ATCA Legacy Program Expression of Interest
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Title:
Deep Imaging of the Circum-galactic Medium with ATCA

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Scientific Aims:
The interaction between galaxies and the Inter-galactic Medium (IGM) or Circum-galactic Medium (CGM) is a crucial aspect of galaxy evolution that is not well understood. Neutral hydrogen is the best tracer of accreting and outflowing gas, however very hard to detect due to its low column density. The Compact Array has a wide range of compact configurations, combining these configurations results in a very good point spread function (PSF) at moderate resolution. The resulting brightness sensitivity and dynamic range is excellent and cannot be achieved with ASKAP.
Simulations predict that in order to detect HI in the extended environment of galaxies, brightness sensitivities well below NHI ~10^{18} cm^{-2} are required (e.g. Popping et al. 2009). The HALOGAS survey on the WSRT (Heald et al. 2011) is currently the deepest survey, that has observed 22 galaxies down to column densities of a few time 10^{19} cm^{-2}. Typically not much extended gas is found at these column densities, making the case for even deeper observations. Ultra deep observation on the GBT around M31 (Wolfe et al. 2016) do reveal isolated clumps of gas at column densities of NHI ~ 10^{18} cm^{-2}.

This project aims to observe a sample of ~30 nearby galaxies of different masses and in different environments, to study their extended HI properties. Most likely these will be well known galaxies with plenty of archival data describing the gas content at high spatial resolution. Ultra-deep observations at low resolution will complete the picture of these galaxies and open up new parameter space, which will only be surpassed by the SKA. Direct aims of the projects include:
- Achieve a 1 sigma NHI of 2.5x10^{17} cm^{-2} over 20 km/s.
- Measure the extended gas content of galaxies to detect gas accretion and outflows.
- Search for companions to better understand the missing satellite problem.
- Detect the densest peak of the underlying Cosmic Web.

Number of objects
To understand to neutral gas properties around galaxies, a representative and unbiased sample of objects is required. This project aims to observe 30 nearby galaxies in different environments covering a wide mass range.

LST ranges
Because the project will observe a large number of targets, these can be selected to cover all LST ranges.

Observing Frequency
To detect neutral hydrogen around relatively nearby galaxies, L-band observations are required at 1.4 GHz

CABB mode
CABB will be used with 64MHz bandwidth. This is more than sufficient to cover the spectral range of individual objects at good spectral resolution.

Array Configurations
To get the optimum UV-coverage and brightness sensitivity, the project will require a combination of several of the compact configurations. Very good results can be achieved by using the four most compact configurations (H75, H168, H214, EW367) and a combination of four of the 750m configurations.

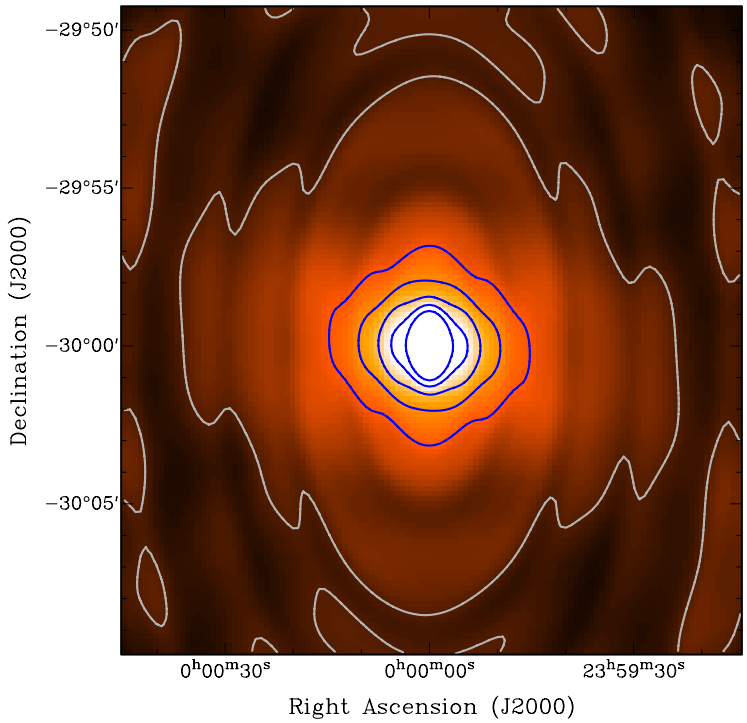

Figure 1: PSF of the anticipated observations at a declination of -30 degrees. Contour levels are at 50, 40, 30, 20, 10 and -1 percent of the peak.

Observing strategy

For this project brightness sensitivity is crucial. Every target will be observed for ~96 hours, broken up in 8 observations of ~12 hours each. Each of the four most compact configurations will be observed together with four 750 meter configurations. Combining these observations using natural weighting will result in a point spread function as shown in Figure 1. The synthesised beam has a FWHM of ~150'' and positive contours are drawn to 50, 40, 30, 20 and 10 percent of the peak. The grey contour indicates negative sidelobes at the 1 percent level and shows the excellent dynamic range of the PSF.

Required Sensitivity

To be able to detect to diffuse emission and to have a significantly better brightness sensitivity than existing surveys a 1sigma column density of a few times 10^{17} cm^{-2} over 20 km/s is required. This can be achieved by the observing strategy as outlined above, resulting in NHI=2.5e17 cm^{-2} over 20 km/s at 2.5 arcmin resolution

Numbers of hours in total and per semester

We are aiming for a total of ~100 hours per object and a sample of 30 objects. The total time request is 3000 hours, there are no strong constraints how this should be broken up per semester but to finish the observations in two years, we anticipate ~750 hours per semester

Indicative resources

For the full proposal the core of the anticipated team will consist of members from ICRAR (UWA) and CASS. The team can contribute the resources to perform the project. Both CASS and ICRAR have many experts on HI observations with ATCA. The team has sufficient expertise to develop robust reduction pipelines that can reduce the data in an efficient manner. ICRAR has an Data Intensive Astronomy (DIA) group that can aid in managing and storing the data.

Specific team expertise not yet identified

The team will have the required expertise and resources to perform this project.