Finding the Pressure Points of the Galaxy

The low-frequency Square Kilometre Array (SKA) is being built here in Western Australia. This new instrument will transform our understanding of the role of the cold, atomic gas in galaxy evolution. The main tracer of this gas is neutral hydrogen (HI) but measuring this does not constrain the physical properties of the gas (e.g. pressure, density). By observing carbon recombination lines (CRRLs) at frequencies less than 350MHz we can study the physical conditions of diffuse, cold clouds within our Galaxy. Using the Murchison Widefield Array to do this is important in pathfinding toward the SKA.

Research Field
Radio Astronomy/Engineering

Project Suitability
PhD, Masters, Honours

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Context:
The interstellar medium (ISM) is a collection of stellar ejecta and stellar nurseries. Cold, diffuse, atomic clouds are a key component of the ISM and contains a large fraction of ionized carbon (C+). This attracts free electrons, causing a cascade to lower energy levels and emitting radio waves at specific frequencies: "radio recombination lines", detectable by radio telescopes. The frequency of the emission is directly related to the size of the carbon atom, such that recombination lines detected at around 10MHz are the size of a virus; 1000 times the size of what can exist on Earth.

These large atoms are very sensitive pressure probes of gaseous environments. If the gas is too dense, larger atoms cannot exist as the outer electrons are sheared off the outer shell. At frequencies less than 100MHz these CRRLs are detected in absorption against strong continuum. At frequencies greater than ~150MHz the CRRLs are detected in emission. However, in between these two frequencies the CRRLs will null as the competing emission mechanisms balance, but the exact frequency at which this happens is highly dependent of the gas density in the region observed.

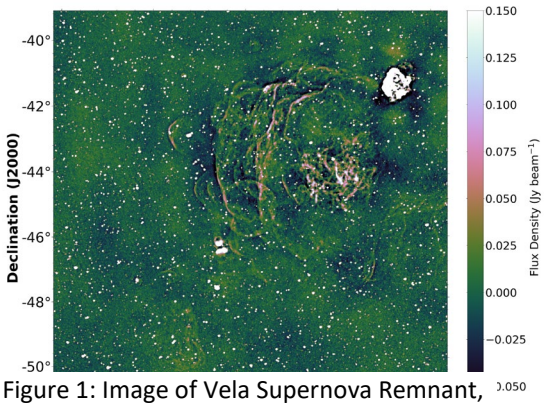

Figure 1: Image of Vela Supernova Remnant, RCW38 star forming region and Puppis taken at 114MHz with the Murchison Widefield Array. This region is currently being surveyed for molecular lines with long integration times.

Aims of project:
Honours: the interested student will utilise existing MWA data cubes or generate new cubes from existing scripts. The data are from the Phase II (extended baseline) MWA and will either study the region around the Vela Supernova Remnant or Orion Molecular Cloud.
Masters or PhD: As above, and additionally: prepare scientific publications on the results, propose observations on the Long Wavelength Array linked with the Karl Jansky Very Large Array at 50—80MHz to examine low-frequency CRRLs, and investigate the implications for SKA surveys.

Requirements:
This project is suited to a student with a strong grounding in astrophysics and a good understanding of or willingness to learn statistics so that these sensitive measurements may be made in a robust and quantitative way. The project will also involve low-frequency data reduction, statistics and large-scale data processing on supercomputers, so organisation and computing skills are also useful.