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Mineralogy of Silicate Dust Particles for Comet 17P/Holmes by Subaru/COMICS

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Abstract

Dust grains and icy materials in comets have been used to investigate the formation conditions of the solar system. It is considered that the existence of crystalline silicate in comets indicates the radial mixing of materials in the early solar nebula. The outburst of comet 17P/Holmes showed on late October, 2007. We carried out low-dispersion spectroscopic observations of 17P/Holmes in mid-infrared region with Subaru/COMICS. We show results of our model fitting analysis by using a thermal emission model for this comet. We discuss about the mineral composition for dust grains of 17P/Holmes.

1. Introduction

Comets are thought to be one of the primordial bodies in the early solar nebula. Comet 17P/Holmes was discovered by E. Holmes in November, 1892. A large outburst of comet 17P/Holmes has occurred in late October 2007. At that time, large amounts of gas and dust particles released from the interior of the cometary nucleus. We carried out the mid-infrared spectroscopic observation of this comet. We investigate composition of mineralogy for dust grains of 17P/Holmes. We detected submicrometer-sized crystalline silicate grains from this comet. Crystalline silicate grains are formed under high temperature conditions. It is considered that the cometary crystalline silicate grains formed in the inner hot region of the solar nebula and transported to the comet forming region by the radial mixing of materials in the early solar system [7].

2. Observations

A large outburst of comet 17P/Holmes has occurred in late October 2007. Just after the outburst began, we carried out low-dispersion spectroscopic observations in mid-infrared region (8-13μm) with COMICS (Cooled Mid-Infrared Camera and Spectrometer) mounted on the 8.2m Subaru Telescope on October 25th – 28th, 2007 UT, when the comet was at 2.44 – 2.45AU from the Sun. Imaging observations in the 8.8μm ($\Delta\lambda$= 0.8μm), 12.4μm ($\Delta\lambda$= 1.2μm) bands were also performed [7]. We selected HD 21552 as a flux standard star for aperture photometry [1].

Table1: Observational conditions of the comet.

UT Date in 2007	R_h [AU]	Remarks
Oct. 25.4	2.441	Central condensation
Oct. 25.4	2.441	Isolated dust cloud
Oct. 26.5	2.445	Central condensation
Oct. 26.5	2.445	Isolated dust cloud
Oct. 27.4	2.449	Central condensation
Oct. 27.4	2.449	Isolated dust cloud
Oct. 28.4	2.453	Central condensation

* R_h :Heliocentric distance

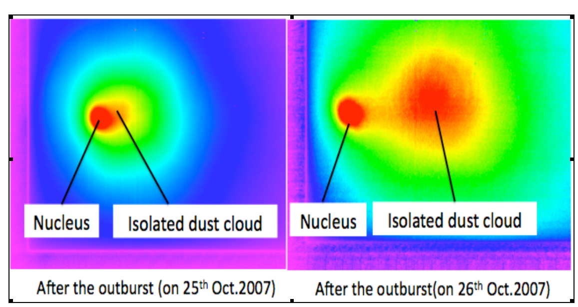

Fig 1: Near nucleus coma of 17P/Holmes taken by imaging mode of the COMICS at 8.8 μm. We could detect the release of "isolated dust cloud" from the nucleus.

3. Fitting Analysis

Thermal emission spectrum of the dust grains is modeled by summing the spectra of minerals. The methods used here are similar to those used in the previous studies [3]. We assume that all dust grains are spherical, homogeneous and at a given heliocentric distance. The temperature of a grain is determined by radiative equilibrium [6]. We consider five kinds of minerals as components of a grain in our model [3, 5] : amorphous olivine, amorphous pyroxene, and amorphous carbon, and crystalline olivine and crystalline pyroxene. In our model, we used the Hanner size distribution for the grains [5]. The Hanner size distribution is given by the following formula [2].

$$n(a) = (1 - a_0 / a)^M (a_0 / a)^N \quad \cdots (1)$$

$$a_p = a_0 (M + N) / N \quad \cdots (2)$$

where, a is the grain radius. a_0 is the minimum grain radius (= 0.1μm). N and M are related to the peak grain radius a_p.

4. Results

Figure 2 shows the spectrum of comet 17P/Holmes observed by COMICS. We can easily see the 11.2μm peak of a crystalline silicate feature onto a broad amorphous silicate feature. We detected crystalline silicates both in the central condensation of the nucleus and isolated dust cloud region. Crystalline-to-Amorphous Ratios (CARs) of the central condensation region and isolated dust cloud region are consistent within the error-bars.

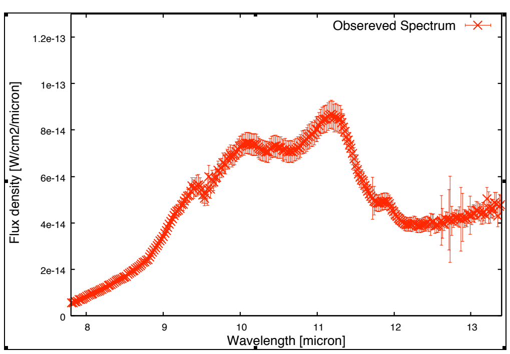

Fig 2: Observed spectrum of comet 17P/Holmes by COMICS on 25th Oct 2007.

5. Conclusions

Our result shows that the submicrometer-sized crystalline silicate grains exist in 17P/Holmes. In general, Oort cloud comets contain the submicrometer-sized crystalline silicate grains. Comet 9P/Tempel 1 contains those grains, too [2]. Therefore, crystalline silicate grains may be also contained inner part of the nucleus of Jupiter family comets. Jupiter family comets and Oort cloud comets might be formed similar region. Or the radial mixing of crystalline silicate grains might occur efficiently in the solar nebula.

Acknowledgements

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