Collisional and orbital history on Comet 9/P Tempel 1

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Jupiter-family comets (JFCs) might have kept primordial materials in the early solar system, because they would come from a cold outer region of the solar system, namely, trans-Neptunian region. To study properties of the primordial materials from observations of JFCs, we need to know how they have been altered thermally. Namely, the information on the thermal history of JFCs nuclei is required. In this case, we need to know how their orbits evolve after they leave the trans-Neptunian region. However, it is not straightforward to derive their orbital history from the present orbits of JFCs, because of their complicated features of the orbital evolution by gravitational perturbation of giant planets as well as non-gravitational forces.

In previous studies, a statistical approach based on many numerical calculations has been conducted to infer the general properties of the orbital history of JFCs. In this case, however, the assessment based on direct comparison with the observation of a JFC is impossible. On the other hand, the study on the crater population observed on JFC nuclei may give some clues on the proper orbital history. A typical orbit of JFCs crosses the asteroid belt region and we may expect that JFC nucleus has crater population formed by impacts of asteroidal bodies. Indeed, recent space missions have revealed the existence of crater populations on JFCs. The collisional probability of a JFC depends on its orbital parameters, and there may be some relations between the number density of the crater population and the past orbits of the comet. In addition, the sublimation process, which erases and deforms the crater population, also depends on the orbital parameters. Therefore, studies on the crater production by asteroidal objects and on the erase process (and the deformation) by the sublimation would give us constraints on each JFC orbital history.

In this study, we estimate the number density of craters formed by asteroid impacts to infer the collisional history on 9P/Tempel 1 (T1). Using the self-consistent numerical model for the main-belt and near-Earth Asteroid (NEA) populations of small asteroids, we derived R-plot against crater diameter for various exposure ages, and compared with the observational data on the T1 nucleus. We found that the time necessary to accumulate the crater population on T1 with diameter larger than ˜150 m is as long as ˜a few tens of thousands of years. On the contrary, the R value for smaller craters with diameters less than 100 m shows less than a few tens of thousands of years. However, the discrepancy in the age between larger and smaller craters may be due to the sublimation process; the sublimation process may preferentially erase the population of small craters. In order to investigate this, we reexamined the number density of craters formed by asteroid impacts with taking into account the sublimation for T1. We found that the total period of the recent orbits, in which the perihelion distance is small enough to cause significant sublimation with erasing a large number of small craters, may be less than two thousands of years. Therefore, we may conclude that T1 crossed the asteroid belt region during at least tens of thousands of years in the past, but the timing of T1's entry into the recent orbit may be later than two thousands of years ago.