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Dynamics of the critical phonon modes in quantum paraelectric SrTiO3

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The proximity of $SrTiO_3$ to a ferroelectric quantum critical point (FE QCP) has become a promising new branch of the study of quantum critical phenomena. New forms of quantum order have been reported in $SrTiO_3$, different from the quantum paraelectric state via dielectric measurements. The critical point here is associated with a soft optical phonon mode responsible for the ferroelectric instability.
We report our recently performed triple-axis inelastic neutron scattering experiments on single-crystal $SrTiO_3$ at the temperature and pressure region of interest. These were the first direct measurements deep into the enigmatic "quantum polar-acoustic state" in the vicinity of the FE QCP. Measurements are taken at and around $q = 0$ in multiple directions in reciprocal space to explore the transverse acoustic and soft optical phonon modes and their hybridization. In addition, we explore how pressure affects the underlying phonon modes in $SrTiO_3$. We also present first-principles calculations in the low-temperature tetragonal phase, in comparison with the experimental observations. Our explorations directly address the coupling of the soft optical mode with the acoustic phonons, and its response to external pressure. We believe this could help us understand the importance of anharmonic lattice dynamics and quantum fluctuations in $SrTiO_3$.

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Primary author: DENG, Shiyu (Institut Laue-Langevin)

Co-authors: IVANOV, Alexandre (ILL); WILDES, Andrew (Institut Laue Langevin); Dr HAINES, Charles R.S. (School of Physics, University of East Anglia,); COAK, Matthew (University of Birmingham); Dr SAXENA, Siddharth S. (University of Cambridge); Dr NIKITIN, Stanislav (Paul Scherrer Institute); FENNELL, Tom (Paul Scherrer Institut); PIOVANO, andrea (ILL)

Presenter: DENG, Shiyu (Institut Laue-Langevin)

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