Visualizing quantum dynamics with superconducting qubits: quantum glass formation at high temperatures.

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I will very briefly review the main features and capabilities of Google superconducting platform and its use for quantum simulations. In the main part of the talk I will focus on our recent study of the disorder driven transition in boson systems simulated recently.

Generally, disorder in quantum many-body systems can drive transitions between ergodic and non-ergodic phases, yet the nature—and even the existence—of these transitions remains intensely debated. Using a two-dimensional array of superconducting qubits, we study an interacting spin model at finite temperature in a disordered landscape, tracking dynamics both in real space and in Hilbert space. Over a broad disorder range, we observe an intermediate non-ergodic regime with glass-like characteristics: physical observables become broadly distributed and some, but not all, degrees of freedom are effectively frozen. The Hilbert-space return probability shows slow power-law decay, consistent with finite-temperature quantum glassiness. In the same regime, we detect the onset of a finite Edwards-Anderson order parameter and the disappearance of spin diffusion. By contrast, at lower disorder, spin transport persists with a nonzero diffusion coefficient. We furthermore track wavefunction statistics across the critical point, showing an evolution from the Porter-Thomas distribution in the ergodic phase to power-law scaling in the glassy phase that holds over remarkably wide range of wave function values. Our results show that there is a transition out of the ergodic phase in two-dimensional systems that does not coincide with the full localization transition.