Towards a Molecular Ion Qubit

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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]. Recent progress in cooling and trapping molecular ions [2], has lead to a increasing interest in these systems, 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 proposed [4] a novel spectroscopic protocol based on novel quantum logic phase gates to characterize the electronic, vibrational, rotational, and even Zeeman structure of these systems. As relevant examples, we have calculated the performance of these gates on $^{14}N_2^+$ and $^{16}O_2^+$ molecular ions in the presence of magnetic fields. I will discuss how, from these calculations, two Zeeman states of $^{16}O_2^+$ appear as very interesting candidates to implement a quantum bit due to their remarkable decoherence properties [5].

References

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[3] See e.g. S. Schiller and V. Korobov, Phys. Rev. A **71** (2005) 032505; J. C. J. Koelemeij et al., Phys. Rev. Lett. **98** (2007) 173002; L. Hilico et al., Eur. Phys. J. D **12** (2000) 449.
[4] J. Mur-Petit, J. Pérez-Ríos, J. Campos-Martínez, M. I. Hernández, S. Willitsch, J. J. García-Ripoll, arXiv:1106.3320 (2011).
[5] J. Mur-Petit, J. Pérez-Ríos, J. Campos-Martínez, M. I. Hernández, J. J. García-Ripoll, in preparation.

Figures

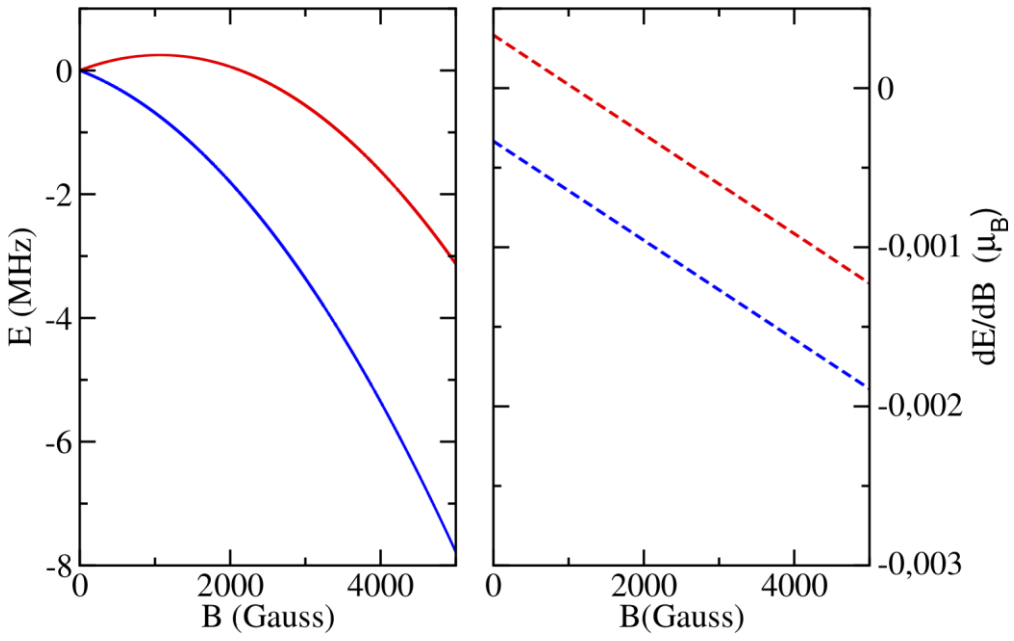

Figure: (a) Energy spectrum and (b) magnetic moment of $^{16}O_2^+$ as a function of applied magnetic field.