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Direct visualization of concerted proton tunneling in a water nanocluster[1] XIANGZHI MENG, JING GUO, JINBO PENG, JI CHEN, ZHICHANG WANG, JUN-REN SHI, Internation center for quantum materials, Peking University, XIN-ZHENG LI, School of Physics, Peking University, EN-GE WANG, YING JIANG, Internation center for quantum materials, Peking University, YING JIANG TEAM, XIN-ZHENG LI TEAM, EN-GE WANG TEAM — Proton transfer through hydrogen bonds is of great importance to many aspects of physics, chemistry and biology, such as phase transition, signal transduction, topological organic ferroelectrics, photosynthesis, and enzyme catalysis. The proton dynamics is susceptible to nuclear quantum effect in terms of proton tunneling, which tends to involve many hydrogen bonds simultaneously, leading to correlated many-body tunneling. In contrast to the well-studied incoherent single particle tunneling, our understanding of the many-body tunneling, especially the effect of local environment on the tunneling process, is still in its infancy. Here we report the real-space observation of concerted proton tunneling within a hydrogen-bonded water tetramer using a cryogenic scanning tunneling microscope (STM). This is achieved by monitoring in real time the reversible interconversion of the hydrogen-bonding chirality of the cyclic water tetramer with a chlorine-terminated STM tip. Interestingly, we found that the presence of the Cl anion at the tip apex may either enhance or suppress the concerted tunneling process depending on the details of coupling symmetry between the Cl anion and the protons. This work opens up the possibility of controlling the quantum states of protons with atomic-scale precision.

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