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Quantum metrology at the 19th decimal place¹

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The tools of trapped-ion quantum logic can be used to enable and enhance precision measurements, with applications in time and frequency metrology and the search for physics beyond the standard model. In this talk, I will describe optical atomic clocks based on Al^+ which operate at this fertile intersection of fields. These clocks use quantum-logic gates with a co-trapped second ion species for preparation and readout of the Al^+ state, and offer the tantalizing prospect of Heisenberg-limited measurements with entangled ions. Recent progress, including an improved ion trap design and sympathetic laser cooling to the 3D ground state, has enabled total fractional systematic uncertainty below 10^{-18} . We have performed frequency ratio measurements between Al^+ , Sr, and Yb clocks with uncertainty below 10^{-17} , which can be used to place constraints on possible temporal variations of fundamental constants and models of ultralight dark matter.

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