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Fundamental Similarity of Water and Ice Dielectric Responses

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Presently, the wideband dielectric spectra of water and ice are accumulated to be accessible for comparative analysis [1, 2]. The spectra reveal striking similarities such as a unified temperature dependence of the dielectric constants [3], related forms of dielectric relaxations (shifted by 6 decades on frequency) [4, 10], close matching of infrared resonances [6], abnormally high dc-conductivities [3, 5].

There is no model to describe the quoted features consistently. Moreover, there is no perspective on resolving the problem because water and ice are mainly studied separately by independent scientific schools. The structure dynamics of water is assumed to be motion of structural polar regions consisting of the long-lived H2O molecules, while the defects migration mechanisms is considered for ice.

There are two related facts which are commonly ignored but seem important: i) the high proton mobility in both water and ice measured electrically is not supported by diffusion measurements [7, 8], ii) any H2O molecule in ice diffuses with D ˜ 2.10-15 m2/s at -10 °C [6] for a thousand of intermolecular distances during the time of X-ray diffraction measurements; this is in poor agreement with an occurrence of sharp X-ray reflections.

In our study, we analyze critically the outlined issues and construct the model of molecular structure that provides a common background to water and ice dielectric responses [9-11]. The model implies a high concentration of the inherent counter charges in the form of H3O+ and OH- ions in both water and ice. The observed dielectric responses are due to bipolar diffusion of the ions and their interconversion with the neutral H2O molecules via the proton exchange.

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Significance statement

Despite the importance, the water and ice dielectric properties are poorly understood. Here we build conceptually new model where simple periodic localizations and mutual transformations of H2O molecules and H3O + and OH-ions are completely responsible for both water and ice wideband dielectric response between kilohertz and teraherts.

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