STUDYING BROADBAND RADIO SPECTRA IN THE CLASSROOM

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ATARP: Australian Teacher Astronomy Research Program
WHAT IS ATARP?

- Australian Teacher Astronomy Research program
- Providing high school science teachers with authentic research experience in Australia’s strongest STEM area, radio astronomy

Photo credit: Rob Hollow, CSIRO
WILLETTON SENIOR HIGH SCHOOL
GIFTED AND TALENTED PROGRAM

• 360 students in the program
• All students in the top 3% of their age group
• Academic focus
• School observatory houses a 36cm f8 robotic RCT
• Median ATAR 97+
• 100% University bound

Photo credit: Jade Woods, Willetton SHS
BYFORD SECONDARY COLLEGE

• New School – Opened in 2014

• Introductory Astronomy as part of our endeavour to encourage students to become proficient in Science, Technology, Engineering and Mathematics (STEM)

• 17 students in Year 9

Photo credit: Anusha Veerahoo, Byford Secondary College
RESEARCH PROJECT: BROADBAND RADIO SPECTRA

• The GaLactic and Extragalactic All-sky Murchison Widefield Array (GLEAM) 4-Jy Sample

• Combining data from the Murchison Widefield Array with the Australia Telescope Compact Array (ATCA)

• Frequency range: 70 MHz to 20 GHz

• ATCA data from the AT20G survey and new observations

• Detected at 20 GHz -> subset of 208 sources
• Accelerated electrons emit photons
• Electron transitions result in a Spectral Energy Distribution with a turnover
• The sum of multiple transitions results in a linear inverse relationship between intensity and frequency
• We expect the majority of radio sources to follow this power law

http://astronomy.swin.edu.au/cosmos/S/Synchrotron+Emission Credit: Swinburne University of Technology
STUDENT PROJECT PROCEDURE

• Open spectral energy distribution plot
• Classify SED plots
• Locate object data (morphology, frequency, GLEAM α, G4Jy α) from the G4Jy catalogue using Topcat
• Collect more information from Simbad database and VLBI image set
• Compile and analyse all data
• Look for trends
A convex or n shaped graph (16%) may be due to the absorption of low frequency emissions by neutral gas in the galaxy. The boost in high frequency emissions (8%) results in a concave U shaped graph. This could be due to new radio jets emerging as the electrons that produce the emissions lose energy.
GLEAM alpha – G4Jy alpha

Mean = 0.0
Median = -0.05
Results normally distributed about zero
n = 158    76%

Mean = 0.11
Median = 0.123
All results positive
n = 33    16%

Mean = -0.21
Median = -0.18
All results negative
n = 16    8%
Mean = 0.636
Median = 0.498
n = 158    76%

Mean = 0.746
Median = 0.529
n = 16     16%

Mean = 0.862
Median = 0.671
n = 8      8%

http://deskarati.com/2012/11/08the-history-of-redshift/
FUTURE WORK

Single Overlay, Double VLBI

Double Overlay, Single VLBI
SCIENTIFIC OUTCOMES

• Linear 76% $z=0.498$, n 16% $z=0.529$, u 8% $z=0.6$ $z=0.671$

• We mostly assume that all radio sources follow a power-law

• Sources with 'u'-shaped spectra appear to be mostly blazars

• 81 of the 208 sources have VLBI images, with 22 of them having a different morphology in VLBI compared to the overlays (i.e. either a 'single' in NVSS/SUMSS is resolved into two jets, or the radio core of a 'double' has been imaged)

• Have identified sources with a 'kink' in the spectrum, which is suggestive of multiple episodes of Active Galaxy Nucleus activity (i.e. distinct 'injections' of electrons)
EDUCATIONAL OUTCOMES

• Given real meaning to astronomical/mathematical terms – RA, Dec, frequency, wavelength, magnitude, redshift, log scales, significant figures,

• Education driven by a purpose gives meaning to student work

• Working as a group with a common goal

• Leadership

• Mastery of spreadsheets

• Astronomical databases

• Organising data

• Real application of statistics

• Exposure to scientific literature
FUTURE WORK (SCIENCE)

• The VLBI check also identified which sources have additional higher-frequency measurements, so add these to the SED plots

• Extend the study of broadband radio spectra to the rest of the sample that do not have an AT20G detection

• Use models for spectral ageing to estimate the age of the radio source (applicable to the 'n'-shaped spectra)

• Obtain measurements of the neutral gas in the system, to disentangle its effect on the spectrum at low frequencies

• Investigate what fraction of the entire sample are blazars, and do they all show 'u'-shaped spectra?

Harwood et al. (2013), Nyland et al. (2018)
FUTURE WORK (EDUCATION)

• Byford Secondary College:
  - Astronomy courses offered to Year 10 students as from 2019 and potentially Years 7 and 8 students as from 2020

• Willetton Senior High School
  - Take optical images of some of the brighter sources that we have studied
  - Look for other trends in the data that we have used

Photo credit: Darren Hamley Willetton SHS