PPS21-P04 Room:Convention Hall Time:May 25 18:15-19:30

Impact experiments in viscous fluid: Implications to crater formation and viscous relaxation on cometary nuclei

ABE, Hitomi[1*] ; ARAKAWA, Masahiko[2] ; YASUI, Minami[2]

[1]Graduate School of Engineering, Yokohama National University, [2]Graduate School of Science, Kobe University

Introduction: A cometary nucleus is supposed to be composed of rocks, ices and organic matters, and comets could be one of the most primordial bodies in the solar system because cometary nuclei would have never experienced high thermal metamorphism to evaporate water ice from the interior since their formation. Thus, it is very interesting to explore the internal structure, but the direct observation of the interior is quite difficult. While the morphology of the impact craters on the surface of cometary nucleus is expected to reflect the internal structure, therefore, it is important to study the formation process of impact craters on the surface simulating the comet nuclei in order to clarify the internal structure of cometary nuclei. Several circular depressions on the surface of cometary nuclei were found by the space craft such as Stardust and Rosetta, but their morphology was quite different from those on the rocky bodies such as the Moon because of the viscosity of refractory organic matters constructing the surface layer. In this study, we carried out impact experiments on viscous fluids and examined the effect of viscosity on the crater volume.

Experimental methods: We did impact experiments by using the one-stage vertical He-gas gun at Kobe University. We prepared a target by mixing glucose syrup with water, and the viscosity was controlled from 10^{-3} to 47 Pas. A projectile was a disk-shaped agar with the diameter of 10 mm and the thickness of 5 mm. We chose the agar as a projectile material because we'd like to study the effect of projectile destruction at impact. The projectile velocity was a constant of 65 ± 15 m/s, and the impact experiments were carried out under the air pressure. The cratering phenomena were observed by a high-speed camera, and we analyzed the crater depth changing with the time and the crater maximum diameter.

Result: We measured the time change of the crater depth and diameter by using the video images, and examined the effect of viscosity on these sizes. First, we found that the crater depth increased with the increase of time, and it became the maximum at a certain time. So we calculated the crater volume by using the maximum depth and the diameter measured at this time. In this study, we examined the relationship between the non-dimensional crater volume, $\pi^{1*}=(V\rho/m)\cdot(1.61gD_p/u^2)^a$ (V: crater volume, ρ: target density, g: gravity, D_p: target diameter, u:velocity, a: constant), and the non-dimensional viscosity, $\pi^{2*}=(\eta/(\rho D_p u))\cdot(1.61gD_p/u^2)^{(a-1)/2}$ (η: viscosity). As a result, the π^{1*} became constant, irrespective of the viscosity at small π^{2*} (gravity regime), while the π^{1*} decreased with the increase of viscosity at large π^{2*} (viscous regime). Fink et al. (1984) showed the similar behavior, so we can say that this trend did not depend on the impact velocity. But our π^{1*} was relatively smaller than that of previous works and the power of the fitting line by using the power equation in viscous regime was larger than that of previous work.

Next, we calculated the relaxation time as the duration from the time when the crater depth became the maximum to the time when the depth becomes 1/e times as large as the maximum. As the result, the relaxation time was larger with the increase of the viscosity. We calculated the theoretical relaxation time by using the equation of $t_R\cong 8\eta/(\rho g D_c)$ (D_c: crater maximum diameter), and compared this theoretical values with our results. As a result, our experimental results were larger than the theoretical values as the viscosity became larger.

Keywords: impact crater, cometary nuclei, viscosity, relaxation time