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Dielectric Response in Ice Ih: Signals Perpendicular to an Electric Field of 1 Hz to 1 MHz Applied to Cubes of Ice

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In ice, the dielectric response signals of a Debye relaxation process have been measured parallel to the applied electric field. Here, we report response signals detected perpendicular to the applied field for ice samples. An alternating electric field (applied voltage V0: 5 Vp-p) of 1 Hz to 1 MHz was applied to a cube (1 × 1 × 1 cm) of single-crystal ice Ih between one pair of planes along the c-axis of the sample. We observed the dielectric response signal (detected voltage Vs) between a pair of planes perpendicular to the applied electric field. The measurements were obtained with a frequency response analyzer from −3 to −56 ℃. The frequency dependence of the response signal (Vs/V0) showed a peak in the kilohertz frequency range. The peak strength at −21 ℃ was 1.2% of the applied voltage. The peak strength decreased with decreasing temperature, and the peak faded below −50 ℃. Peak frequency f0 (1065 Hz at −21 ℃) also shifted to the low-frequency side with decreasing temperature. The frequency dependence of the response signal was described with a simple equation related to the current oscillating in an inductor-resister-capacitor (LRC) series circuit. The temperature dependence of the characteristic time, 1/(2πf0), showed that the activation energy was 0.30 eV in the range of −10 to −50℃. This result means that the proton mechanism of the response signal (0.30 eV) is different to that of the Debye dielectric dispersion (0.58 eV) in ice. The peak phenomenon related to the response signal suggests that there was some kind of proton oscillating current (e.g. the migration of point defects) on the ice crystal lattice in only the high-temperature region above −50 ℃.

Significance statement

We will report new experimental results in ice Ih, as response signals detected perpendicular to the applied field for ice cube samples. The signal showed a peak in the kilohertz frequency range. Simple discussion for the peak phenomenon is given.

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