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Topological order and error correction on fractal geometries: fractal surface codes

In this talk, I will focus on topological order, quantum codes, and error correction on fractal geometries. Firstly, I will present a no-go theorem that Z_N topological order cannot survive on any fractal embedded in two spatial dimensions and then show that for fractal lattice models embedded in 3D or higher spatial dimensions, Z_N topological order survives if the boundaries on the holes condense only loop or membrane excitations. Next, I will discuss fault-tolerant logical gates in the Z_2 version of these fractal models, which we name fractal surface codes, using their connection to global and higher-form topological symmetries. In the second half of the talk, I will discuss the performance of such fractal surface codes as fault-tolerant quantum memories. I will discuss decoding strategies with provably non-zero thresholds for bit-flip and phase-flip errors in the fractal surface codes with Hausdorff dimension 2+\epsilon. In particular, I will describe the adaptation of the sweep decoder to fractal lattices which maintain its self-correcting and single-shot nature, and state the code performance of a particular fractal surface code with Hausdorff dimension 2.966. I will summarize with ongoing directions.