Invited talk for the PMQ29 mini-colloque

Spin-mechanics with trapped diamonds

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Observing and controlling macroscopic quantum systems has long been a driving force in research on quantum physics. To this end, many groups are investigating platforms for coupling the motion of levitating particles to the spin of individual atoms at the quantum level. The angular degrees of freedom of levitating diamonds coupled to embedded Nitrogen-Vacancy (NV) centers offer bright prospects towards this purpose [1]. I will present our experimental progress in this direction.

First, I will present our results on coherent manipulations of the spin of NV centers [2] and of the spin-dependent torque and spin-cooling of the angular motion of diamonds levitating in a Paul trap [3]. I will then discuss our recent efforts towards using dipolar interactions between NV centers to control the angular motion of diamonds [4] as well as our observations of spin-diamagnetism mediated by NV centers under magnetic field above a level crossing at ≈ 0.1T (see Figure 1). I will show how the negative magnetic susceptibility enables microwave-free magneto-optical alignment of the diamond main axes along the magnetic field [5], offering prospects towards spin-levitation and angular control of diamonds under liquid environments.

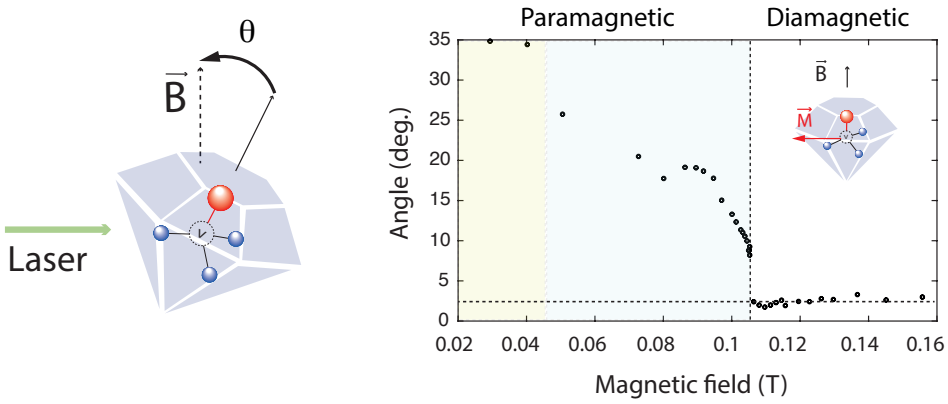

FIG. 1: Left : Magnetic torque on a levitating diamond using optically polarized NV centers. Right : Angle of one of the diamond [111] axis versus magnetic field amplitude.

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[1] M. Perdriat, C. Pellet-Mary, P. Huillery, L. Rondin, and G. Hétet, Micromachines **12** (2021).
[2] T. Delord, P. Huillery, L. Schwab, L. Nicolas, L. Lecordier, and G. Hétet, Phys. Rev. Lett. **121**, 053602 (2018).
[3] T. Delord, P. Huillery, L. Nicolas, and G. Hétet, Nature **580**, 56 (2020).
[4] C. Pellet-Mary, P. Huillery, M. Perdriat, and G. Hétet, arXiv e-prints arXiv:2103.00836 (2021), 2103.00836.
[5] M. Perdriat, P. Huillery, C. Pellet-Mary, and G. Hétet, arXiv e-prints arXiv:2102.13637 (2021), 2102.13637.