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Towards high-resolution spectroscopy of N_2^+

High resolution spectroscopy of molecular nitrogen ions is a prime candidate to measure potential temporal changes in the proton-to-electron mass ratio, μ [1].
Ion traps facilitate a high degree of localisation in a highly isolated and stable environment. In addition, the shared motional modes of ions co-trapped in the same potential enable techniques such as sympathetic cooling [2] and quantum logic spectroscopy [3]. These techniques allow cooling and read-out of the internal state of a molecular ion, provided a suitable auxiliary ion can be found.
In this experiment, a single $^{14}N_2^+$ ion will be co-trapped, in a linear Paul trap, with a $^{40}Ca^+$ ion which will act as a frequency reference and be used for the sympathetic cooling and state detection of the nitrogen ion. A vibrational Raman transition in the electronic ground state of $^{14}N_2^+$ will be compared to a quadrupole transition in the $^{40}Ca^+$ ion. After excitation, the state of the $^{14}N_2^+$ ion will be transferred to the $^{40}Ca^+$ ion via the shared motion of the ions in a quantum logic spectroscopy scheme.
Prerequisite to this are the preparation of $^{14}N_2^+$ into a specific rovibronic state and its non-destructive state detection. Recently, a 2+1'resonance-enhanced multiphoton ionisation (REMPI) scheme was developed, using the $a^1\Sigma_g(v=6) \leftarrow X^1\Sigma_g^+(v=0)$ band in $^{14}N_2$ for the resonant excitation. This scheme was demonstrated to prepare $^{14}N_2^+$ in the rovibronic ground state with high purity [4].

References

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