Matthew P. A. Fisher "Monitored" Quantum Systems

When a quantum system is coupled to a dissipative environment an initially pure state becomes rapidly mixed as information is lost, and classical behavior invariably follows. Recently, another type of open system dynamics has been explored, when a quantum system is continuously "monitored" by an observer, making a sequence of measurements, and a pure quantum state remains pure. Importantly, the repeated measurements do not simply read out a preexisting unitary dynamics: they yield a new dynamics, which is kind of a random walk thru Hilbert space. The resulting quantum trajectories constitute an ensemble of pure states, which can (in principle) be experimentally accessed in digital quantum simulators. In the many-body context, these quantum trajectories can have a rich entanglement structure, exhibiting - for example - dynamical phase transitions between volume law and area law entanglement, and between phases with or without symmetry breaking and/or topological order. Quantum circuits of qubits provide a setting to theoretically explore such many-body non-equilibrium phenomena, the simplest being a structureless circuit with random two-qubit unitaries and randomly interspersed single qubit measurements (see Figure 1), but additional structure can be readily included thereby allowing symmetry enriched monitored dynamics. For mixed initial density matrices, monitoring can lead to a plethora of purification transitions, and reveals underlying connections with quantum encoding. Accessing such physics in the lab is challenged by the need for post-selection, which might be circumnavigated by decoding using active error correction.

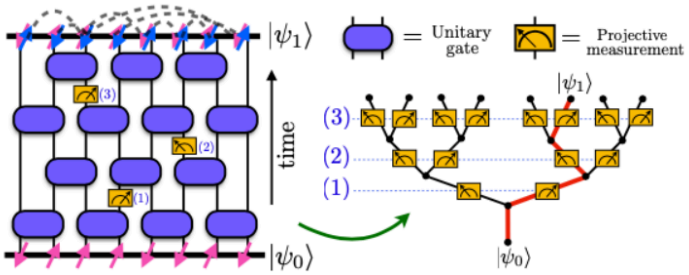

Figure 1: A spacetime diagram for a "monitored" quantum circuit, consisting of a brickwork structure of two-site unitary gates interspersed with local projective measurements. A pure-state trajectory corresponding to a particular sequence of measurement outcomes is shown, though the inherently probabilistic nature of the measurement outcomes could yield other trajectories.