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測地および月震データよる月内部構造制約のシミュレーション研究
A simulation study for constraining the lunar internal structure by geodetic and seismic data

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Internal structure and composition of the Moon provide important clue and constraints on theories for how the Moon formed and evolved. The Apollo seismic network has contributed to the internal structure modeling. Efforts have been made to detect the lunar core from the noisy Apollo data (e.g., [1],[2]), but there is scant information about the structure below the deepest moonquakes at about 1000 km depth. On the other hand, there have been geodetic studies to infer the deep structure of the Moon. For example, LLR (Lunar Laser Ranging) data analyses detected a displacement of the lunar pole of rotation, indicating that dissipation is acting on the rotation arising from a fluid core [3]. Bayesian inversion using geodetic data (such as mass, moments of inertia, tidal Love numbers k2 and h2, and quality factor Q) also suggests a fluid core and partial melt in the lower mantle region [4]. Further improvements in determining the second-degree gravity coefficients (which will lead to better estimates of moments of inertia) and the Love number k2 will help us to better constrain the lunar internal structure. Such improvements will be made by future lunar missions including Japanese SELENE-2. A preliminary simulation study shows that the k2 accuracy of better than 1% is anticipated by the SELENE-2 differential VLBI mission for which one of the radio sources is fixed on the moon serving as the reference to determine the orbiter's trajectory.

We carried out a feasibility study using Bayesian inversion on how well we can constrain the lunar internal structure when such improvements are made on the geodetic data. It is difficult to tightly constrain the internal structure from the geodetic data only because there are trade-offs among crust, mantle, and core structures. However, when combined with the existing Apollo seismic data which constrain the structures of crust and mantle, such geodetic data will contribute to narrow the range of the core structure models. We will discuss the impact of the crustal structure uncertainties on the estimation of the core structure, and also the assumption we have to place on the mantle structure in order to recover the core structure.

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