A DETERMINATION OF CHARACTERISTICS OF IMPACT BASINS FROM "KAGUYA" GEODETIC DATA. Y. Ishihara[1], T. Morota[2], Y. Saruwatari[3], A. Sawada[3], and Y. Hiramatsu[3], [1]RISE Project, National Astronomical Observatory of Japan (2-12 Hoshigaoka, Mizusawa-ku, Oshu, Iwate 023-0861, Japan; ishihara@miz.nao.ac.jp), [2]Nagoya University (Furo, Chikusa, Nagoya, Aichi 464-8601, Japan), [3]Kanazawa University (Kakuma, Kanazawa, Ishikawa 920-1192, Japan).

Introduction: 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 and other planets with solid surface. 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 [1][2], 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 topographic model obtained by the lunar explorer SELENE/Kaguya and try to determine the characteristics of the lunar impact basins.

Impact Basin as An Axisymmetric Depression: Impact basin is a large impact crater. So, basic characteristics of the impact basin should show the same characteristics inherent in small impact craters. According to laboratory experiments of hypersonic impact and numerical simulations of impact cratering, almost of all resulting structures (craters) have simple axisymmetric depression except for extremely oblique impact conditions[ref?]. The structures of impact craters changes gradually from small simple craters to complex (peak / peak-ring / multi-ring) craters. However, large-scale features of the complex craters are still axisymmetric such as almost concentric multi-rings and and/or circler depression. Even though the topography of some impact basins is modified by subsequent mare volcanism and impact cratering, those effects are probably not so significant for broader structures. It is difficult that mare basalt fills up whole basin structures (floor to rim). Huge numbers of small craters are required for disrupting entire basin structures.

Localized Spherical Harmonics Method: As mentioned above section, 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 fraction of zonal component power contribution through the following procedure of 3 steps to virtual centers,

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

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

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

In this study, we apply a spherical cap type localization of spherical harmonics function [3], which enable us to spatio-spectral localization with isotropic characteristics.

Numerical Simulations: We have test the ability of our procedure by simple numerical simulations. First, we construct three simple synthetic models that consist a circular basin like depression, a multi-ring circular basin like depression, and an elliptic basin like depression located on (45 ºN, 45 ºE), and spherical harmonic expansion for that artificial topographic figures. Then, we apply the procedure for the synthetic models.

In case of the simple circular and the multi-ring basin like depressions, our procedure works well. On the other hand, in case of elliptic depression, our procedure encountered some difficulty due to dispersion or splitting of peak value of harmonic degrees with zonal power ratio.

Application to actual lunar data and results: 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 (Fig. 1). 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. A power-law relationship is recognized between the diameter and the height of the rings identified in this study (Fig. 2). However exponent value of the power-low is much larger then that obtained by a previous study [4]. These differences are mainly due to the difference of the resolution of data used in these studies. In short, the previous study using Clementine LIDAR data was not possible to measure the deepest and highest parts of each basin. We also find a power-law relationship among the diameters of neighboring rings. These relationships suggest the regularity of the formation mechanism of the rings of impact basins.

Acknowledgments: We used the Generic Mapping Tools (GMT) software [5] for drawing figures. SHTOOLS ver. 2.5 [6]was used for localization of spherical harmonics model.

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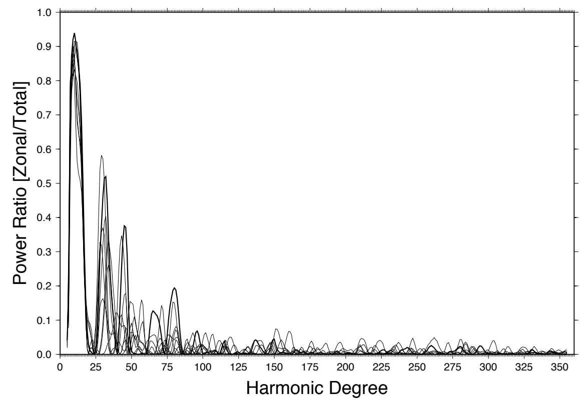

Fig. 1 Power ratio between zonal and total term of each harmonic degree for Orientale Basin (localized cap radius = 60 º). Black line is the result of virtual center at previously reported location (-95 º, -19 º) case [1], and gray lines are different location cases.

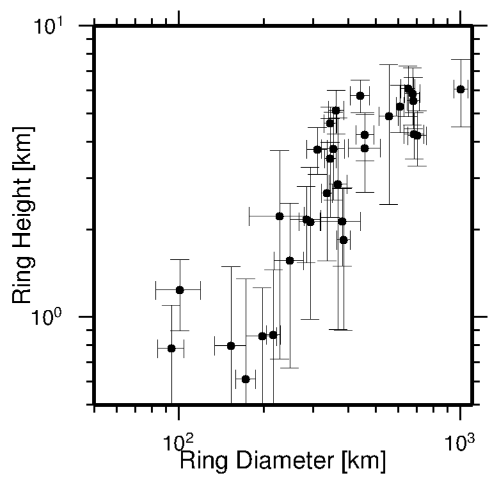

Fig. 2 Relationship between diameter and height of each ring of the basins analyzed in this study.