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## Experimental quantum channel discrimination using metastable states of a trapped ion

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One of the hallmarks of quantum mechanics is the impossibility of perfectly distinguishing non-orthogonal states. Extending this to the task of discriminating among quantum channels (such as unitary evolution or projective measurements) reveals a far richer problem, where seemingly non-orthogonal channels can sometimes be distinguished with certainty with only a few queries of the channel. Using quantum signal processing-based algorithms, we present experimental demonstrations of accurate and unambiguous single-shot discrimination between three quantum channels using a single trapped  $^{40}\text{Ca}^+$  ion. The three channels cannot be distinguished unambiguously using repeated single-use queries, the natural classical analogue, but coherently interleaving the channel queries with quantum signal processing operations enables us to fashion targeted response functions to extract information about the channel. We develop techniques for using the 6-dimensional  $D_{5/2}$  state space for this quantum information processing task, implementing protocols to discriminate among the quantum channel analogues of two data encodings commonly used in classical radio communication. These demonstrations achieve discrimination accuracy exceeding 99%, with inaccuracy entirely attributable to known experimental imperfections.

**Primary authors:** DEBRY, Kyle (MIT/MIT Lincoln Laboratory); SINANAN-SINGH, Jasmine (Massachusetts Institute of Technology); Dr BRUZEWICZ, Colin D. (MIT Lincoln Laboratory); Dr REENS, David (MIT Lincoln Laboratory); Dr KIM, May E. (MIT Lincoln Laboratory); ROYCHOWDHURY, Matthew P. (MIT Lincoln Laboratory); Dr MCCONNELL, Robert (MIT Lincoln Laboratory); Prof. CHUANG, Isaac L. (Massachusetts Institute of Technology); Dr CHIAVERINI, John (MIT Lincoln Laboratory)

**Presenter:** DEBRY, Kyle (MIT/MIT Lincoln Laboratory)

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