Searching for the birth of the first stars

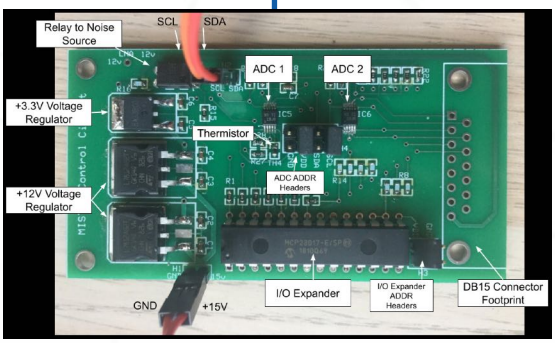
Dr. Raul Monsalve *is a Research Associate in the McGill Physics Department and a co-PI of MIST. Other MSI team members on MIST include undergraduates* ***Christian Bye, Ian Hendricksen****, and* ***Erika Hornecker****; MSc student* ***Matheus Pessoâ****; and faculty members* ***H. Cynthia Chiang*** *and* ***Jonathan Sievers****.*

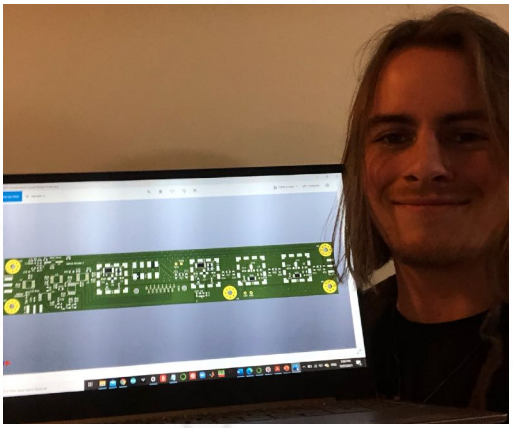
Why this is important

Almost nothing is known about the very first stars that ignited in our universe, and detecting their signals at radio wavelengths is exceptionally challenging. McGill plays a leading role in the MIST experiment, which uses state-of-the-art technology to shed new light upon this elusive signal.

About 100 million years after the Big Bang, the first stars ignited in the universe during a period known as "cosmic dawn." When these first luminous sources appeared, they emitted UV and X-ray radiation that interacted with the surrounding neutral hydrogen gas that pervaded the universe. 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 the period of cosmic dawn and probe the nature of the first stars by literally tuning one's telescope to the appropriate wavelengths.

The first and only tentative detection of the cosmic dawn signal was reported by the EDGES experiment in 2018. Cosmic dawn measurements are exceptionally challenging because they demand stringent control over instrumental uncertainties and other potential signal contaminants. Dr. Raul Monsalve is leading the Mapper of the IGM Spin Temperature (MIST), a new experiment that aims to probe cosmic dawn and elucidate the nature of the first stars. Dr. Monsalve and other MSI team members have built the MIST instrument from the ground up, and the design has been carefully optimized to minimize instrumental systematic errors. Areas of active research and development have included the antenna (Matheus Pessoâ), front-end electronics (Ian Hendricksen, Erika Hornecker), and readout electronics (Christian Bye). Despite the challenges of COVID isolation, the modular nature of MIST has allowed team members to work on small subsystems from home, using makeshift MacGyver-like setups to forge ahead on instrumentation development. The construction of MIST is nearly complete, and the instrument will ultimately observe from multiple radio-quiet sites, including the McGill Arctic Research Station on Axel Heiberg Island, Nunavut, and the Atacama desert in northern Chile.





Clockwise from top left: Matheus Pessoâ testing a MIST antenna prototype on the McGill campus;; Christian Bye testing a low-cost analog to digital converter; Ian Hendricksen and his design for a miniaturized MIST front-end electronics board; control circuitry for an ultra-portable version of MIST, designed and constructed by Erika Hornecker; Christian Bye's home set up.