The Role of Polarization in 21 cm Radio Surveys

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A great effort is currently underway to map out the radio sky at lower frequencies ($\ltorder 1$ GHz) in order to acquire a three-dimensional map of the universe extending out to large redshifts. This map interpolating between the surface of last scatter ($z\approx 1100$), which has already been well characterized by cosmic microwave background observations, and the nearby universe, which has been well mapped by a host of traditional galaxy surveys, will most notably enable: (1) the discovery of how the universe first became reionized, through the formation of the first generation of stars and quasars, (2) the use of Baryon Acoustic Oscillations (BAOs) to characterize the properties of the Dark Energy, of which almost no details are presently known, and (3) the realization of a host of other new science objectives such a understanding the physical mechanism underlying Fast Radio Bursts (FRBs), and the discovery of numerous new quasars.

A key challenge to be overcome is removing from the raw maps the contribution of the synchrotron radiation from our own Galaxy, which is much brighter than the signal for (1) and (2) above, but happily has a smooth frequency dependence. Another difference is the polarization of the signal. While the galactic synchrotron emission is highly polarized, the cosmological signal is unpolarized. The BAOs are imaged using the redshifted 21 cm line, which is unpolarized. The thesis will deal with the challenges introduced by polarization from a general perspective, and the methodology developed will be applied to the forthcoming data from the HIRAX array in the Karoo Desert in South Africa, which will allow the approaches developed to be validated and improved. Part of the study will involve using and improving models for the synchrotron emission of our galaxy. Another aspect will be to develop requirements for the antenna patterns used in these surveys and their calibration, and to develop analysis techniques that can extract the desired signal for a real experiment, as opposed to the idealized simulations that have already been carried out.

This proposition includes a more targeted M2 project as well as the PhD thesis project.