CMB spectral distortion at low radio frequencies – radio background, first stars, galaxies and the sources of first light!!!!

The Cosmic Microwave Background (CMB) i.e. the relic radiation from the Big Bang is the oldest electromagnetic radiation in the Universe. CMB has been precisely measured by the COBE/FIRAS instrument between 30-600 GHz and it is shown to be a thermal blackbody at a 2.725K. Since then, various ground, space-based and balloon-borne experiments measured the CMB temperature covering the frequency range of 0.4 to 600GHz. At frequencies lower than 400 MHz the CMB temperature measurement is increasingly difficult due to instrumental complexity and galactic and extragalactic radiation that are at least 3 orders of magnitude brighter than the CMB. However, at these frequencies, in the absolute temperature spectrum of the CMB, hidden is the answer to one of the most important question of the cosmology: **how and when did the first sources of light come to exist.**

Research Field

Engineering, Observational Cosmology, Radio Astronomy

Project Suitability

PhD

Masters

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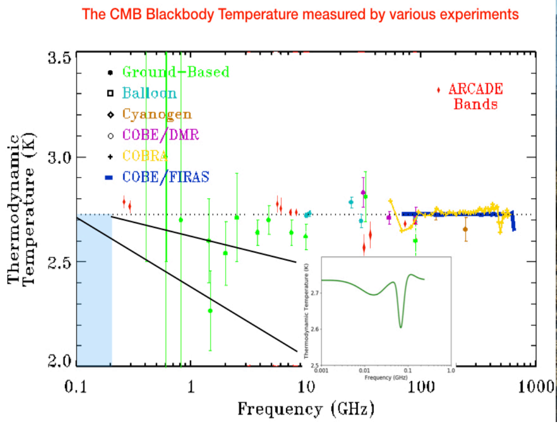
Below 200 MHz, the CMB is expected to deviate from its blackbody temperature of 2.725K and exhibit a specific spectral signature that resulted from the interaction between the CMB photons with the primordial neutral hydrogen at very early times, even before the first sources of light began to form. This is known as the ***redshifted 21cm signal***, detection of which is one of the biggest challenges of present-day cosmology. When detected, it will provide a information about the early Universe, structure formation, nature of the first sources and evolution history of the Universe. Detection of the 21cm signal is identified as the science priority in various decadal surveys. Over a dozen experiments attempted to detect the redshifted 21cm signal using the single element radio telescope over past decade with only two producing any data of scientific significance.

This project will make a precision all-sky radio background measurement between 30-150MHz to detect the redshifted 21cm spectral signature in the CMB. It is a unique opportunity to build and deploy a second generation, single element radio telescope leveraging a vast number of recent developments in instrument design and data analysis. Resulting publications will be in the field of engineering, science and computation. It is particularly suitable for someone with an inclination to experimental radio astronomy, especially with a solid background in Electrical/ Telecommunication/Computer Science Engineering, Experimental Physics/Astrophysics. A good organizational skill, mathematical aptitude and some programming expertise in any language is desired.



The CMB blackbody temperature measured by various experiments at discrete frequencies. Between 20-200 MHz, the CMB temperature is expected to deviate from its blackbody temperature of 2.725K and take certain spectral shape known as the 21cm signal. This spectral shape depends on the evolution history of the Universe. A representative form of such deviation is shown in this figure.

Right : SARAS radio telescope – a precursor to the proposed work located at the Gouribidanur radio observatory, India : a single element radio telescope purposed developed to detect the redshifted 21cm signal by precision radio background measurements. Left: HYPERION – an interferometer designed and developed at the UC Berkeley and initially deployed at the Caltech's Owen's Valley Radio Observatory to detect the redshifted 21cm signal by precision radio background measurements. The proposed project is a continuation of this work.