4th year Projects with Denise Gabuzda

"Active Galactic Nuclei", or AGN, generate huge amounts of energy whose source is believed to be a supermassive black hole at the galaxy's centre. These objects sometimes produce oppositely directed jets of plasma (presumably along the rotational axis of the black hole), which emit radio synchrotron radiation that can be studied with high resolution using Very Long Baseline Interferometry (VLBI). Multi-wavelength polarisation-sensitive VLBI can be used to study the morphology and magnetic (B) fields of the jet structures, and also Faraday rotation occurring near the radio jets – a rotation of the observed polarisation direction that arises when the radiation passes through a region with free electrons and B field. The amount of Faraday rotation is proportional to the wavelength squared, and its sign (direction) is determined by the direction of the line-of-sight B field in the Faraday-rotation region, making it possible to use the Faraday rotation measure (RM) to probe this field. For example, if the jet carries a helical B field (believed to form due to the rotation of the central black hole plus the jet outflow), this will give rise to a gradient in the Faraday rotation across the jet, due to the systematic change in the line-of-sight component of the helical field.

No prior knowledge of or experience in astrophysics beyond PY2106 is necessary; all essential physics is core physics, and will be applied here to AGN and VLBI. I can take more than one student for this project, with different students working on data for different AGNs.

Project:

AGN jets on parsec to decaparsec scales

The student working on this project will make radio images of a number of AGN at wavelengths of 6, 13, 18 and 22cm, in order to study the jet structurs and B fields, and also to search for examples of AGN whose jets show firm evidence of transverse Faraday rotation gradients betraying the presence of helical jet magnetic fields. These new data are very sensitive to Faraday rotation due to the large range of wavelength squared that is covered. The results will be used to derive fundamental information about the physics of AGN jets – the directions of the helical field "twist" and of the dominant currents along the jets.

Literature for further reading:

Gabuzda (2008), "Radiation Processes in the Universe: Synchrotron Radiation and Propagation Effects"

http://adsabs.harvard.edu/abs/2008mcct.confE...9G

Gabuzda (2006), "The Compact Polarised Emission of AGN"

http://adsabs.harvard.edu/abs/2006evn..confE..11G

Gabuzda (2016), "The Origin and Structure of the Magnetic Fields and Curents of AGN Jets"

http://www.mdpi.com/2075-4434/5/1/11

Examples of recent research results from the UCC AGN group:

Gabuzda, Roche, & Nagle (2018), “The Jets of Active Galactc Nuclei as Giant Coaxial Cables”, *Astronomy & Astrophysics*, vol. 612, p.67.

Gabuzda, Roche, Kirwan, Knuettel, Nagle & Houston (2017), “Parsec-scale Faraday-rotation structure across the jets of nine active galactic nuclei”, *Monthly Notices of the Royal Astronomical Society*, vol. 472, p. 1792

Gabuzda, Knuettel & Bonafede (2015), “Evidence for a toroidal magnetic-field component in 5C4.114 on kiloparsec scales”, *Astronomy & Astrophysics*, vol. 583, p.96.

Gabuzda, Knuettel & Reardon (2015), “Transverse Faraday-rotation gradients across the jets of 15 active galactic nuclei”, *Monthly Notices of the Royal Astronomical Society*, vol. 450, p. 244

Gabuzda, Reichstein & O’Neill (2014), “Are spine–sheath polarization structures in the jets of active galactic nuclei associated with helical magnetic fields?”, *Monthly Notices of the Royal Astronomical Society*, vol. 444, p. 172

Gabuzda, Cantwell & Cawthorne (2014), “Magnetic field structure of the extended 3C380 jet”, *Monthly Notices of the Royal Astronomical Society,* vol. 438, p. L1.

Blue = undergraduate research student