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Progress in preparation of a 21cm global spectrum experiment from the lunar Orbit

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Measurement of the 21cm global spectrum from the dark ages, cosmic dawn and epoch of reionization is highly challenging, as the signal amplitude is smaller than the foreground radiation at the corresponding frequencies by a few orders of magnitude. Contamination by systematic effects such as the ionosphere absorption or refraction, and ground reflection can also generate features in the measured global spectrum, which can be mistaken as the signal. A dedicated experiment in the lunar orbit can avoid a number of such systematic errors, especially those induced by the ionosphere of the Earth. The ground reflection is also significantly reduced and would not produce spectral features that could be confused with the 21cm signal.

We will present the basic design of the Discovering the Sky at the Longest wavelength (DSL) project (also known as the Hongmeng project)[1-3]. In this scheme, a group of satellites will be launched by a single rocket to the lunar orbit. Once in orbit, the satellites will be released to form a linear array along the orbit, one satellite is dedicated to make precision measurement of the global spectrum in the frequency band of 30-120 MHz, and eight satellites are dedicated to make interferometry imaging in the frequency band of 0.1-30 MHz, as well as make global spectrum measurement in the same band. The data collected by these satellites will be collected by a "mother satellite" at the head or tail of the linear array and transmitted to Earth.

We will also report on the research progress in preparing this experiment. We simulated the radio signal received on the lunar orbit, and found that despite the presence of anisotropic Galactic foreground radiation, detecting the 21cm signal is feasible as long as the chromatic anisotropy of the antenna beam pattern is limited. In the design of the antenna for the DSL high frequency band (30-120 MHz), we imposed this requirement. Noting that the satellite body can also affect the antenna beam pattern, we have designed the basic shape of the satellite together with the antenna to satisfy the requirement on the antenna beam pattern.

We have carried out ground based 21cm global spectrum experiments, in which we tested different designs of the antenna and receiver circuit, and analyzed the source of error in the measurements, especially those arising from the calibration of the antenna and receiver. We will report our prelimnary results from these experiments.

References

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