In situ electron diffraction analysis of stacking sequences in ice I under interstellar conditions

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Infrared (IR) observations toward interstellar molecular clouds reveal that water ice without a long-range ordered structure (amorphous water) is the dominant solid component in icy dust grains. At high temperatures, amorphous water is crystallized into ice I, which consists of stable hexagonal ice Ih, metastable cubic ice Ic, and their mixed structure. Although the morphology of water ice affects the reactivity of chemical reactions in icy dust grains [1], the selection rule of those different ice structures is not completely understood yet.

In laboratory, interstellar ice analogues are usually prepared by deposition of a water vapor onto a cold substrate (vapor-deposition). Crystallinity of water ice depends not only on the temperature of a substrate but also on the deposition rate of a water vapor [2]. Recently, the formation of crystalline ice is reported even at extremely low temperatures by a method arranged from vapor-deposition (for details, see ref. [3]). However, because the previous study [3] analyzed the ice only by IR spectroscopy, the amount of cubic or hexagonal stacking sequences in the ice is still unknown. *In situ* diffraction analysis is crucial to determine the extent of stacking sequences in ice I.

By using newly developed reflection high-energy electron diffraction (RHEED), we found that the amount of hexagonal stacking sequences in the ice I formed by the new method at 13 K was lower than that in the ice I prepared by annealing vapor-deposited amorphous water at 143 K (Fig. 1) [4]. The formation of less hexagonal stacking sequences in ice I at higher supercooling degree is qualitatively in line with the study of cubic ice Ic formation by using classical thermodynamics theory [5]. In the session, we will introduce further information about the experiment and its astrophysical implications.

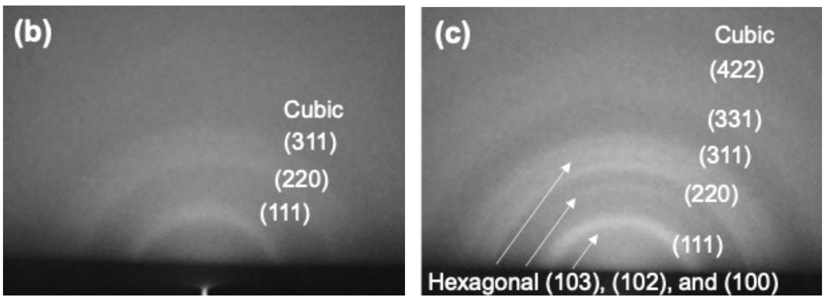

Figure 1: RHEED images of ice I obtained by the new method at 13 K (left), and ice I obtained by annealing vapor-deposited amorphous water at 143 K (right).

References

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