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Ultrafast non-thermal heating of water initiated by an X-ray Free-Electron Laser

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The bright ultrafast pulses of X-ray Free-Electron Lasers allow investigation into the structure of matter under extreme conditions. We have used single pulses to ionize and probe water as it undergoes a phase transition from liquid to plasma. We report changes in the structure of liquid water on a femtosecond timescale when irradiated by single 6.86 keV X-ray pulses of more than 10^6 J/cm². These observations are supported by simulations based on molecular dynamics and plasma dynamics of a water system that is rapidly ionized and gets out of equilibrium. This exotic ionic and disordered state at liquid density is suggested to be structurally different from a neutral thermally disordered state.

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