COMPARISON OF 3 MICRON FEATURES OF TRAPPED H_2O AND H_2O FROST IN SiO CONDENSATE WITH OBSERVED DUST FEATURES

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ABSTRACT We synthesized a SiO condensate trapping H_2O and H_2O ice deposited on it. An IR spectrum of the condensate and that of a protostar NGC 7538/IRS 9 were compared. The spectrum of the condensate agreed well with the protostellar spectrum.

1. Introduction

In spectra of protostellar objects absorption features are observed at 3.07 μm and near 10 μm (Willner et al., 1982). They are attributed to H_2O ice and amorphous silicate, respectively. Day and Donn (1978) and Nuth and Donn (1982) synthesized grains from SiO and Mg gas and showed that their IR spectrum exhibited a broad feature peaked near 10 μm. We synthesized a condensate from SiO gas. The condensate trapped H_2O gas into its structure. This H_2O causes a broad 3 μm feature peaked at 2.94–2.99 μm (Wada et al., 1990). We deposited H_2O ice on the SiO condensate. It was examined whether the protostellar feature can be accounted for the SiO condensate frosted with ice on it.

2. Experiments and Results

Powder of SiO_2 and Si mixed with equal mole amounts was heated in a tantalum boat to 1,300 °C, and SiO vapor was produced. The SiO vapor was condensed onto a KBr or KRS-5 crystal substrate, and a copper substrate, both of which were cooled by liquid nitrogen. When the condensate was formed, H_2O was trapped into the SiO condensate.

We made a cell specially designed for IR measurement at low temperature. Crystalline H_2O ice was deposited onto the condensate (referred to "frosted SiO") at about –50 °C. Then the deposited ice was defrosted by evacuation in the cell (this material is referred to "defrosted SiO"). A JASCO-810 IR spectrophotometer was used to obtain IR spectra of the condensates.

The 3 μm spectrum of the SiO condensate trapping H_2O was compared to the observed spectrum toward the Galactic Center source IRS 7 (Butchart et al., 1986, Fig.1). IR spectra

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of the "frosted SiO" in the cell were compared to the observed spectrum of protostellar dust (Willner et al., 1982) in Fig.2.

3. Discussion

The 3 μm feature caused by trapped H_2O in SiO condensate agreed well with the feature toward the Galactic Center source IRS 7, in which the peak is at 2.95–3.00 μm (Fig. 1). It is uncertain as yet whether the dust which causes the 3 μm feature exists in interstellar space or near the Galactic Center. Tanaka et al. (1990) found a similar broad absorption feature peaked at 2.95 μm around M type stars. This 3 μm feature is observed in hot circumstellar space or diffuse cloud regions. In this "dry" condition, molecular H_2O ice frost or dirty ice cannot exist. Trapped H_2O into Si-O structure may survive the condition.

There is a clear difference between the IR feature toward the Galactic Center sources and protostellar dust features. The peak is at 2.95–3.00 μm for the feature toward the Galactic Center sources, including IRS 7 (McFadzean et al., 1989), and at 3.07 μm for the protostellar feature. The difference in the 3 μm features is caused by different chemical and physical conditions of H_2O. In a dense cloud H_2O is deposited onto the surface of "dry" core dust grain containing trapped H_2O. The deposited H_2O ice adds a peak at 3.07 μm on the broad 2.95–3.00 μm feature. Therefore, the 3 μm feature of protostellar dust can be attributed mainly to a mixed feature of the two H_2O components.

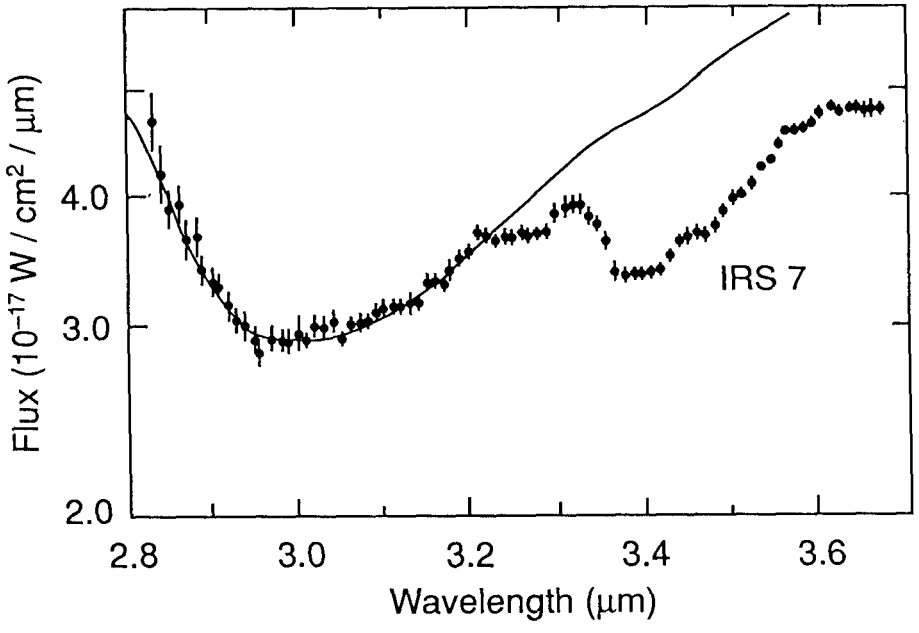

Fig.1. Comparison of a 3 μm spectrum of trapped H_2O in SiO condensate to that toward the Galactic Center source IRS 7.

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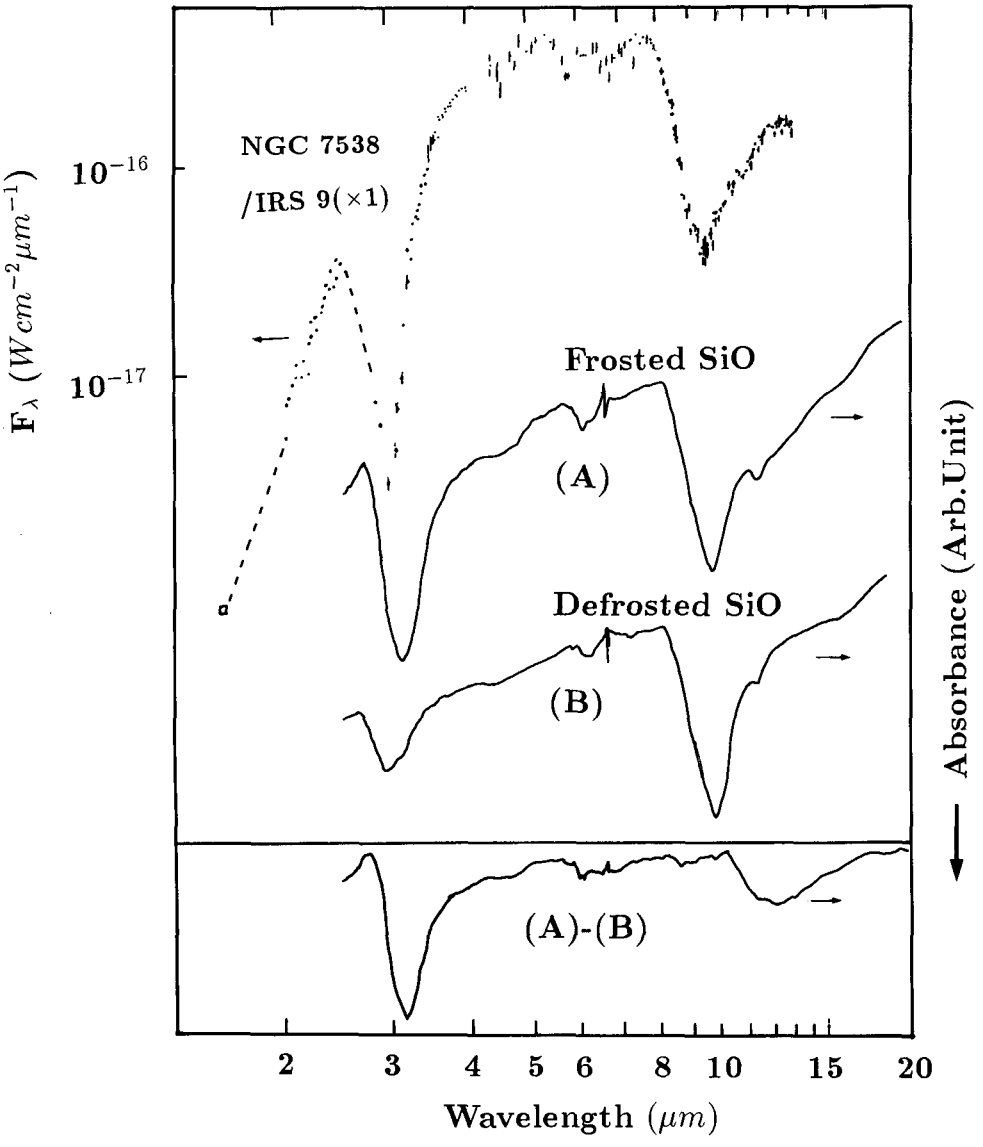

Fig.2. Comparison of IR spectra of "frosted SiO condensate" and "defrosted SiO condensate" to a spectrum of protostar NGC 7538/IRS 9 (after Willner et al., 1982). (A)–(B) shows a difference spectrum of (A) and (B).

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In the 10 μm wavelength region, there is another difference between the dust feature toward the Galactic Center source IRS 7 and protostellar dust features. The 10 μm absorption feature toward the Galactic Center sources is narrower than that of the protostellar feature (Aitken et al., 1986). Pure H_2O ice causes a broad feature peaked near 12 μm (Léger et al., 1979). In our experiment, "frosted SiO" did not show a hump at 12 μm, instead resulted in broadening the 10 μm feature in long wavelength region. This "frosted SiO" exhibits a feature similar to the NGC 7538/IRS 9.

In a course of star formation, protostellar dust which is coated with H_2O ice would be dried. "Defrosted SiO" may be an analog to this kind of dust grains. Its IR spectrum shows a peak at 2.94 μm and 10 μm (Fig.2 (B)).

4. Conclusion

1. Deposition of small amount of crystalline H_2O ice on SiO condensate containing trapped H_2O shows a similar feature to that of a protostar NGC 7538/IRS 9.

2. The 3 μm feature of protostellar dust can be attributed mainly to a mixed feature of the two H_2O components, trapped H_2O into Si-O structure and H_2O ice.

3. H_2O ice deposited on SiO condensate resulted in broadening the 10 μm feature in long wavelength region.

4. In a 3 μm spectrum of defrosted SiO condensate the peak is located at 2.94 μm.

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