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Magnetic measurement of H2O at low-temperature and high-pressure

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Water ice is universal material in space and has fifteen polymorphs reported so far. Because of difficulty in detection of subtle structure change corresponding to hydrogen shift, and slow kinetics of low-temperature ice, some phase boundaries at low temperature are still not confirmed experimentally, which is very important information in planetary science. In this study, we tested a possibility of new method for studying structural change of ice using magnetic measurement at low-temperature and high-pressure. H2O is diamagnetic substance, and the signal intensity of magnetic susceptibility is not detectable if we use a conventional method of magnetic measurement. However, positional ordering of hydrogen atoms should change the spin state of ice. Therefore, we can expect finite change in magnetic susceptibility.

Magnetic measurements were conducted in Superconducting Quantum Interference Device magnetometer (SQUID, MPMS-7, Quantum design). We measured the magnetic moment of ice at temperature below room condition. The measurement was also conducted at high-pressure condition to 0.2GPa to detect phase boundary between phase IX and phase I. Highly purified water with 5 M ohm resistivity or salted waters was used as starting sample in the Teflon capsule with /without a piston cylinder type high pressure cell made of beryllium copper alloy. After many trials of accurate evaluation of magnetic moment of all material surrounding sample as background signal to be subtracted, we measure the signal with water ice in the capsule. The magnetic field applied was 1T. The sample was first cooled to around 100K, then, the temperature elevated to room condition at the rate of 0.25K/s.

Solid-liquid transition of pure water was reproducibly detected with abrupt decrease of magnetic susceptibility. In the case of salt water, magnetic susceptibility decreased gradually with a temperature width as figured by thermodynamics. In the high-pressure run, we found an another jump in the profile of magnetic susceptibility measurement. The condition was close to solid-solid phase boundary proposed. We will report further detail of the experiments as possible detection of phase change in low-temperature water ice.

Keywords: water ice, magnetic measurement, high pressure, phase transition, SQUID