Deployable Antenna Concepts for the Dark Ages Radio Explorer Mission

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The Dark Ages Radio Explorer (DARE) is a concept for a space-based cosmology mission designed to measure the sky-averaged spectrum from the highly-redshifted hyperfine 21 cm transition from neutral hydrogen (J.O. Burns, J. Lazio, et al., Adv. Space Res., 49, 433–450, 2012). From this sky-averaged spectrum, the formation of the first luminous objects at the end of the Dark Ages and during Cosmic Dawn (redshifts z = 11–35) can be tracked by their effect on the neutral intergalactic medium. The specific science objectives for the DARE mission are (1) When did the first stars form? (2) When did the first accreting black holes form? (3) When did Reionization begin? (4) What surprises does the end of the Dark Ages hold (e.g., dark matter decay)? The DARE spacecraft orbits the Moon for a mission lifetime of 3 years and takes data above the lunar farside, the only location in the inner solar system proven to be free of human-generated radio frequency interference and any significant ionosphere.

The relevant range of redshifts correspond to radio frequencies of 40–120 MHz. The DARE Science Instrument is a VHF band radiometer, consisting of electrically-short, tapered, bi-conical dipole antennas, an analog receiver, and a digital spectrometer. The notional size of the bi-conical dipole antenna is 1.5 m, which may be too large to fit within the envelope of typical Explorer-class launch volumes.

We present concepts for implementing deployable bi-conical dipole antennas. When operational, the central axis of each antenna must be parallel to a ground plane, which is assumed to be mounted to the deck of the host spacecraft. The range of concepts that we have considered include (1) Hinged antennas, in which the antennas are stowed with their central axes perpendicular to the ground plane, then raised into position; (2) Variants on telescoping bi-cones, in which the cones are compressed along their central axes, then deployed by springs; and (3) Lowering the antenna assembly closer to the spacecraft deck. We illustrate proof-of-concept telescoping bi-cones.