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×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 the thus estimated near-field pattern were compared with theoretical calculations based on physical optics in which 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.