Precision Design, Analysis and Manufacturing of Quasi-optic Lens/Reflector Antenna Systems for CubeSat MMW/SMMW Radiometers

Lavanya Periasamy and Albin J. Gasiewski
Department of Electrical, Computer, and Energy Engineering,
University of Colorado, Boulder, CO.

The prediction of weather and climate from meso to global scales necessitates the use of precision satellite data, closely sampled in both temporal and spatial extent. Atmospheric temperature variations of 0.1 K or smaller over a decade are relevant to the detection and prediction of global change. Radiometric sounding measurements used to provide such data are strongly affected by the main-beam, ohmic, and spillover efficiencies of the optics, as well as inhomogeneities in the scene and background radiation fields. The interpretation of radiometric data is also affected by the accuracy with which these efficiencies can be determined. To emphasize this point, it is to be noted that a space-borne radiometer observing a 300 K scene in cold space requires that the error in the estimation of spillover efficiency be 0.03% or smaller in order to obtain corrected brightness temperature measurement accuracies of ~0.1 K or better.

The Gaussian (paraxial) beam mode approximation is a commonly used method for optical analysis of antenna subsystems with limited off-axis accuracy for millimeter and sub-millimeter wavelength diffracted fields. Its use stems from the computational burdens and inaccuracies associated with full solutions to Maxwell's equations over a volume that may be up to hundreds of wavelengths on a side. Moreover, subtle changes in the feedhorn design parameters, including changes that induce feedhorn mode phasing such as corrugation depth or step diameters, produce pattern changes at the reflector that are not captured by the Gaussian approximation. To provide a more precise determination of the requisite efficiencies for radiometry, this study focuses on the precise numerical analysis of the complex diffracted field produced by a feed at the focal point of a lens/reflector focusing element. The analysis leads to the determination of an optimal feed horn and lens/reflector geometry such that the main beam and spillover efficiencies of the system are maximized, and these and the ohmic efficiency are precisely known. The above analyses is applied to the antenna subsystem of the PolarCube 3U CubeSat 118.75 GHz radiometer payload which comprises a spinning offset paraboloidal main reflector and a stationary corrugated feed.

The feasibility of 3D printing techniques to manufacture the antenna system of such a CubeSat radiometer is also being investigated. Presently, a 3D printed (aluminum) conical horn is being tested and its performance compared to a standard gain gold-plated horn. The antenna system performance of PolarCube will be evaluated at the NIST **C**onfigurable **Ro**botic **M**illi**m**eter-wave **A**ntenna facility (CROMMA) in Boulder, CO.