Prospects for the study of comets with surface sample return spacecraft

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Introduction: Comets are small bodies composed of molecular ices and dust that spent most of their lifetime in the outer regions of the Solar System. Their nuclei contain pristine material that have not evolved very much since the time of their formation in the early solar nebula. Therefore, characterizing the chemical composition of the coma can help to constrain the distribution of molecular material during the epoch of planet formation. In addition, studying the role of the volatile ice composition in the sublimation of material from the surface is important in the understanding of nucleus activity. Remote-sensing observations of cometary atmospheres at various wavelengths are an efficient tool for investigating the physical and chemical diversity of comets, and substantial efforts have been made in the last decades to develop a chemical classification of comets that displays a great compositional diversity (A'Hearn et al. 1995; Biver et al. 2002; Bockelée-Morvan et al. 2004; Mumma & Charnley 2011). However, close-up detailed measurements on the nucleus and inner coma of this comet can only be provided by in-situ observations such as a flyby, orbiting mission or a sample collection robotic probe.

In-situ observations: The results from flyby, orbiting and in-situ exploration from spacecraft in the past decades have revealed critical information about the composition of the material in the comet nuclei, such as the Deep Impact mission in 2005 and the Rosetta spacecraft first successful landing on of the Philae lander on comet 67P/ChuryumovGerasimenko in 2014. These latter mission has carried out a great variety of measurements including isotopic ratios, dust and organic compounds by analysing the gas in the coma and nucleus material, thus providing a comprehensive view of the comet. In addition, The comparison of spacecraft measurements with Earth-based observations gives a unique opportunity to test observing techniques currently used for comets. The measurements from Rosetta indicate that the D/H isotopic ratio in water vapour in comet 67P/ChuryumovGerasimenko is significantly larger from the value in Earth’s oceans. Characterization of the nucleus density by the Rosetta instruments suggests that it is formed by a loose accumulation with higher porosity than previously thought. Therefore extracting a sample off the surface of the nucleus for laboratory analysis on Earth, a goal that was recognized as a priority in NASA’s Solar System Exploration Roadmap, is the next step for a cometary mission.

Comet surface sample return mission: A mission to collect material from the surface of a comet nucleus to be returned to Earth for laboratory analysis has been studied by the National Academy of Science’s Decadal Survey. Several sample return missions have been proposed since this study was recommended to NASA to develop a medium-class mission (e.g., Smith et al. 2007; Weissman et al. 2010; Chu et al. 2014). Laboratory analysis of the composition of a cometary sample on Earth using state-of-the-art techniques will provide crucial information about the composition of the nucleus and the evolution of the Solar System. In this poster we describe mission designs to extract the sample within a capsule and deliver the sealed sample back to Earth.

References


