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DARTS – Distributed Aperture Radio Telescope in Space – First Starlight Explorer

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Several studies and proposals have been undertaken in recent years to design a low frequency space radio telescope. However, despite the strong science case for the opening up of a brand-new window on the Universe at a low radio frequency that is largely unexplored, mission proposals have been significantly challenged with the lack of flight proven technologies, to implement a space telescope using low cost small spacecraft formations. In recent years, the advent of CubeSat technologies, interplanetary missions and radio frequency inter-satellite link (ISL) technology, have improved to the point that developing a mission where a space radio telescope is formed using a constellation of small satellites is now viable, to bring unique science offerings.

The main science goal of the DARTS mission is to detect radio emissions from the time period in the history of the Universe when matter started to clump together and gave birth to the first stars, black holes, and galaxies. This is achieved by observations of 21-cm emissions from neutral Hydrogen from this period. Today, those emissions are redshifted to low radio frequencies. Since different frequencies correspond to different redshifts, the observations to be attempted with DARTS will represent the evolution of the Universe during its epoch of structure formation, which has never been observed.

As a concomitant product of the main science goal, DARTS will produce large scale surveys of the celestial sky within the frequency range 5-120 MHz. Currently, the only similar surveys are the Haslam all-sky survey at 408 MHz and the one by Cane at 10 MHz, but neither of these cover the frequency range considered by DARTS.

The surveys provided by DARTS will be done through the well-established technique of interferometry by exploiting the distribution of spatially sampled points provided by the array of spacecraft. To take advantage of the instantaneous all-sky field-of-view unique to DARTS, we will make use of a new type of interferometry developed particularly for all sky imaging [2]. This work shows that one can image the entire celestial sphere instantaneously and with the same computational complexity as for the standard two-dimensional (2D) Fast Fourier Transform (FFT). It also successfully demonstrated the technique, called Spherical Wave Harmonics Transform (SWHT), using data from the LOFAR radio telescope.

DARTS is a very focused mission, which will operate at Sun-Earth L2 in all-sky imaging mode 24/7 for an operational life time of 3 years. Driven by the main science goal to detect the global 21-cm signal, DARTS will perform measurements in the 5-120 MHz frequency range in steps of 5 MHz. In addition to the global 21-cm spectrum, the end data product from the DARTS mission will be a set of 24 images, one for each observation frequency, of the full celestial sphere with unprecedented sensitivity and resolution for this frequency range. The final all-sky images will each be based on data from up to 500 hours of observations. They will be used to subtract the galactic and extra galactic foregrounds so that the extremely weak global 21-cm signal can be recovered [3].

With a focus on break through science objectives, DARTS is a novel low frequency space radio telescope, designed to operate in a region and environment which has been unexplored to date. It will also demonstrate key formation flying technologies needed for more ambitious science missions in the future.

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