PhD project in ASTROPHYSICS
(one page)

Title of the Project: The role of relativistic jets in the assembly of the first supermassive black holes: a multi-band approach

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Scientific Case: Little is observationally known above redshift z = 6, when the Universe was young and the first sources (including active galactic nuclei, AGN) ionised their surrounding gas in the period called cosmic reionization (e.g., Zaroubi 2013). The AGN detected at these cosmological distances have already masses higher than 10^{8-9} $M_{\odot}$ (e.g., Vito et al. 2019) which are indicative of a fast and efficient growth that challenges supermassive black holes (SMBH) standard formation models (e.g., Volonteri 2012; Wu et al. 2015). Among the high-z AGN those that are also radio-loud are about 10% of the entire AGN population (Bañados et al. 2015; Padovani et al. 2017), and provide a unique opportunity to study the role of jets in the accretion of SMBH (e.g., Volonteri et al. 2015), their feedback on the host galaxy (e.g., Fabian 2012), the cosmic evolution of the AGN radio luminosity function (Padovani et al. 2015) out to the largest distances; they can also be used as cosmological probes (e.g., Gurvits et al. 1999).
The radio-loud AGN called blazars have their relativistic jets oriented along the line of sight (Urry & Padovani 1995). Since their non-thermal radiation is relativistically amplified, and not obscured along the jet direction, blazars are very bright and visible up to high redshifts, allowing the study of the radio-loud AGN population across cosmic time (e.g., Ajello et al. 2009; Caccianiga et al. 2019). Indeed, our team has been recently involved in the discovery of the highest redshift blazar (Belladitta et al. 2020) and its follow-up at high angular resolution (Spingola et al. 2020).

Outline of the Project: The proposed PhD project will focus on confirming and characterizing the high-z blazar population by:
1) performing a multi-band analysis using state-of-the-art VLBI observations of the entire sample of blazar candidates at z>4 to constrain the actual number of high-z blazars;
2) assessing the low (150MHz) and ultra-low (50 MHz) properties for the first blazar at z>6 and the entire sample to connect the Mpc to pc-scale emission for the first time at those redshifts. LOFAR data for the first blazar are already in hand, those for the other sources will be searched for in the available deep surveys or requested with dedicated new observing proposals. The characterization of the low-frequency spectral turnover has the power to assess the physical conditions (e.g. magnetic field) and the radiative mechanisms (e.g. FFA vs SSA) in AGN up to extremely high redshifts.
3) An important domain to detect and study high-redshift blazars at high energies is the X-ray band. Hard X-ray data, available or requested in the future, will be used to study the properties of a sample of candidate and confirmed high-z blazars; new soft X-ray data from e-ROSITA will also be publicly available for the characterization of this sample.
4) The typical spectral energy distribution of high-z blazars makes their detection in gamma rays very challenging, with only a handful of blazars discovered at high-energy, which is however critical in characterizing the emission mechanisms. A research on gamma-ray emission from high redshift blazar candidates will be performed, and predictions for future missions and ground-based instruments will complete the PhD Thesis topics.

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