**Observation of Quantum Criticality of a Four-Dimensional Phase Transition**

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Understanding how a system's behavior extrapolates beyond the dimensionality of our 3D world is a fundamental question throughout physics – spanning from the pursuit of unification theories to the exploration of exotic materials and into the realms of critical phenomena. In statistical physics, the strength of the fluctuations is very sensitive to the dimensionality, which in turn plays a key role in the existence and nature of phase transitions. Most often, low-dimensional systems often exhibit suppression of phase transitions, while high-dimensional systems tend to display simpler, mean-field-like behavior. In a few outstanding cases, among which the celebrated Anderson localization-delocalization transition in disordered media, criticality has been predicted to remain highly non-trivial even in dimensions larger than three – posing great theoretical challenges to the existing frameworks. In this work, using a periodically-driven ultracold atomic gas to engineer both disorder and synthetic dimensions, we experimentally observe and investigate a phase transition between (dynamically) localized and delocalized phases. Our results clearly exhibit three fundamental characteristics that define the specific 4D nature of the observed phase transition: 1) the relevant observables perfectly follow the d=4 critical scale invariance, 2) the measured critical exponents are in excellent agreement with numerical predictions of the 4D Anderson transition and, 3) they show good agreement with Wegner's relation in 4D. These results open a new paradigm for experimentally exploring complex critical phenomena, and physical theories in general, in higher dimensions.