A PATCH ANTENNA CONCEPT FOR THE LUNAR-ORBITING DAPPER SPACECRAFT. R. F. Bradley

The Dark Ages Polarimeter Pathfinder (DAPPER) is a lunar-orbiting mission concept designed to detect and characterize the spectral signature of hydrogen produced during the Dark Ages epoch of the early universe. Two specific spectral features will be targeted: one in the 18-40 MHz band and the other in the 60-110 MHz band.

Precise calibration of the instrument together with the application of modern pattern recognition techniques will be applied toward the detection task. While high accuracy of the receiver can be achieved through thermal control of the hardware, on-board calibration, and in-depth equivalent circuit modeling, understanding the antenna beam pattern to better than a part in 10,000 over the instrument bands will present the greatest challenge.

The initial wire antenna configuration adopted for DAPPER made use of fundamental and higher-order wave resonances in an attempt to cover the two bands. Upon further analysis, the more structured beam patterns resulting from this approach have very strong frequency and thermal dependencies. In addition the mechanical oscillation modes of the extended wires forced changes in the operation of the spacecraft dynamics to reduce but not fully eliminate these effects during observation times. These factors greatly complicated the electromagnetic behavior of the antenna and brought into question concerns about modeling the antenna to the degree needed for the science measurement. To address these concerns, a two-band patch antenna configuration is being studied as a replacement for the wire antennas.

Patch antennas are layered structures consisting of two metal plates with a dielectric material placed between them to form a capacitor-like structure. At radio frequencies where the patch size approaches one-half wavelength within the dielectric, the antenna can efficiently acquire linearly polarized radiation from the fringing fields at the edges of the patch. These antennas are usually considered narrow-band structures due to its cavity-mode nature of operation. Techniques for increasing the bandwidth include increasing the thickness of the dielectric, stacking several plates / dielectrics with differing resonant frequencies, and feeding the antenna out of phase on opposite sides.

These techniques, together with stacking two square patch antennas on top of one another, are used in a dual polarized design to cover both DAPPER bands simultaneously. The low band patch is a 3.1:1 scaling of the high band counterpart located above it. Each patch consists of two dielectric layers and three thin metal layers. The lower and upper dielectrics have a relative dielectric constant of 6 and 1, respectively. To reduce the mass of the lower material, a composite of thin sheets of high dielectric constant material laminated together with low loss foam sheets is being explored to synthesize a dielectric with an effective dielectric constant of 6.

Additional details of the patch antenna will be presented along with the modeling and simulation results. A sketch of the proposed patch antenna concept for DAPPER is show below.

[Sketch of the proposed patch antenna concept for DAPPER]