Exploring the Cosmos from Nunavut

Around 400,000 years after the big bang, the universe cooled sufficiently for neutral hydrogen atoms to form for the first time. The following period, known as the "dark ages," lasted for a few hundred million years until the first stars began to ignite during "cosmic dawn." Both of these epochs are uncharted territory and ripe for new discoveries; the first and only tentative detection of cosmic dawn was reported by the EDGES experiment in 2018, and the dark ages is entirely unexplored to date.

Fortunately, the Universe has given observers an extremely powerful tool for probing the distant past: neutral hydrogen atoms naturally emit light with a wavelength of 21 cm, and because the Universe is expanding, this wavelength is stretched or "redshifted" in proportion to how far away (or, equivalently, how long ago) the hydrogen emitted its light. Thus, by measuring the sky at radio frequencies, it is possible to access specific epochs of the Universe's history by tuning one's telescope to the appropriate wavelengths.

The required observational frequencies (<150 MHz) for Cosmic Dawn and the Dark Ages are exceptionally difficult to measure because of contamination from terrestrial radio-frequency interference (RFI) and ionospheric effects. Instruments aiming to make these measurements must operate from remote locations where RFI is minimized and ionospheric conditions are quiet: polar latitudes, especially at night during solar minima, are excellent candidates.

Prof. H. Cynthia Chiang is leading a new research program to perform the first radio astronomy observations from the Canadian High Arctic. In summer 2019, she and her team (research fellow Dr. Raul Monsalve and undergraduate Taj Dyson) deployed new radio instrumentation at the McGill Arctic Research Station (MARS) at Expedition Fjord on Axel Heiberg Island. Preliminary observations suggest that MARS is an exceptionally quiet site for radio astronomy work. In particular, there is no persistent visible transmission from FM radio stations (88-108 MHz), one of the most pernicious contaminants for experiments aiming to observe the low frequency sky.

Over the next few years, Prof. Chiang's team will install several other radio antennas near MARS with the observational goals of 1) weighing in on the EDGES detection of cosmic dawn, and 2) imaging the low-frequency sky as a first step toward laying the groundwork for future explorations of the cosmic dark ages. The inaugural 2019 campaign has demonstrated that the Canadian High Arctic is a unique environment that offers some of the cleanest conditions in the world for observing the radio sky.

Top right: Prof. Chiang and undergraduate Taj Dyson on an RFI survey near MARS.. Right: Research fellow Raul Monsalve and Taj Dyson install the instrument. (Image credits: Prof. Cynthia Chiang)

Prof. H. Cynthia Chiang *is an Associate Professor of Physics at McGill. The primary focus of her research is observational cosmology and instrumentation development. She specializes in precision measurements of redshifted 21-cm emission of neutral hydrogen and the cosmic microwave background.*

Why this is important

Almost nothing is known about the very first stars that were born in our Universe, and detecting their signals at radio wavelengths is exceptionally challenging. McGill researchers have demonstrated that the High Arctic presents a unique Canadian geographic advantage that may allow us to open a brand new window on the radio sky.