The environments of the most distant radio galaxies

Understanding galaxy formation and evolution across cosmic time is a fundamental topic in astrophysics, and key science driver for the forthcoming Square Kilometre Array (SKA). In the early Universe, high-redshift radio galaxies (HzRGs; e.g. review by Miley & De Breuck 2008, A&AR, 15, 67) are crucial beacons for investigating how the most massive galaxies form (e.g. left panel below), and their link to the massive 'red and dead' ellipticals that are the brightest cluster galaxies in the more local Universe.

HzRGs are rare. An efficient way of finding these objects is to select samples of sources with ultra-steep (USS) radio spectra, i.e. where the source flux density decreases rapidly with increasing frequency. Using lower-frequency catalogues with deep detection limits is therefore expected to be advantageous, and indeed has recently led to the discovery of the most distant radio galaxy currently known (right panel below).

Research Field
Radio Astronomy

Project Suitability
PhD

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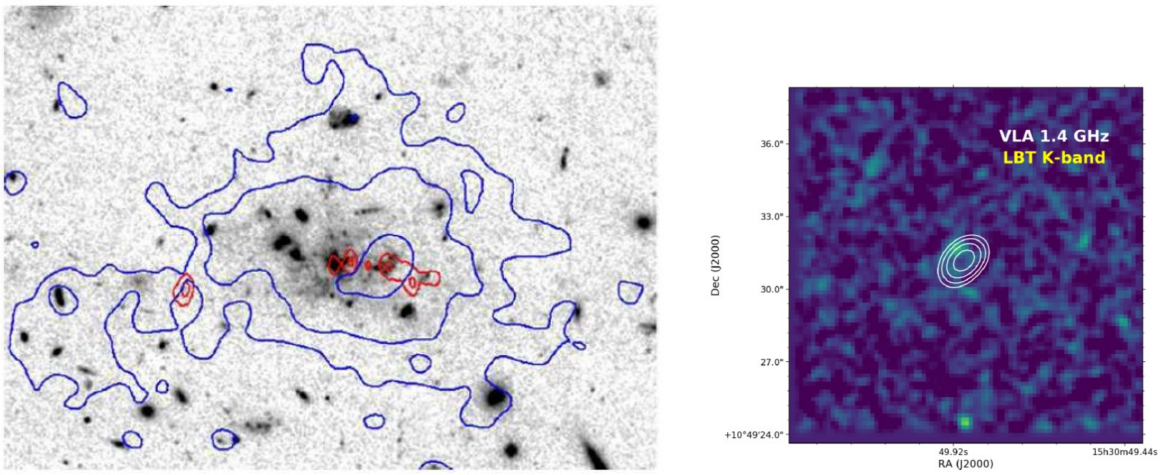
In this project, you will use data from the Murchison Widefield Array (MWA), the Australian SKA Pathfinder (ASKAP), and the Australia Telescope Compact Array (ATCA), as well as additional multi-wavelength data from other facilities, to find and subsequently investigate new HzRG candidates. This project will address, but is not limited to, topics such as the following:

(i) Can the deepest MWA observations uncover a significant number of previously unknown distant radio galaxies?
(ii) What is the underlying reason for the success of the USS selection method? The superb broadband coverage of the MWA, ASKAP and the ATCA will enable new important insights.
(iii) What are the typical environments in which the most distant galaxies reside, and how is this reflected in their properties (particularly their radio polarimetric properties, such as polarisation fraction and Faraday rotation measure)?
(iv) Given a multi-wavelength dataset, what does a HzRG typically look like? Moreover, how can we most efficiently select HzRG candidates in the era of the SKA, where catalogues will comprise billions of sources?



Left: The 'spiderweb galaxy' at redshift z = 2.2: witnessing the formation of a dominant cluster galaxy in the early Universe. The greyscale is a Hubble Space telescope image, while Lyα (blue) and radio contours (red) are also shown. Figure from Miley et al. 2006 (ApJ, 650, L29). *Right*: Radio contours overlaid on a near-infrared *K*-band image of the most distant radio galaxy currently known, TGSS J1530+1049 at a redshift z = 5.72 (i.e. when the Universe was only 1 billion years old). Figure from Saxena et al. 2018 (MNRAS, 480, 2733).