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Quantum logic for molecular quantum information processing J. MUR-PETIT, J. PEREZ-RIOS, J. CAMPOS-MARTINEZ, M.I. HERNANDEZ, Instituto de Fisica Fundamental, IFF-CSIC, Spain, S. WILLITSCH, Department of Chemistry, University of Basel, Switzerland, J.J. GARCIA-RIPOLL, Instituto de Fisica Fundamental, IFF-CSIC, Spain — Very recently, molecular ions have been trapped and cooled to the mK regime in well defined internal states [1] opening a new window for precision spectroscopy of molecular species and quantum information with cold molecular ions. A first requirement for both applications is the ability to control and measure the state of molecular ions. I will present our proposal [2] of a fast, non-destructive and temperature independent spectroscopy method suitable to study electronic, vibrational, rotational and Zeeman transitions in complex ions that implements quantum logic schemes [3] between an atomic ion and the molecular ion of interest, using optical forces on the atom, and optical forces or magnetic field gradients on the molecule. This method sets a starting point for a hybrid quantum computation scheme with molecular and atomic ions, covering the measurement and entangling steps. Finally I will discuss the remarkable decoherence properties of two Zeeman states of the $^{16}O_2^+$ molecular ion that make it a promising system for QIPC purposes [4].

[1] X. Tong *et al.*, Phys. Rev. Lett. **105**, 143001 (2010).
[2] J. Mur-Petit *et al.*, arXiv:1106.3320
[3] P. O. Schmidt *et al.*, Science **309**, 749 (2005).
[4] J. Mur-Petit *et al.*, in preparation.

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