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Can quantum phase transition be a coherent process?

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Quantum phase transitions are transitions between two distinct ground states of a many-body system. Key features of a quantum phase transition include an initial stage with rapidly growing order (called inflation), formation of topological defects, and relaxation toward new ground state. Because of its complexity, the transition is commonly described in a classical picture where quantum coherence is suppressed. Based on Bose-Einstein condensates in a shaken optical lattice, we observe strong evidences that quantum critical dynamics remains coherent during the inflation and relaxation phases. The inflation manifests in the exponential growth of density waves and momentum state populations. After the inflation, we find surprisingly that the coherent evolution, evident in both real and momentum spaces, extends over multiple domains and persists much longer than the time scale of domain formation. Reference: Coherent inflationary dynamics for Bose-Einstein condensates crossing a quantum critical point Lei Feng, Logan W. Clark, Anita Gaj, Cheng Chin, Nature Physics 14, 269 (2018).