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Properties of ferroelectric and hydrogen ordered ices on Planets

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In the Galaxy, ice is one of the major solid components in a low-temperature environment. Ice crystal has been identified by infrared spectra in interstellar molecular clouds. Icy grains broadly exist in the early solar system. The main ingredient of planets beyond Jupiter is ice. The icy grains grow and become big icy bodies, such as Pluto and Charon.

The nucleation and growth of ferroelectric ice, named ice XI (eleven), has been studied by time-resolved neutron diffraction experiments on High Flax Isotope Reactor (HFIR) at Oak Ridge National Laboratory. The study shows that the hydrogen in ice is slowly ordered at 55 - 70 K and the resulting solid becomes ferroelectric [1,2].

The properties of ferroelectric ice are of interest in space because of long-range electrostatic force. The strong electrostatic force promotes the growth and agglomeration of icy grains. Furthermore, ferroelectric ice captures a number of electrons and ions in space. These properties of ice may have an important role for planetary formation and material evolution.

In this conference I report recent neutron diffraction studies and preliminary results of hydrogen-ordered ices under high pressure. The ferroelectric ice and hydrogen-ordered ices are stable in wide range of temperature and pressure. Therefore it is estimated that a large amount of hydrogen-ordered ice exists in our solar system. We have measured infrared absorption spectra of those ices. Our results demonstrate that the ordered ices in space are detectable using infrared telescope and planetary exploration. I discuss a whole picture of water ice in a low-temperature environment.

Keywords: Hydrogen bond, Planets