

# Towards Quantum Information Processing with Cold Molecular Ions

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Trapped atomic ions constitute one of the most advanced and promising physical systems to implement Quantum Information Processing and Computation (QIPC) protocols due to the exquisite experimental control, low decoherence rates, and the precise theoretical understanding of the physics involved [1]. Due to the recent progress in cooling and trapping molecular ions [2], it seems interesting to extend these tools to study molecular ions, both because of their intrinsic interest as systems with a complex internal structure, and because they have been proposed as appropriate systems to analyze a number of fundamental physical questions, such as the time variation of fundamental constants, or high-precision spectroscopy of simple molecular ions to test with theoretical calculations [3]. In this context, we have recently developed a new spectroscopic protocol suitable to study electronic, vibrational, rotational, and Zeeman transitions in complex ions [4]. In this reference, we present the specific experimental requirements for a system composed of  $^{40}\text{Ca}^+$  and  $^{14}\text{N}_2^+$  ions, based on calculations of the Zeeman structure of  $^{14}\text{N}_2^+$  ions.

We have extended these calculations for the case of  $^{16}\text{O}_2^+$  ions. The nucleus  $^{16}\text{O}$  is a doubly magic nucleus and, as such, has zero spin. As a consequence, the Zeeman structure of  $^{16}\text{O}_2^+$  molecular ions is considerably simplified as compared to the  $^{14}\text{N}_2^+$  case. This has allowed us to identify a pair of levels in the ground rovibronic state that look promising for QIPC purposes. In this presentation, I will present our calculations on the energy spectrum under a magnetic field for nitrogen and oxygen molecular ions, and discuss the actual prospects of using them for quantum information processing and quantum computation.

## References:

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