Single-crystal elasticity of Ice at high pressures

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Recent astronomy studies observed the existence of hundreds of ice giants in the universe. Ice is one of the major components of these ice giants. Experimental studies on the physical properties of ice at high pressures are thus important for understanding the composition and evolution of these ice giants. Here, we have synthesized high-quality single-crystal H\textsubscript{2}O-ice with 0.5 m NaCl. Single-crystal elasticity of ice was measured by Brillouin spectroscopy combined with X-ray diffraction up to 93 GPa at 300 K using diamond anvil cells. All the elastic moduli of ice-VII exhibit a nearly linear increase with pressure up to 43 GPa at 300 K, although the off-diagonal modulus $C_{12}$ and shear modulus $C_{44}$ slightly deviate from the Cauchy relation between 10 and 20 GPa. The longitudinal modulus, $C_{11}$, and $C_{12}$ show a clear softening when ice-VII changes to the pre-transition ice-VII state. Meanwhile, we also observed a weak drop in the unit cell volume across this change in our high-quality single-crystal X-ray diffraction measurements. We also present first experimental measurements on the single-crystal elasticity of ice-X. Our experimental results were also used to model the anisotropy of ice at high pressures.