Stirring the false vacuum via interacting quantized bubbles on programmable quantum annealer

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False vacuum decay, the transition from a metastable quantum state to a true vacuum state, is a crucial phenomenon in quantum field theory and non-equilibrium processes such as phase transitions and dynamical metastability. However, its non-perturbative nature and the limited experimental accessibility of this process make it difficult to study, leaving open questions about the formation, movement, and interactions of true vacuum bubbles. Here [1], we directly observe the quantized formation of these bubbles in real time, a fundamental aspect of false vacuum decay dynamics, using a quantum annealer to simulate a tilted Ising model spin chain. We develop an effective model that accurately describes both the initial bubble formation and subsequent interactions, even in the presence of dissipation. The annealer uncovers coherent scaling laws in the driven many-body dynamics over more than 1,000 intrinsic qubit time units. This work establishes a framework for exploring false vacuum dynamics in large quantum systems using quantum annealers and provides a basis for further explorations of false vacuum decay phenomena in two-dimensional spin models.

[1] Vodeb, J., Desaules, JY., Hallam, A. et al. Stirring the false vacuum via interacting quantized bubbles on a 5,564-qubit quantum annealer. Nat. Phys. 21, 386-392 (2025).