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Universality and Dynamic Localization in Kibble-Zurek of the Quantum Ising Model[1]

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Recent work has suggested that the Kibble-Zurek mechanism can be re-interpreted as a theory of critical scaling out of equilibrium. While this has been shown for some classical and integrable models, in this work we demonstrate one crucial aspect of critical scaling theory: universality. We solve for the time-dependent finite-size scaling functions of the 1D transverse-field Ising chain during a linear-in-time ramp of the field through the quantum critical point. We then simulate Mott-insulating bosons in a tilted potential, an experimentally-studied system in the same equilibrium universality class, and demonstrate that universality holds for the dynamics as well. We find qualitatively athermal features of the scaling functions, such as negative spin correlations, and show that they should be robustly observable within present cold atom experiments. In addition, we discuss recent results in which the Ising model is extended by imbuing the magnetic field with dynamics. We predict using Kibble-Zurek scaling and numerically confirm that the magnetic field ramp is dynamically arrested at the quantum critical point. Extensions of this theory indicate that dynamic localization near critical points should be omnipresent in nature, and may have implications in particle physics as a possible mechanism for giving the Higgs boson a light mass.

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