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Paris, 27th of March 2019,

*Submission of our manuscript :* « Rotating a Diamond Crystal using Interacting Spin Ensembles».

Dear editors,

Please find enclosed the abstract of our manuscript entitled « Rotating a Diamond Crystal using Interacting Spin Ensembles »  which we submit for consideration in Physical Review Letters. In brief, we succeeded in *using the magnetic dipole-dipole interactions amongst individual spins Nitrogen-Vacancy centers to rotate a diamond crystal.*

Our work could be considered to be of bottom-up approach for the study of magnetic forces. The detailed microscopic origin of magnetism in many materials depend crucially on the relaxation mechanism of the spins. In typical material it is not controlled because of the lack of efficient tuning knobs and because of the very short damping, making a complete determination of the Gilbert-damping coefficients and dipolar interactions a complicated task. In this work we control both the interaction and the relaxation on a paramagnetic material (the doped-diamond).

The exquisite sensitivity of the spin-torque read-out that we employ also enables high precision read-out of dipolar interactions. Our work may thus open a path towards using NV centers to probe microscopic effects in magnetism.

In addition, our findings will find direct implications in the field of spin-mechanics at the quantum level.

There are many predictions in matter-wave interferometric schemes with large objects, gravitationally induced decoherence and mechanical sensing of very minute forces of genuinely quantum nature that could be studies using levitating objects. Recent theory and experiments show that interactions between the optical dipoles NV centers enhances optical binding forces. The interaction between the electronic spins of distant NV centers may also show similar spin-mechanical scaling which important implications for the afore-listed applications of spin-mechanical platforms.

As an example, we predict a new cooling methods which will enable micro-wave free reduction of the temperature, a potentially important ingredient as one approaches the motional ground state.

This wealth of applications implies high impact in many fields of physics, so we are very enthusiastic about the idea of presenting our results to Physical Review Letters and believe that the manuscript meets the requirements for publication.

Thank you very much for your efforts on our behalf.

Best regards,

Gabriel Hétet, on behalf of the authors.