PhD project in ASTROPHYSICS

Title of the Project: Exploiting deep radio surveys to assess the growth of black holes and the role of jet-induced AGN feedback in galaxy evolution

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Scientific Case: Understanding the evolution of galaxies, from the end of the 'dark ages' through to the complexity and variety of systems we observe in the local Universe, remains a primary goal for observational and theoretical astrophysics. A crucial piece of the evolutionary picture is the role that active galactic nuclei (AGN) play in shaping galaxies over cosmic time. Indeed, the energy released by the AGN through radiative winds and/or radio jets is widely believed to regulate the rate of star formation in their host galaxies via so-called "AGN feedback". However, the details of how and when this occurs remains uncertain from both an observational and theoretical perspective (e.g. see reviews by Heckman & Best 2014; Harrison 2017).

It is widely accepted that recurrent jet-mode AGN activity is a fundamental component of the lifecycle of the most massive galaxies, responsible for maintaining these as 'old, red and dead' (e.g. Best+06; Bower+06; Sabater+19). There is however mounting evidence that at least a fraction (~30%; Delvecchio+17) of radio-quiet (RQ) AGN (i.e. Seyfert galaxies and quasars) host compact AGN-triggered radio cores, possibly associated with mini-jets on (sub-)galactic scale (see also Maini+16; Herrera-Ruiz+16; Radcliffe+18). If mini-jets are a common feature (Jarvis+19), jet-driven feedback could play a significant role in shaping galaxy evolution even at lower stellar masses. These findings open new very exciting perspectives for next-generation radio-continuum surveys.

Outline of the Project: The supervisor is actively participating and has leading roles in international legacy projects involving wide-field and/or deep radio-continuum surveys of some of the most popular extra-galactic fields (GOODS-N, COSMOS, etc.), carried out with SKA pathfinders/precursors (eMERLIN, JVLA, LOFAR, MeerKAT, ASKAP, etc.). At the depths probed by these surveys the radio sky is dominated by star-forming galaxies (SFG), and RQ AGN, while powerful radio galaxies (RG) and radio-loud quasars (RL-QSO) only represent a minor contribution (e.g. Prandoni+18). These surveys hence provide a powerful dust/gas-obscuration-free tool to 1) get a complete census of AGN (including Compton-thick objects missed by X-ray surveys), and study how the Type-1/Type-2 AGN fractions evolve with both luminosity and redshift; 2) assess the incidence of mini-jets in RQ AGN populations and shed light on their role in shaping galaxies across cosmic time.

The Phd thesis project will make use of data from one or more of the following surveys:

- eMERGE with JVLA and eMERLIN (see e.g. Guidetti+17; Muxlow+20)
- MIGHTEE with MeerKAT (see e.g. Jarvis+17; Delvecchio+21)
- EMU with ASKAP (see e.g. Norris+2011)
- J1030 field with JVLA, LOFAR, ALMA (see e.g. Gilli+19; D'Amato+20; Mignoli+20)
- LoTSS Deep Fields with LOFAR (see e.g. Tasse+21; Sabater+21; Mandal+21)

which offer complementary views on faint AGN populations. Through a comparative study of RQ and low (radio) luminosity RL AGN we will be able to identify common trends and systematic differences, that will shed light on the origin of the radio emission in the radio quiet population. The study will be done by combining radio data with the deep, extensive multi-band coverage (UV/optical/IR/sub-mm/X-ray) available for these fields. A multi-frequency, multi-band approach is essential to link the radio properties (radio power, size, spectrum and morphology) to the AGN (e.g. accretion rate, duty cycle) and host galaxy properties (stellar and dust mass, star formation rate, redshift, environment, etc.). In some cases, high quality (HI or optical) spectroscopy is available, allowing us to directly explore the link between radio emission and gaseous outflows.

Depending on the student's interests and skills the focus of the thesis can vary: more weight can be given to radio or to ancillary multi-band data analysis; to theoretical or observational studies.

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