7th European Conference on Trapped Ions

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Advances in state-preparation, cooling and state detection of N2+ molecular ions

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Manipulation of single trapped molecules on the quantum level has gained notable interest in recent years. Their complex energy-level structure with rotational and vibrational degrees of freedom provides a plethora of transitions with various properties but also presents challenges toward molecular state initialisation, manipulation and readout. Building on the methods known for trapped atomic species, for the state readout, we follow a quantum-logic protocol that uses a single co-trapped atomic ion as a probe for the molecular state [1]. We implemented EIT cooling of an atomic-molecular two-ion string to investigate how the state-readout fidelities are affected by the populations of different motional modes of the two-ion crystal. We are also implementing precision-spectroscopic measurements on a narrow infrared quadrupole transition of the nitrogen molecular ion N_2^+ referenced to the Swiss primary frequency standard at METAS in Berne via an optical fibre link. The present method paves the way for the implementation of molecular qubits with excellent coherence properties, for establishing new frequency standards in the mid-IR regime, for investigating state-to-state dynamics of chemical reactions, and for exploring beyond-standard-model physics by tracking a possible temporal variation of fundamental constants.

[1] M. Sinhal, Z. Meir, K. Najafian, G. Hegi, S. Willitsch, Science., 2020, 367, 1213–1218.

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