Spectral lines – HI

Completing the Census of HI in the Circumgalactic Medium of M31

D.J. Pisano (WVU/UCT, djpisano@mail.wvu.edu), F.J. Lockman (GBO)

The circumgalactic medium (CGM) is a poorly understood component of galaxies, yet highly critical for understanding their evolution. The CGM is where gas flows from the intergalactic medium onto the disks of galaxies fueling continued star formation. It is also where gas is ejected from disks via supernovae and AGN feedback leading to the quenching of star formation. As such, the CGM is the repository of a large fraction of all the baryons within the virial radius of galaxies. As the closest large galaxy with a virial radius spanning over 20 degrees, the Andromeda Galaxy (M31), provides the best case study for understanding the CGM of a large, spiral galaxy. Using the ALPACA on the GBT, we can study the HI in the CGM of M31 with unprecedented sensitivity and spatial resolution. Using multiple background QSOs, project AMIGA (Lehner et al. 2020) showed that the baryon mass of the CGM of M31 is $>4\times10^{10}$ $M_{\odot}$ as traced by UV absorption from warm-hot ions. Similarly, deep HI observations by Braun & Thilker (2004) showed diffuse HI emission at $N_{HI} \sim 10^{17}$ cm^{-2} covering a large fraction of M31's CGM. However, more recent GBT observations taking advantage of higher angular and velocity resolution have shown that this gas is quite clumpy in a small region of the CGM (Wolfe et al. 2013, 2016) and is not representative of a smooth cosmic web. While the clumpy nature of the CGM has been predicted by cosmological simulation (Damle et al. 2022), this has been ascribed to ram-pressure stripping of gas from dwarf galaxies. If we are to fully understand how gas is flowing into and out of the disk of a large spiral galaxy like M31, we need a complete map of the CGM with high spatial resolution (~2 kpc) and velocity resolution (~ 5 km/s). We propose to map the entire CGM of M31 down to a detection limit of $N_{HI} \sim 10^{17}$ cm^{-2} and $M_{HI} \sim 10^{4}$ $M_{\odot}$ (matching Wolfe et al. 2016). This requires a 1-sigma noise of 3.5 mK per 5.15 km/s channel over an area of 1500 square degrees. With the current GBT L-band receiver, this would take about 50000 hours. With ALPACA, we can do this in 2500 hrs (including overhead). Given the proposed capabilities of ALPACA, we can do commensal searches for FRBs (such as proposed by Cordes here) to gain a complete picture of the neutral and ionized CGM of M31.