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アポロ月震計データと最新の測月データから推定される月深部構造
Deep interior structure of the Moon inferred from Apollo seismic data and the latest selenodetic 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 weakly suggests a fluid core and partial melt in the lower mantle region [4]. Further improvements in determining the second-degree gravity coefficients and the Love numbers will help us to better constrain the lunar internal structure.

Recent analyses of GRAIL data have achieved the improved k_2 accuracy; JPL solution is 0.02405±0.00018 [5], and GSFC solution is 0.02427±0.00026 [6]. The two solutions are consistent with each other within their error bounds, and the accuracy of k_2 is now about 1 %. By introducing the improved gravity coefficients and k_2 from GRAIL mission, the updated LLR data analysis has also resulted in a better h_2 determination. Such accurately-determined Love numbers will contribute to constrain the structure of the lunar deep interior, such as the radius of the possible liquid core. It is difficult, however, to tightly constrain the internal structure from the geodetic data only because there are trade-offs among the structures of crust, mantle, and core. The combination of the Apollo seismic data and the geodetic data therefore afford the key to better determination of the lunar interior structure. We included geodetic data of the mass, the mean moment of inertia, the Love numbers h_2 and k_2, and 262 P and S travel time data in the analysis.

Markov Chain Monte Carlo (MCMC) method is used to infer the model parameters. When we used a five-layer model consisting of crust, upper-mantle, mid-mantle, lower-mantle, and core, the core radius is estimated to be 483±22 km, and the core density values tend to be sampled around the assumed lower limit of 3600 kg/m^3. However, the inferred core radius is significantly larger than the magnetic constraint from SELENE data [7] which predicts the upper bound of the core radius to be 400 km. This discrepancy might be attributed to a possible low velocity layer above the core-mantle boundary which was not included in the five-layer model. We will discuss the results when such a low velocity layer is taken into account.

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[6] Taken from the PDS label of GRAIL Derived Data Products
[7] Simizu et al. (2013), Icarus, 222, doi:10.1016/j.icarus.2012.10.029

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