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A determination of characteristics of impact basins from data of the Japanese lunar explorer ”Kaguya”

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Impact cratering, especially large impacts such as basin-forming impacts, is one of the most important driving forces for surficial and interior structure (˜ upper mantle) evolutions of the Moon. The formation process of impact basins has, however, remained unsolved. It is, therefore, important to determine accurate characteristics of the impact basins, such as the location of the center, the size and the height of a ring, and to understand the structure of the impact basins.

Visual inspection of photographs and/or topographic data has been a main tool to estimate the location of the center and the size of the impact basins, lacking quantitative capability and objectivity on those estimations. We propose here a new quantitative and objective procedure to estimate the characteristics based on a spherical function model. Furthermore, we apply the procedure to the latest lunar data, a topographic and a gravity models, obtained by the lunar explorer ”Kaguya” and try to determine the characteristics of lunar impact basins.

Impact basins are expected to show an axisymmetric depression or a ring structure except of the case of extreme oblique impact. If the center of an impact basin is located at the North Pole, a broader structure of the impact basin can be represented by the sum of zonal terms of the spherical function over degrees that correspond to the size of the impact basin and smaller. This feature enables us to determine the center of the impact basin quantitatively and objectively as the location with the highest zonal component through the following procedure of 3 steps to virtual centers,

(1) a rotation to shift a virtual center of the impact basin at the North Pole,

(2) a localization to remove the effect of the structure far outside the impact basin,

(3) a calculation of the contribution of the zonal components.

In this study, we apply the new procedure mentioned above to lunar impact basins, determine the location of the center of the impact basins and estimate the size and the height of the rings. The data we use here is the spherical function model of lunar topography and the 1/16-degree gridded lunar topographic data.

We set virtual centers with an interval of 0.1 degree for latitude and longitude for an impact basin and estimate the location of the center as the location with the highest zonal component. Some impact basins with multi-rings show dominant zonal components at several degrees. In this case, we determine the location of the center for each degree. For the determination of the size of rings, we reproduce a topography map using lower terms of the lunar topographic coefficients, pick out points with the slope of topography of zero using cross-sections of the topography of the impact basins, and choose points that correspond to ring structures comparing to the topography map of the 1/16-degree gridded lunar topographic data. We estimate the size of a ring from the average of the distance from the center to each point on the ring. We also estimate the height of the ring from the difference between the average altitude of the points and the altitude of the center.

The procedure we apply here is powerful to estimate the characteristics of 25 impact basins. On the other hand, we cannot determine the location of the center of elliptical and polygonal impact basins. Some impact basins with multi-rings show offsets, up to 92 km, of the location of the center of each ring. We find a power-law relationship among the diameters of neighboring rings. A power-law relationship is recognized also between the diameter and the height of the rings identified in this study. These relationships suggest a regularity of the formation mechanism of the rings of impact basins.

Keywords: Impact Basin, the Moon, Spherical Harmonics, SELENE (Kaguya)