FM3 – Radio Galaxies: Resolving the AGN Phenomenon

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Focus Meeting #3: Radio Galaxies – Resolving the AGN Phenomenon†

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Radio galaxies provide excellent laboratories for investigating the physical aspects, unification and cosmic evolution of active galactic nuclei (AGN). Thanks to recent multi-wavelength observations, we are now able to separate many different physical components of radio galaxies through imaging and spectroscopy. Observations from radio through X-ray wavelengths can probe the ejection of matter into jets and monitor decades of jet evolution. Gamma-ray observations have shown that radio galaxies are detectable up to the very-high-energy range despite unfavorable jet alignment.

We observe radio galaxies out to redshifts greater than $z = 5$, which makes them important cosmological probes. Planck maps have provided us with new insights into the populations of radio galaxies and their distributions in space in the $30 - 900$ GHz range. NuSTAR provides high-quality spectra in the hard X-ray range. The Event Horizon Telescope (EHT) has begun mapping close to the event horizon of the Milky Way's central black hole, and the Square Kilometre Array (SKA), the next generation of extremely large telescopes (ELTs) and other future telescopes will open up a new and vast discovery space.

Focus Meeting #3 brought together multiwavelength observers and theorists to synthesize progress made over the last three years and to define future directions. In order to channel the presentations and discussions, the meeting was organized into five sessions:

• During the first session, starting on August 22nd, we discussed the radio-galaxy structures that are produced on kiloparsec scales and beyond, with an emphasis on plasma composition, and sought to address their underlying causes. Daniel Schwartz (Harvard-Smithsonian Center for Astrophysics, USA) talked about high-resolution studies of 100 kpc jets based on data from the Chandra X-ray Observatory. For example, a new Chandra survey for jets in radio quasars at $z > 3$ has revealed X-ray jets and lobes extending beyond the region of detected radio emission (Schwartz 2018).

• The second session focused on the central engine and production of the jet(s). Alexander Tchekhovskoy (University of California, Berkeley, USA) introduced the topic with a presentation about how numerical simulations incorporating general relativity and magnetism allow us to use black hole accretion phenomena to quantitatively probe strong-field gravity and constrain black hole physics in various astrophysical contexts.

• On the second day of the meeting we first discussed populations and statistics of radio galaxies, motivated by a review from Elaine Sadler (University of Sydney, Australia) focusing on results from multi-wavelength radio surveys.

• This was followed by a session about future prospects. Lindy Blackburn (Harvard-Smithsonian Center for Astrophysics, USA) started the discussion with a presentation on the goals and status of the EHT, which has already revealed structure on the scale of

† This article was originally published with its supplementary material missing. This has since been updated in the online PDF and HTML versions and a correction notice has been published.

the Schwarzschild radius in Sagittarius A*, the supermassive black hole at the centre of our galaxy, and in Messier 87 in the Virgo Cluster.

• A fifth session dealt with the interaction of radio galaxies with their environments. Andy Fabian (Institute of Astronomy, Cambridge University, UK) discussed AGN feedback in clusters of galaxies and explained how energy can be transported and dissipated throughout the cluster core.

In addition to the invited reviews, 20 high-profile contributed talks reviewed the state of the art within the field, and 20 posters had been selected for one-minute/one-slide presentations. The sessions were accompanied by dedicated discussions, giving the audience ample opportunities to help us obtain a wide and complete view of what is driving radio galaxies and what we can learn from them about physical processes in the universe.

Finally, Annalisa Celotti (International School for Advanced Studies (SISSA), Italy) wrapped up FM3 by giving a summary of the results presented during the 1.5 days of the meeting.

In the following the proceedings present the review article of Dan Schwartz, followed by eight contributions, which are representative of the presentations given at the focus meeting: Birkinshaw, Rawes & Worrall (2019), Bruni *et al.* (2019), Jarvis (2019), Morganti *et al.* 2019, Nyland (2019), Shaballa (2019), Whittam (2019), and Worrall, Duffy & Birkinshaw (2019). These articles are sorted in alphabetical order. Additional articles can be found in the supplements of these proceedings. Photos of the focus meeting can be found on Twitter under https://twitter.com/iau18radiogalax

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Supplementary materials

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1743921319003442.

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