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CONCEPT STUDY FOR JAPANESE COMET SAMPLE RETURN EXPLORATION IN THE 2030S

Abstract

Sample-return missions can provide valuable information for understanding the history of the early Solar System. In 2020, the Japanese probe Hayabusa2 successfully returned samples from the asteroid Ryugu, which are currently being analyzed worldwide and have yielded numerous scientific results. Similarly, OSIRIS-REx brought samples from the asteroid Bennu to Earth. Japan is also planning a sample return mission from the Martian satellite Phobos, MMX, for its launch in 2026. Further, JAXA is studying a Next Generation Small Body Sample Return (NGSR) mission following MMX. A study team, which includes many Hayabusa2 project members, is currently preparing a proposal for a strategic large-class mission to be launched in the 2030s by ISAS/JAXA.

We defined the NGSR as a mission to reveal the origin of the Solar System and set our scientific goal to elucidate I) the origin of the Solar System "materials" in the galactic evolution process and II) the origin of the Solar System "bodies" to form planetesimals. To achieve this goal, comets have been selected as the primary target. So far, the only samples taken from comets were obtained by the Stardust mission during its flyby. The NGSR aims to collect samples from the surface of a comet and bring them back to

the Earth. It also plans to try to collect subsurface material, as Hayabusa2 did. This mission is crucial in expanding our understanding of cometary materials, geology, internal structure, and consequently the cometary origin and evolution.

As a result of the orbital study, a Jupiter-family comet, 289P/Blanpain, was selected as a candidate target for launch in the 2030s. Its perihelion and aphelion distances are approximately 0.96 au and 5.1 au respectively, and the orbital period is around 5.18 years. The best launch timing is early 2034, with a round-trip flight time of approximately 13 years. A spacecraft system that allows for flexible comet proximity operations is being investigated, considering the lessons learned from Hayabusa2. It consists of a transport vehicle for the round-trip cruise and a 100 kg class lander for sampling during the comet proximity phase. Additionally, an impactor is planned to excavate the cometary surface and make the subsurface materials accessible, along with ultra-compact landers. The entire exploration system is expected to be in the 2-tonne class.

This paper describes our comet sample return expeditions of the 2030s, including mission objectives, spacecraft systems, and operational plans.