COMPLEXITY OF ITERATED QUANTUM PROTOCOLS

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Iteration of a post-selective quantum operation acting on quantum systems in an identical state is ubiquitous in quantum entanglement distillation, where the quantum system consists of qubit pairs or more qubits. The same type of iterated dynamics applied to single qubit systems can lead to nonlinear, chaotic dynamics. One can construct an operation corresponding to each quadratic (in general, nth-order) rational complex function. For example, the Mandelbrot set can be directly realized in this way. The emerging time-evolution can be exponentially sensitive to the initial pure quantum state for single qubit systems as well as for qubit pairs. The above considerations assumed a perfect, pure initial quantum state. In a realistic situation, the initial state will be affected by noise and, in general, it will be a mixed state. Our analysis of the dynamics related to a specific circuit shows that the fractals dividing the different convergence regions will be present for moderate initial noise, up to a critical purity. Similar behavior occurs for the same protocols for higher-order dynamics. We note that two steps of the iterated protocol leading to ergodic dynamics have been experimentally realized in a photonic arrangement.

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