COLLISIONAL EVOLUTION OF MAIN-BELT ASTEROIDS WITH HIGH INCLINATION.
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Introduction: The size distribution of main-belt asteroids (MBAs) gives implications for their collisional evolution. It is primarily shaped by the balance between depletion of bodies through disruptions and fragment production in each size bin. A collisional fragmentation is controlled by asteroid impact strength represented by the catastrophic disruption threshold, Q^*_D [1]. Q^*_D increases with size in proportion to D^s, where D is the diameter and s is the power-law index, in the size range beyond ~1 km called the gravity-scaled regime [2]. For a collisional steady-state population, s determines the power-law of the size distribution [3]. Therefore, the study for MBA size distribution gives constraints of the Q^*_D law [4].

The Q^*_D law is likely to vary with impact velocity [5]. Around the era of Jupiter formation, the dynamical excitation by planetary embryos and Jupiter raised MBAs' eccentricities and inclinations [6]. The pumping-up of eccentricities/inclinations increased their impact velocities to more than the current mean value (~5 km sec^{-1} [7]). It means that such hypervelocity collisions occurred frequently in the main belt during this phase. The dependency of the Q^*_D law on impact velocity affects the collisional evolution of MBAs in the final stage of the planet formation.

Methods: For investigating the Q^*_D law in hypervelocity collisions exceeding 5 km sec^{-1}, the size distribution of high-inclination (high-*i*) MBAs is useful. Asteroids with $i > \sim 15^o$ mostly collide with another body at high velocity around 7 km sec^{-1} in the main belt [8]. For example, the mean collision velocity for 2 Pallas with inclination of 35^o reaches 10 km sec^{-1} [9]. High-*i* MBAs have collisionally evolved under higher impact velocities than low-*i* MBAs.

The MBA size distribution has been revealed down to sub-km size by several of previous extended surveys. However, the size distribution of the high-*i* populations is still unknown, especially around the small end. Our goal is to determine the size distributions of high-*i* MBAs for understanding the collisional processes in the primordial main belt.

Observations: We performed an optical wide-field survey using 8.2-m Subaru telescope in 2008 [10]. The regions with high ecliptic latitude around $+25^o$ were selected as the observation fields because those are suitable for detecting high-i MBAs. In addition, we used the archive data of Subaru telescope. The total area of our survey is 9 deg^2. We searched asteroids on the obtained images using an analysis technique for efficient detection of moving objects [11].

Results: We detected more than 600 objects as MBA candidates. The detection limit is 24.0 mag in the r'-band (0.63 μm), which corresponds to 0.7 km in diameter assuming the albedo of 0.10–0.14. The complete sample of MBAs with $D > 0.7$ km contains 160 objects. About 40 percent of them have inclinations higher than 15^o. We found that the fraction of bodies with $D < 1$ km is ~0.45 for low-*i* MBAs ($i < 15^o$), but is ~0.30 for high-*i* MBAs ($i > 15^o$). It shows a population deficiency of sub-km asteroids in high-*i* MBAs.

The cumulative size distributions (CSD), described by $N(>D) = C\,D^{-b}$ (C is the coefficient and b is the power-law index), were obtained from the low-*i* and high-*i* MBA samples. The best-fit power-law index of the CSD is $b = 1.79 \pm 0.05$ for the low-*i* sample and is $b = 1.62 \pm 0.07$ for the high-*i* sample. In addition, we constructed continuous CSDs covering the entire diameter range of $D > 0.7$ km using published asteroid databases, ASTORB [12] and SDSS MOC [13]. The combined CSDs also show the same result that the high-*i* population has a CSD with a shallow slope ($b = 2.02$) compared to the low-*i* population ($b = 2.17$).

The shallow size distribution of high-*i* MBAs implies a large s value, namely, a steep increase of Q^*_D in the gravity-scaled regime under hypervelocity collisions. It indicates that during the dynamical excitation phase in the main belt, small asteroids were more difficult to survive relative to large ones than at present. We also found that S-type asteroids have a shallow CSD in high inclination, whereas C-type asteroids show little variation in CSD slope with inclination.

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