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From Quantum Computers to Optical Clocks

In recent years tremendous progress has been made in the coherent manipulation of trapped ions with laser light. Although these methods have been developed for quantum computing, the first applications emerged in the field of precision measurements. The so-called "quantum logic spectroscopy" allows the investigation of atoms lacking a suitable transition for laser cooling and detection. Using this method, one of the most accurate clocks based on a single aluminium ion could be demonstrated recently. For this, a logic ion is trapped together with the aluminium clock ion in the same potential well of a Paul trap. Using laser pulses and the strong coupling between the two ions, the internal state information after spectroscopy of the clock transition is transferred from the aluminium to the logic ion, where it can be detected with high efficiency. In my talk, I will present the quantum logic spectroscopy technique used in the aluminium clock, starting from the methods developed for quantum information processing. Furthermore, I will discuss extensions of this technique that open many applications, ranging from spectroscopy of ions with a complex level structure to ground state cooling of the internal degrees of freedom in molecules. The proposed experiments represent not only an important step towards the development of optical clocks with unprecedented accuracy and stability, but will also allow improved tests for a variation of fundamental constants.

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