Studying the accretion-outflow connection in AGN with large observational surveys

Research Areas: Galaxies, High-energy Astrophysics.

THE ROYAL SOCIETY

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My research is at the intersection of theory and observation and my interests are fairly broad, but fundamentally I am interested in the extreme and exotic physics that can be probed using accreting black holes and the outflows they produce. In particular, my work focuses on particle acceleration, accretion disc winds, astrophysical jets and the connections between these topics.

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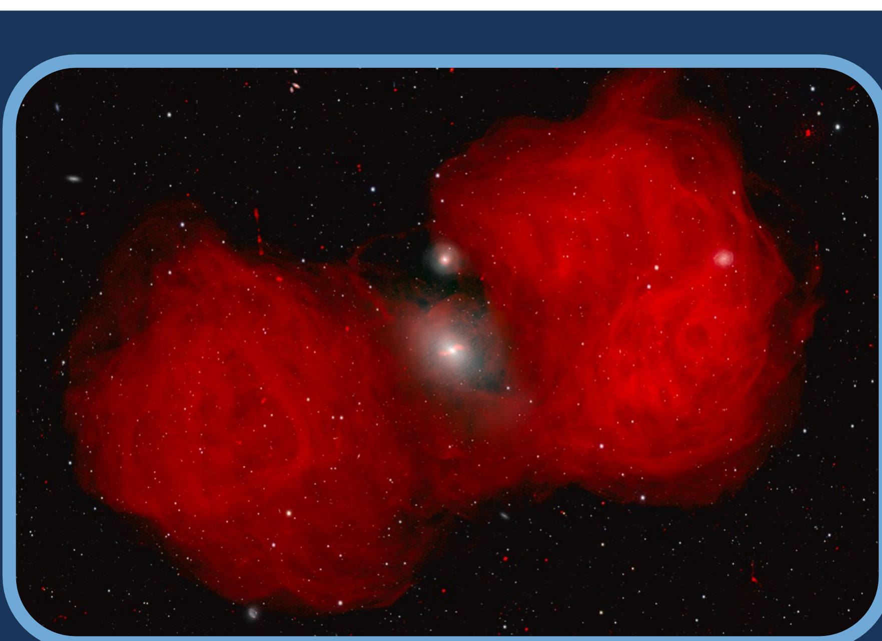
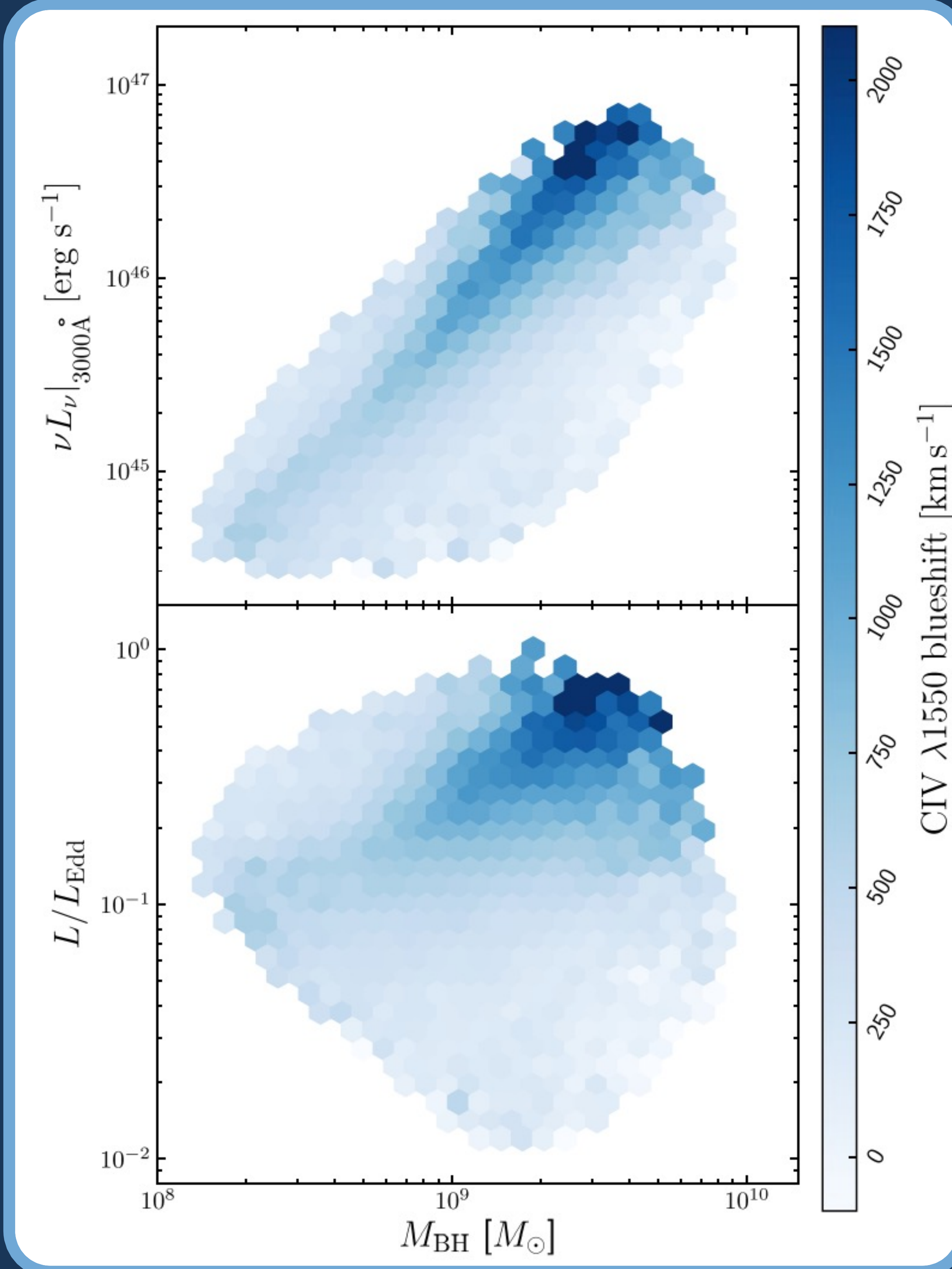
I work on a range of topics relating to AGN, cosmology and galaxy evolution, mostly using state-of-the-art observational surveys at multiple wavelengths. I am PI of the MeerKAT project MIGHTEE and am also heavily involved in WEAVE-LOFAR and VIDEO. In recent years I have also devoted a lot of time to initiatives to promote equality, diversity and inclusion, and I am an Associate Head of MPLS Division for People.

Context

Supermassive black holes are thought to lie at the centre of virtually every galaxy, and many of them are "active", in the sense that they accrete matter from their surroundings and give off prodigious amounts of radiation. These Active Galactic Nuclei (AGN) are fascinating and important objects. Remarkably, the accretion process also expels outflowing material, a process that can transport huge amounts of energy and momentum to vast distances, allowing the AGN to influence physical proceedings far from its gravitational sphere of influence. These outflows are split into two broad classes -- narrow beams of relativistic material called jets and slower, wider-angle flows called winds. Both winds and jets represent important "feedback" channels, but both are also intimately connected to the underlying AGN accretion disc.





Top: MeerKAT image of Fornax A, a nearby radio galaxy. The lobes are produced by jets from the central black hole (Maccagni+ 2020).

Right: The "blueshift" of the Carbon IV emission line in a large SDSS sample of quasars at z~2, as a function of quasar properties. (Temple+ 2023). Combining analysis such as this with radio data will allow us to test the accretion-outflow connection in more detail.

The four main instruments we will use for this work: The LOFAR core (top left), the MeerKAT radio telescope (top right), the SDSS telescope at Apache Point (bottom left) and the WEAVE spectrograph on the WHT (bottom right).

Main Goals

In this project, we will use rest-frame ultraviolet (UV) spectroscopy and radio observations to study the connection between accretion discs and their associated winds and jets in high luminosity AGN (also known as quasars), at moderately high redshift (z~1.5-4). In particular, we will use spectra from the Sloan Digital Sky Survey and WEAVE -- a brand new multi-object spectrograph on the WHT -- to study emission and absorption line signatures of AGN winds. We will combine this analysis with radio data from the LOFAR Two metre sky survey and the MeerKAT SKA pathfinder to look at jet signatures, as well as radio emission from star formation and wind shocks. The overall goal of the project is to build a cutting edge census of accretion and outflow activity in AGN and make progress towards a more complete physical understanding of these processes. While the emphasis is primarily observational, the work concerns the extreme physics of black holes, jets and winds, so theory will form an important part of the project; in addition, there will be opportunities to get involved with radiative transfer modelling of the accretion disc and the spectral signatures produced by AGN winds.

Why Oxford Astrophysics?

Being at Oxford will give you the chance to engage with world-class researchers with both observational and theoretical backgrounds. You will join a vibrant research group with the opportunity to work with additional Oxford personnel, in particular research fellow Dr Imogen Whittam, as well as external collaborators in Cambridge, Southampton, Edinburgh, the US and Chile. Oxford is heavily involved in the LOFAR, MeerKAT and WEAVE projects and the student will have the opportunity to formally join relevant observational collaborations. This will place the student in an excellent position for exploiting other facilities, such as LSST and the SKA.

Links and Further Reading

You can find more details on these projects together with a full list of references and links to movies at jhmatthews.github.io/dphil.

Alternatively, use this QR code.