Spécialité de Master « Optique, Matière, Paris »

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

Proposition de stage (ne pas dépasser 1 page)

Date de la proposition : 02/10/2018

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Titre du stage : Coherent processes in metastable helium and defects in diamond: applications to quantum optics

Simple two level systems can model many light-matter interaction phenomena. But three level systems are necessary to study some effects when the existence of two optical transitions gives rise to coherent processes, that makes it possible to transfer states from light to atoms (and vice-versa). In the so-called Λ-system (when two optical transitions share the same excited state), an initially opaque medium for a weak probe, which couples one of the transitions becomes transparent when the other transition is excited with a stronger coupling laser beam: this is the electromagnetically induced transparency (EIT) phenomenon. The dispersive properties associated with EIT allow a control of the light group velocity, and to go from a slow light regime to a fast light regime and even to negative group velocities. It is also extensively used to perform light storage experiments.

Alkali atoms are usually used for this kind of experiments, but metastable helium has the advantage of being free from any hyperfine levels. Using this simple atomic structure we could isolate some years ago, without any doubt, a three-level Coherent Population Oscillation (CPO) resonance [1], which is a very different phenomenon from EIT. We could then demonstrate both experimentally and theoretically that it can be used to store and retrieve light in a Λ-system [2,3]. Recent experiments also confirmed that non-classical squeezed states of light can be generated with such a helium cell [4], and one objective is to study these states and their possible storage via the EIT or CPO phenomena. We also plan to study the same phenomena in SiV and GeV colored centers in diamond: preliminary experiments have begun on this subject.

The trainee will be associated with the ongoing experimental and theoretical work, depending on his/her own interests. But more specifically, he/she will be part of either experiments starting on colored centers in diamond, or on a new project about spin noise spectroscopy [5], in collaboration with researchers from the Raman Research Institute of Bangalore. The fluctuations of N spins generate fluctuations of the order of $N^{1/2}$, that can be optically detected through Faraday rotation of a linearly polarized light: the noise spectrum exhibits a resonance, the characteristics of which depend on the physical parameters of the system. We have already seen these resonances that should now be studied experimentally and theoretically.

This research work is part of strong collaborations in India (R. Ghosh, Shiv Nadar University and S. Chaudhuri, Raman Research Institute) and in Brazil (J. Tabosa, University of Pernambuco)

[1] T. Laupretre, S. Kumar, P. Berger, R. Faoro, R. Ghosh, F. Bretenaker and F. Goldfarb, Phys. Rev. A **85**, 051805(R) (2012)
[2] M.-A. Maynard, F. Bretenaker and F. Goldfarb, Phys. Rev. A **90**, 061801(R) (2014)
[3] Neveu P., Maynard M.-A., Bouchez R., Lugani J., Ghosh R., Bretenaker F., Goldfarb F., and Brion E., Phys. Rev. Lett., **118**, 073605 (2017)
[4] Neveu P., Banerjee C. Lugani J., Bretenaker F., Brion E. and Goldfarb F.., New J. Phys., **20**, 083043 (2018)
[5] N. A. Sinitsyn, Y. V. Pershin, Reports on Progress in Physics **79**, 106501 (2016)

Toutes les rubriques ci-dessous doivent obligatoirement être remplies

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

Si oui, financement de thèse envisagé/ *financial support for the PhD***:** Contrat doctoral par concours ED

Lumière, Matière, Interactions	**X**	Lasers, Optique, Matière	**X**

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