Measurements of the Offset-Cassegrain Antenna of JEM/SMILES Using a Near-Field Phase-Retrieval Method in the 640 GHz Band

Takeshi Manabe*, Toshiyuki Nishibori†, Kazuo Mizukoshi†, Fumiaki Ohtsubo‡, and Satoshi Ochiai§,

*Department of Aerospace Engineering
Graduate School, Osaka Prefecture University
Email: manabe@ieee.org

†Japan Aerospace Exploration Agency

‡Advanced Engineering Services Co., Ltd.

§National Institute of Information and Communications Technology

Abstract

SMILES, Superconducting Submillimeter-Wave Limb-Emission Sounder, is a highly sensitive limb-sounding spectrometric radiometer to observe altitude profiles of ozone and ozone-depletion-related molecules in the stratosphere in the submillimeter frequency bands, 624.32–626.32 GHz and 649.12–659.32 GHz. SMILES was launched aboard the H-II Transfer Vehicle by the H-IIB launch vehicle on September 11, 2009, and was attached to the Japanese Experiment Module (JEM), dubbed "*Kibo*," of the International Space Station. The objective of the SMILES mission is to demonstrate highly sensitive submillimeter-wave soundings and to monitor global distributions of the stratospheric trace gases. For these requirements a superconductive low-noise receiver with a mechanical 4-K refrigerator is used in space for the first time.

In order to observe the stratospheric atmosphere with an altitude resolution of about 3 km from the ISS orbit about 2000 km away, a 400-mm$\times$200-mm elliptical offset Cassegrain antenna with a high beam efficiency of 90% and low sidelobe levels below -20 dB is employed to vertically scan the atmosphere with an elliptical beam with half-power beam widths of 0.09° in elevation and 0.18° in azimuth.

In this paper, the results of the measurements made for the flight model of the offset Cassegrain antenna of SMILES are described. Although we have tried to make near-field measurements in which the amplitude and phase of the near field of the antenna aperture by using a submillimeter vector network analyzer at first, it did not work well because of its malfunctioning in the phase-lock circuit. Then, we have decided to employ a near-field phase retrieval method in which the aperture phase distribution is estimated only from the amplitude distribution measurements over two near-field planes. The far-field pattern estimated from thus estimated near-field pattern were compared with theoretical calculations based on physical optics in which the the surface errors measured for the main and sub reflectors were taken into account. As a result of the comparison, the far-field pattern estimated from the phase retrieval method were found to be in very good agreement with the physical optics calculations to the sidelobe levels as low as -55 dB. This demonstrates that the phase retrieval is an effective method to evaluate aperture antennas in the submillimeter-wave region where accurate phase measurement is rather difficult.