray energies thus providing fundamental data for the selection and the study of high-z QSO.

Current Team

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