Purifying arbitrarily noisy quantum states

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Quantum state purification is the task of recovering a nearly pure copy of an unknown pure quantum state using multiple noisy copies of the state. We derive an efficient purification procedure based on the swap test for qudits of any dimension, starting with any initial error parameter. For constant initial error parameter and dimension, our procedure has sample complexity asymptotically optimal in the final error parameter, and almost matches the known optimal protocol for qubits. Our protocol has a simple recursive structure that can be applied when the states are provided one at a time in a streaming fashion, requiring only a small quantum memory to implement. Joint work with Andrew Childs, Honghao Fu, Zhi Li, Maris Ozols, Vedang Vyas.