Spécialité de Master « Optique, Matière, Plasmas »

Stage de recherche (4 mois minimum, à partir de début mars 2012)

Proposition de stage pour l'année 2011-2012 (ne pas dépasser 1 page)

Date de la proposition : 7 November 2011

Responsable du stage / *internship supervisor*:

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Nom du Laboratoire / *laboratory name*: **Laboratoire Matériaux et Phénomènes Quantiques**

Code d'identification : **UMR 7162** Organisme : **Université Paris Diderot and CNRS**

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Lieu du stage / *internship place*:

Titre du stage / *internship title*: **Numerical simulation of protected qubits**

Résumé / *summary*

Due to the fragility of quantum bits, quantum error correcting codes are deemed a crucial tool for the implementation of quantum algorithms [1]. Soon after their discovery, it was shown that some errors can be self–corrected by assigning them an energetic penalty. This is based on the encoding of a single logical qubit in the degenerate ground state of a composite system whose excited states are separated by a finite energy gap from the ground state subspace [2]. Following the pioneering proposal by Kitaev [3], it has been shown that when this scheme is implemented using specific Hamiltonians with collective symmetries, it can reduce exponentially the influence of decoherence on logical qubits and quantum gates [4]. There has thus been a growing interest for such systems which could be a promising avenue for quantum calculations.

In order to use such logical qubits to perform calculations, one must in particular be able to manipulate them, *i.e.* to perform arbitrary single and two qubits rotations. However, for a protected qubit, there is an apparent conflict between the protection and the ability to manipulate it. Studying the properties of the perturbation theory expansion with respect to the symmetries, we have shown to overcome these difficulties using time varying Hamiltonians [5]. We have shown that using simple magnetic fields, one can make arbitrary, deterministic rotation of the logical qubit around two orthogonal axes, allowing for any arbitrary rotation in a noise resistant manner.

The first goal of the project is to test numerically these predictions, in particular in the case of large systems (*e.g.* 4x4 arrays…). The second goal of the project is to study controlled manipulation of two logical qubits.

[1] P.W. Shor, Phys. Rev. A 52, 2493 (1995); A.M. Steane, Phys. Rev. Lett. 77, 793 (1996).
[2] D. Bacon et al., Phys. Rev. Lett. 87, 247902 (2001); S.P. Jordan et al., Phys. Rev. A 74, 052322 (2006); Y.S. Weinstein and C.S. Hellberg, Phys. Rev. Lett. 98, 110501 (2007)
[3] A. Kitaev, Ann. Phys. 303, 2 (2003), quant-ph/9707021.
[4] E. Denis et al., J. Math. Phys 43, 4452–4505 (2002);L. B. Ioffe et al., Nature 415, 503 (2002); B. Douçot et al. Phys. Rev. B 71, 024505 (2005); D. Bacon, Phys. Rev. A 73, 012340 (2006); P. Milman et al., Phys. Rev. Lett. 99, 020503 (2007).
[5] T. Coudreau et al., Phys. Rev. Lett. 107, 030502 (2011)

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : To be discussed**

Si oui, financement de thèse envisagé/ *financial support for the PhD*:

Lasers et matière	X	Lumière, Matière : Mesures Extrêmes	X
Optique de la science à la technologie	X	Plasmas : de l'espace au laboratoire	

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