Novel quantum dynamics with superconducting qubits

Pedram Roushan

Google Quantum AI, Santa Barbara, California

pedramr@google.com

The prevailing view is that quantum processors can be used to tackle certain problems beyond the reach of classical approaches. Recent years have witnessed significant progress in this direction; in particular, superconducting qubits have emerged as one of the leading platforms for quantum simulation and computation on Noisy Intermediate-Scale Quantum (NISQ) processors. This progress is exemplified by the study of non-equilibrium dynamics of elementary excitations and low-energy states in quantum systems [1,2,3].

In a (2+1)D lattice gauge theory, we image charge and string dynamics, revealing two distinct regimes within the confining phase: a weak-confinement regime with strong transverse string fluctuations and a strong-confinement regime where these fluctuations are suppressed [1]. Turning to condensed matter, we observe novel localization in one- and two-dimensional many-body systems that lack energy diffusion despite being disorder-free and translationally invariant [2]. Additionally, we show that strong disorder in interacting multi-level landscapes can induce superfluidity characterized by long-range phase coherence [3]. Together, these results show that NISQ processors, even without fault tolerance, are powerful tools for probing and advancing our understanding of complex non-equilibrium quantum dynamics.

References

[1] Cochran et al., Nature 642, 315–320 (2025)

[2]Gyawali et al., arxiv.org/abs/2410.06557, Science (2026)

[3] Ticea et al., arxiv.org/abs/2512.21416