SIZE DISTRIBUTIONS OF BLUISH AND REDDISH SMALL MAIN BELT ASTEROIDS. Natsuho Maeda[1], Tsuyoshi Terai[2], Keiji Ohtsuki[1], Fumi Yoshida[3,4], Kosuke Ishihara[1,2,5], and Takuto Deyama[1,6], [1]Department of Planetology, Kobe University, Kobe 657-8501, Japan; nmaeda@stu.kobe-u.ac.jp, [2] National Astronomical Observatory of Japan, [3]University of Occupational and Environmental Health, [4]Chiba Institute of Technology, [5]The Graduate University for Advanced Studies, [6]NTT Data MSE Co.

Introduction: Main belt asteroids (MBAs) have various spectral types. S-type and C-type are two of the most major types in the main belt (e.g., [1]). S-type asteroids are thought to have a stony composition, while C-type asteroids are characterized by carbonaceous composition and hydrous minerals (e.g., [2], [3]). Although S-type asteroids and C-type asteroids are thought to have different compositions and origins, their radial distributions partly overlap in the current main belt (e.g., [1, 4, 5]). This indicates that they were mixed in some way (e.g., planetary migration) in the early solar system. Therefore, understanding the evolutions of asteroids with different spectral types provide a clue to reveal the history of the early solar system. As a first step, we focus on the collisional evolution of asteroids with different spectral types. For instance, information about their internal structure can give us a clue to their collisional evolution.

The size distribution of a population of asteroids strongly reflects the process of their collisional evolution (e.g., [6]). The size distribution in the collision equilibrium is primarily determined by the size dependence of impact strength (e.g., [7]) even though the size distribution of fragments generated by a single collision between a pair of objects is dependent on collisional conditions (e.g., [8-10]). Therefore, we can obtain a clue to reveal the relationship between spectral types of asteroids (corresponding to their composition) and their collisional evolution by comparing size distributions of asteroids with different spectral types. Although some previous observational works studied size distributions of asteroids with different spectral types (e.g., [4, 5]), there is little research especially for objects smaller than 1 km and it has not yet been fully understood.

In this work, we focus on the size distribution of MBAs with about 14 to 20 mag in absolute magnitude, which corresponds to several hundred meters to several kilometers in diameter. We classify the asteroids into two populations according to their *g-r* color and compare their size distributions. Our purpose is to investigate the relationship between asteroids' spectral types and their collisional evolution process.

Observation: We use data obtained on January 26, 2015 by our wide-area imaging observations using the Hyper Suprime-Cam (HSC) installed on the 8.2 m Subaru Telescope. The survey area consists of 8 fields of view near the opposition and the ecliptic plane. The diameter of the field of view is 1.5°. We used the *r*- and *g*-band filters. Each field was visited five times for each filter with 200-second exposures at intervals of 40 minutes. With this, we can approximately cancel the effects of asteroid spin.

Data analysis: We detected 3,809 MBAs based on their apparent motions (e.g., [11]). We estimated their orbit with the assumption that they have circular orbits because we observed them for only one night [12]. We measured their apparent magnitudes by aperture photometry. Both *r*- and *g*-band magnitudes were measured from 3,459 asteroids. We estimated their absolute magnitudes assuming a constant slope parameter of 0.15 [13]. From the asteroids we obtained above, we selected those with apparent magnitudes brighter than 24.2 mag and heliocentric distances less than 3.0 au as our statistical sample to remove a detection bias.

We measured *g-r* color for each sample and classified them into two groups, i.e., reddish "S-like" asteroids and bluish "C-like" asteroids. We defined the classification criterion with reference to the data of S-type and C-type asteroids in the fourth release of the Sloan Digital Sky Survey Moving Object Catalog (SDSS MOC4, [9, 14-21]). Figure 1 shows the color distribution of our samples and our classification criterion based on the SDSS MOC data.

Results: We converted the absolute magnitude of each sample into a diameter D assuming an albedo of 0.21 for S-like asteroids and 0.07 for C-like asteroids, respectively, which are the mean values of the S- and C-type MBAs measured by the infrared astronomical satellite AKARI [22]. Then we obtained the size distributions of each sample. We found that the shapes of the size distributions of the S-like and C-like samples are very similar. Figure 2 shows the cumulative size distribution of each sample. To compare them, the vertical axis is normalized by the values at D = 0.4 km. We found that the cumulative size distributions of the S-like and C-like samples agree within statistical errors for 0.4 km < D < 1.5 km. We evaluated the goodness of the fit by the

Kolmogorov-Smirnov test [23]. We found that the significance probability was 0.22 for 0.4 km < D < 4.7 km, and the null hypothesis that the two samples are drawn from the same distribution cannot be rejected at a 5% significance level.

Discussion & Conclusion: The similarity between the size distributions of the S-like and C-like asteroids indicates that their size dependences of impact strength are also similar at least in the size range from several hundred meters to several kilometers. On the other hand, asteroids' spin period distribution shows that the spin rates of most asteroids in this size range have an upper limit of 2.2 hours, the so-called "spin-barrier" (e.g., [24, 25]). This is interpreted as showing that the asteroids in this size range are rubble-piles, i.e., they consist of numerous pieces of components held together by their self-gravity. The impact strength of rubble-pile asteroids is likely insensitive to the composition of the constituent particles. The similarity of the size distributions between the S-like and C-like asteroids that we found seems to support the view that these asteroids in the size range we examined have a rubble-pile structure.

References:

[1] DeMeo, F. E., and Carry, B. (2014) *Nature*, *505*, 629. [2] DeMeo, F. E. et al. (2015) *in Asteroids IV*, 13. [3] Usui, F. et al. (2019) *Publ. Astron. Soc. Japan*, *71*, 1. [4] Ivezić, Ž. et al. (2001) *Astron. J.*, *122*, 2749. [5] Yoshida, F., and Nakamura, T. (2007) *Planet & Space Sci.*, *55*, 1113. [6] Bottke, W. F. et al. (2015) *in Asteroids IV*, 701. [7] O'Brien, D. P., and Greenberg, R. (2003) *Icarus*, *164*, 334. [8] Durda, D. D. et al. (2007) *Icarus*, *186*, 498. [9] Benavidez, P. G. et al. (2012) *Icarus*, *219*, 57. [10] Jutzi, M. et al. (2019) *Icarus*, *317*, 215. [11] Terai, T. et al. (2013) *Astron. J.*, *146*, 111. [12] Jedicke, R. (1996) *Astron. J.*, *111*, 970. [13] Bowell, E. et al. (1989) *in Asteroids II*, 524. [14] Bus, S. J., and Binzel, R. P. (2002) *Icarus*, *158*, 146. [15] Carvano, J. M. et al. (2010) *Astron. & Astrophys.* *510*, 43. [16] Fukugita, M. et al. (1996) *Astron. J.*, *111*, 1748. [17] Gunn, J. E. et al. (1998) *Astron. J.*, *116*, 3040. [18] Juric, M. et al. (2002) *Astron. J.*, *124*, 1776. [19] Pier, J. R. et al. (2003) *Astron. J.*, *125*, 1559. [20] Stoughton, C. et al. (2002) *Astron. J.*, *123*, 485. [21] Ivezić, Ž. et al. (2010) SDSS Moving Object Catalog V3.0. *EAR-A-I0035-3-SDSSMOC-V3.0.*, PDS. [22] Usui, F. et al. (2013) *Astrophys. J.*, *762*, 56. [23] Press, W. H., et al. (1992) *Numerical Recipes in C*, Cambridge University Press. [24] Carbognani, A. (2017) *Planet & Space Sci.*, *147*, 1. [25] Chang, C-K., et al. (2015) *Astrophys. J.*, *219*, 27.

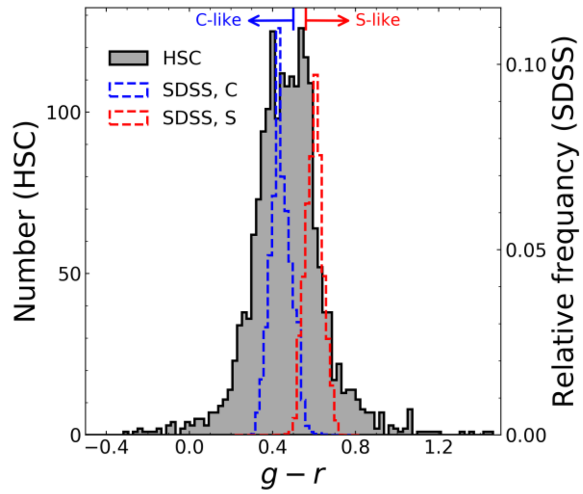

Figure 1: The *g-r* color distributions of our HSC samples (gray, with left vertical axis). The SDSS MOC4 data corrected for the difference of the filter systems between HSC and SDSS are also plotted for reference (the red and blue lines mean S-type and the C-type, respectively, with right vertical axis). The color borders of our samples are shown as short vertical lines with arrows, which correspond to 0.50 for the blue one and 0.56 for the red one.

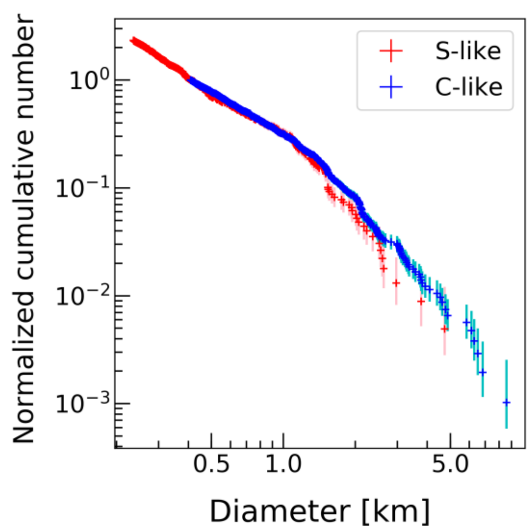

Figure 2: The cumulative size distributions of reddish S-like (red points) and bluish C-like (blue points) asteroids. The values of the vertical axis are normalized by the value at a diameter of 0.4 km. Diameters are obtained from the absolute magnitudes assuming an albedo of 0.21 for S-like and 0.07 for C-like asteroids, respectively [22]. The sample numbers of each population are 479 for the S-like asteroids, and 1,026 for the C-like asteroids, respectively. The error bars represent Poisson's statistical error.