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Lunar internal structure estimated from local admittance between gravity and topography

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A new spherical harmonic model of the lunar gravity field, complete to degree and order 100, has been developed from four-way Doppler measurements of Kaguya (SGM100h). On nearside, a comparison of SGM100h with a previous lunar gravity models reveals a general agreement. On farside, in contrast, the new gravity field model shows several circular signatures that correspond to topographic structures such as Moscoviense, Freundlich-Sharonov, Mendeleev, Hertzsprung, Korolev and Apollo basins. Those basins used to be identified as linear signatures in previous models. On the basis of new global gravity model, we classify lunar basins into Type I, Type II, and primary mascon basins.

For study of internal structure of those basins, we adopt spectral filter of wavelet. Wavelet analysis localizes the gravity and topography without a loss of spectral information. This advantage is particularly important for distinguishing compensation mechanisms of different types of lunar basins. We adopt a method with application of B-spline function of order 3 for isotropic window function. In addition, a scaling factor, f_S, that controls sizes of window in spatial and spectral domains varies from 2 to 5 in this study while the original method uses fixed value of 2.

We first calculate admittances of lunar highland where a good correlation between gravity disturbance and uncompensated topography is expected in short wavelengths. In order to estimate an appropriate f_S, admittances between gravity and topography in north polar area centered at 90 deg N and 0 deg E are calculated for f_S between 2 and 5. While the calculated admittances decrease in almost all degrees as f_S increases from 5 to 10, a difference between those for f_S of 10 and 15 is negligible. Therefore we use fS of 10 as a nominal value for the study of lunar highlands.

Admittances for highlands in the north polar area, nearside (45 deg S, 15 deg E), and farside (35 deg N, 145 deg W) increase with increasing degree up to 40 suggesting compensation of long-wavelength topography by lithospheric elasticity. Between degree of 40 and 65, admittance curves reach plateau corresponding to a ratio between gravity and uncompensated topography. The plateau values are between 110 and 130 mGal km^{-1} possibly suggesting a variation of crustal density between 2600 and 3000 kg m^{-3}.

We adopt f_S of 2 for lunar basins because major topographic and gravity signatures of basin are spatially compact.The Type I basins include Korolev, Dirichlet-Jackson, and Mendeleev basins on the farside. Admittance curves of these basins show similar trend that is characterized by one broad peak. A center of the admittance curve appears corresponding to central gravity high of Type I basin.

The Type II basins include Freundlich-Sharonov, Hertzsprung, and Orientale basins on the farside and limb. the Type II basins are distinguished from those for the Type I basins in that their admittance curves show two peaks; narrow peak around degree of 35 and broad peak at degree higher than 50. Magnitude of the narrow peak is equal to or higher than that of the broad peak. Degree of the narrow peak appears corresponding to wide central gravity high and volcanism associated with the Type II basins. In contrast to the Type I basins, the admittance curves of the Type II basins show a wide variation likely suggesting that the Type II basins are transitional between the Type I basins and primary mascon basins on the nearside.

Admittance curves of primary mascon basins are similar to those of the Type II basins and show two peaks. Unlike the Type II basins, however, magnitude of first peak at low degree is smaller than that of second peak at high degree. Besides, the second peak is as narrow as the first peak. An average of the admittances is nearly zero suggesting that the topography is isostatically compensated.

Keywords: lunar gravity, Kaguya