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State-preparation and quantum control of polyatomic molecular ions

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Trapped molecular systems are excellent tools for precise quantum control, offering a wide range of applications in quantum computing, precision spectroscopy, tests of fundamental physics and state-to-state chemistry [1,2]. However, these systems have complex internal energy-level structures and in addition, they lack readily accessible closed cycling transitions which makes their state preparation, laser cooling, quantum control and coherent manipulation difficult.
Currently, in our lab, we utilize quantum logic spectroscopy to co-trap molecular ions such as N_2^+ with atomic ions such as Ca^+ ions in an RF ion trap [1,2]. N_2^+ is prepared in its ground rovibrational state, sympathetically cooled using Doppler cooled Ca^+ atomic ions and non-destructively state detected using quantum logic spectroscopy [3].
Quantum-logic schemes have proved to be useful for the cooling, for the non-destructive detection of the quantum states and for the coherent manipulation of diatomic molecular ions which was otherwise challenging [1,4,5]. Our goal is to work towards the quantum control of complex polyatomic molecular systems and further understand their chemistry, spectroscopy and collision dynamics.

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