Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PPS024-28 会場:103 時間:5 月 23 日 15:00-15:15

SELENE-2/VLBI ミッションで探る月深部構造
SELENE-2/VLBI mission for study of lunar deep internal structure

松本 晃治 [1*], 菊池 冬彦 [1], Goossens Sander[1], 鎌田 俊一 [2], 岩田 隆浩 [3], 花田 英夫 [1], 石原 吉明 [1], 佐々木 晶 [1]
Koji Matsumoto[1*], Fuyuhiko Kikuchi[1], Sander Goossens[1], Shunichi Kamata[2], Takahiro Iwata[3], Hideo Hanada[1], Yoshiaki Ishihara[1], Sho Sasaki[1]

[1] 国立天文台 RISE 月探査プロジェクト, [2] 東京大学大学院理学系研究科, [3] 宇宙航空研究開発機構宇宙科学研究所
[1]RISE Project, National Astronomical Obs., [2]The University of Tokyo, [3]ISAS/JAXA

VLBI (Very Long Baseline Interferometry) radio sources were on board the SELENE two sub-satellites, Rstar and Vstar. The radio waves from the radio sources (called VRAD) were received at multiple ground stations which forms a type of tracking data, i.e. delay in arrival times of the wave of a radio source at two different stations forming a baseline carries information about the angular position of the radio source. Differential VLBI data between Rstar and Vstar, when both the radio sources were within the beam width of the ground antennas, were of particular importance because they are highly accurate with atmospheric and ionospheric disturbances almost cancelled out by the simultaneous observation. Such tracking data, i.e. "same-beam differential VLBI data" were used to develop an improved lunar gravity field model SGM100i [1].

The Japanese future lunar mission SELENE-2 will carry both a lander and an orbiter. We propose to put the VRAD-type radio sources to these spacecraft in order to accurately estimate lunar potential Love number k2 and low-degree gravity coefficients through precision orbit determination of the orbiter with respect to the lander by using the same-beam VLBI tracking technique. We also propose a new type of observation called inverse VLBI [2] in order to further improve the k2 estimate. The same-beam VLBI observation is only possible when the separation angle between the two radio sources is smaller than the beam width of the ground antennas. The relatively large shape of Rstar's orbit (100 km x 2400 km) did not allow the same-beam observation all the time, but the situation can be improved by adequately setting the orbit. For example, the Vstar-like orbit (100 km x 800 km) will almost always keep the separation angle smaller than the S-band beam width of domestic VERA stations since one of the radio sources is fixed on the near-side lunar surface.

A preliminary simulation study has been conducted under the condition of 2-week arc length, 12-week mission length, 6 hours/day 2-way Doppler observation plus S-band same-beam VLBI observation with the 4 VERA stations. The k2 uncertainty is evaluated as 10 times the formal error considering the errors in solar radiation pressure modeling and in lander position. The results show that, when combined with the historical tracking data including SELENE and when the orbiter inclination was 90 degrees, the k2 uncertainty is below 1 percent.

The potential Love number k2, together with displacement Love number h2, lunar mass, and lunar moment of inertia can constrain lunar interior properties such as radial profiles for density and shear modulus. The size and state of the core (liquid or solid) are of particular interest. The Love number h2 is obtained from lunar laser ranging (LLR) data, the mass is obtained from satellite tracking data, and moment of inertia is obtained from combination of LLR-based estimates of dynamical flattening and satellite-based 2nd degree gravity coefficients. Lunar Broad Band Seismometer (LBBS) will detect layer boundaries. We will discuss how well the internal properties can be inferred from the above-mentioned four parameters which will be improved by SELENE-2. We will also discuss the possible synergy of combining VLBI, LLR and LBBS data.

References: [1] Goossens et al., Journal of Geodesy, in press. [2] Kawano et al., Journal of Geodetic Society of Japan, 45, 181-203, 1999.

キーワード: 月, SELENE-2, VLBI, 人工衛星追跡, 重力場, 潮汐ラブ数
Keywords: Moon, SELENE-2, VLBI, artificial satellite tracking, gravity field, tidal Love number