SPICA Spectroscopy of Cometary Refractory and Icy Dust Grains

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ABSTRACT

We propose mid/far-infrared spectroscopy of comets to study (1) precise astromineralogy of cometary refractory dust and, (2) environment of H_2O ice formation (temperature and gas density) in the early solar nebula. The mid/far-infrared spectroscopy is a powerful diagnostic tool to investigate the size, shape, and chemical composition of cometary dust, so that it will enable us to reveal the process of refractory grain growth and radial transportation of dust grains in the early solar nebula. However, it is not easy to disentangle constituent minerals clearly only with the 10 μm-band of ground-based observations. The crystalline silicate bands at 33, 49, and 69 μm are a clue to investigate the dust size and chemical composition. Whether cometary H_2O icy dust grain is amorphous or crystalline reflects its formation environment (temperature and gas density). The H_2O ice bands are at 6, 12, 44 and 65 μm. Since the reason why crystalline H_2O icy grains were detected in a few comets is still unclear, statistical study on the abundance of the cometary crystalline H_2O ice dust is important to reveal the history of formation and evolution of the comets.

1. BACKGROUND AND MOTIVATION

1.1. Astronmineralogy of Cometary Refractory Dust

The mid/far-infrared spectroscopy is a powerful diagnostic tool to investigate the size, shape, and chemical composition of cometary dust, so that it will enable us to reveal the process of refractory grain growth and radial transportation of dust grains in the early solar nebula. However, it is not easy to disentangle constituent minerals clearly only with the 10 μm-band of ground-based observations.

Comets are generally thought to be the icy remnants body of the early solar nebula. They are divided into two different groups according to its orbital characteristics which reflect its formation region. One group is Oort Comets (OCs) which are thought to be formed in Jupiter-Uranus region, and ejected out to the Oort cloud (Morbidelli 2007). The other is Ecliptic Comets (ECs) which are thought to be formed in trans-Neptunian region (Duncan & Levison 1997). Thus these two groups are expected to have different physical or chemical properties.

1.2. Cometary H_2O Icy Dust

The H_2O ice bands are at 6, 12, 44 and 65 μm. Whether cometary H_2O icy dust grain is amorphous or crystalline reflects its formation environment (temperature and gas density). In addition, energy of transition of H_2O ice from amorphous to crystalline is considered to be one of possible drivers of the outburst activity (e.g., Meech & Svoren 2004). However, the detection of cometary H_2O icy grains is so rare that the reason why crystalline H_2O icy grains were detected in a few comets is still unclear. Therefore, statistical study on the abundance of the cometary crystalline H_2O ice dust is important to reveal the history of formation and evolution of the comets. Especially, it is important to detect H_2O icy grains on the Centaurs/distant comets and the main-belt comets and, to perform statistical comparison of whether it is crystalline or amorphous.

1.3. Goal

The goal of our proposal is as follows:

1. Reveal the process of grain growth and radial transportation of dust grains in the early solar nebula by the investigation of the size, shape, and chemical compositions of cometary dust.
2. Reveal the history of formation and evolution of the comets by the statistical investigation of the crystallinity of H_2O icy dust grains of comets.

Table 1. Observation strategy.

Instruments & Mode	MCS MRS-S/L + Safari
Target	cometary refractory/icy dust grains
Line Features	10, 20, 33, 49, and 69 μm for silicate dust
	6, 12, 44 and 65 μm for H_2O icy dust
Number of targets	~30 comets (Ecliptic/Oort comets, Centaurs, Main-belt comets)

2. OBJECTIVE AND OBSERVATION STRATEGY

2.1. Astromineralogy of Cometary Refractory Dust

One of our objectives is to observe mid-IR + far-IR crystalline silicate features at 33, 49, and 69 μm of dozens of comets (for Ecliptic comets, Oort cloud comets, and Halley-type comets), and:

1. Estimate the Fe/Mg ratio and pyroxene/olivine ratio of silicate grains. Based on the result, study the temperature and chemical environment in the early solar system disk.
2. Investigate the dust grain size evolution and the formation mechanisms of cometary nuclei.

2.2. Cometary H_2O Icy Dust

Another is to observe mid-IR + far-IR H_2O ice bands at 6, 12, 44 and 65 μm of dozens of comets (for Centaurs and Main-belt comets, as well as Ecliptic comets, Oort cloud comets, and Halley-type comets). In addition, our objectives are also to detect H_2O icy grains and, to study the correlation between crystallinity of H_2O ice and distance, activity, or orbital character of the comet statistically.

2.3. Observation Strategy

Observation strategy is summarized in Table 1. We would like to note that simultaneous spectroscopic observations of 33 and 69 μm crystalline silicate features can be carried out only with *SPICA*/MCS+Safari.

REFERENCES

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