Slot Antenna Array for CMB Polarization Detection

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ABSTRACT

Cosmic Microwave Background (CMB) radiation contains the most valuable relic of the early universe. The details of the structure and evolution of the universe are believed to be encoded in the anisotropy of the CMB. It is believed that the direct evidence of the inflationary epoch – the rapid expansion of the universe after the Big Bang – lies in the traces of gravitational waves in the CMB, which manifests in the temperature anisotropy and polarization of the CMB. If inflationary gravitational waves do indeed exist, they will be the oldest relic of the universe, created 500,000 years before the CMB was emitted. The measurement of the CMB polarization – the B-mode polarization in particular – will be the indirect proof of the existence of the inflationary gravitational waves and will give insight into the epoch of inflation.

Cryogenic detectors currently in use for CMB instrumentation are sensitive enough to reach the photon noise limit which is governed by the photon arrival statistics and depends on the intensity of the background radiation. CMB space missions offer the opportunity to reach fundamental cosmic background limits, and therefore, further improvements in the detector sensitivity is not helpful. The only avenue available for improving the overall experimental sensitivity for a wide field survey is to increase the throughput, which simply corresponds to capturing more photons. The only way that will be possible is to increase the number of detectors. As a result, future CMB experiments are expected to require large focal planes with thousands of detectors.

For CMB experiments, the field of view of each detector is restricted in order to reduce the pickup of stray radiation. Currently, the collimation of the incoming beam is achieved using metal feedhorns. Though feedhorns have excellent performance, their mass, size, and expense make them unsuitable for large arrays. A highly desirable solution to these problems would be to fabricate monolithic array of antenna-coupled detectors on a planar substrate. In this paper, we describe a novel dual-polarization planar slot antenna array concept which produces quite a narrow (F/4) beam with no additional optical coupling elements such as substrate lens or micro-machined horns. The design, simulation, and preliminary measurement of the antenna array will be presented.

The research described herein was carried out at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA, under contract with National Aeronautics and Space Administration.