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Precision infrared molecular spectroscopy as an instrument for probing variations of fundamental constants

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Precision spectroscopy of dipole-forbidden rovibrational infrared transitions in molecular ions could serve as a probe for detecting possible temporal variation of fundamental constants and testing fundamental theories [1]. However, until recently, it was impossible to achieve the required precision due to the lack of control over the molecular ions on a single quantum level. We developed new methods which allow us to prepare a single molecular ion in its rovibrational ground state [2], detect its quantum state with high-fidelity [3] and perform highly sensitive and precise spectroscopic experiments on dipole-forbidden infrared transitions in N_2^+ [4] driven by a quantum cascade laser [5]. The absolute frequency stability of the measurements is provided by referencing all laser frequencies to the Swiss primary frequency standard, the Cs atomic fountain clock FoCS-2, operated by the Swiss Federal Institute of Metrology METAS in Bern [6]. These will allow us to reach an absolute measurement precision level of 10^{-15}, establishing new state-of-the-art infrared spectroscopy of the molecular ions and approaching the boundary where BSM physics could be detected.

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