Quantum Logic Spectroscopy of trapped Ions

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Precision spectroscopy is a driving force for the development of our physical understanding. However, only few atomic and molecular systems of interest have been accessible for precision spectroscopy in the past, since they miss a suitable transition for laser cooling and internal state detection. This restriction can be overcome in trapped ions through quantum logic spectroscopy. Coherent laser manipulation originally developed in the context of quantum information processing with trapped ions allow the combination of the special spectroscopic properties of one ion species (spectroscopy ion) with the excellent control over another species (logic or cooling ion). In my talk I will show that quantum logic spectroscopy enables the development of accurate optical clocks based on aluminium and highly-charged ions as well as precision spectroscopy of broad and non-closed transitions in calcium isotopes. Finally, I present non-destructive internal state detection and spectroscopy of molecular ions using quantum logic. This represents a first step towards extending the exquisite control achieved over selected atomic species to much more complex molecular ions. Applications of quantum logic spectroscopy ranging from the measurement of atomic, molecular and nuclear properties over optical clocks for relativistic geodesy to the search for a variation of fundamental constants will be discussed.