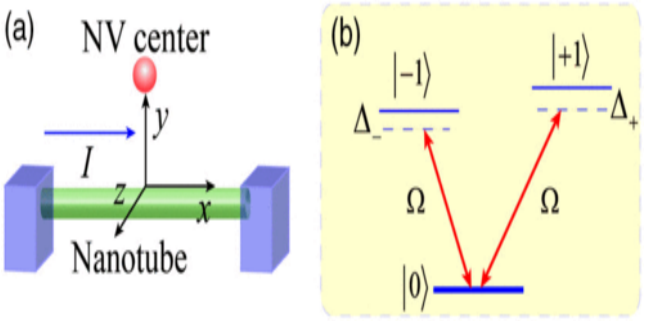
Hybrid Quantum Device with Nitrogen-Vacancy Centers in Diamond Coupled to Carbon Nanotubes

Objective

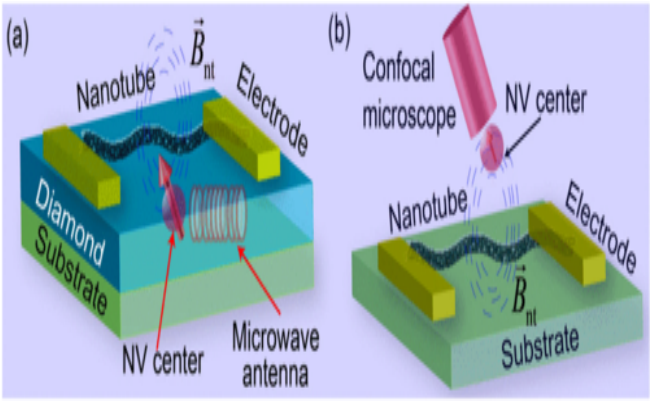
To study hybrid quantum devices with Nitrogen-Vacancy centers in diamond coupled to carbon nanotubes

Summary of Research Activities

- We showed that nitrogen-vacancy (NV) centers in diamond with a suspended carbon nanotube carrying a dc current can facilitate a spin-nano-mechanical hybrid device.
- We demonstrate that strong magneto-mechanical interactions between a single NV spin and the vibrational mode of the suspended nanotube can be engineered and dynamically tuned by external control over the system parameters.
- This spin-nanomechanical setup with strong, *intrinsic*, and *tunable* magneto-mechanical couplings allows for the construction of hybrid quantum devices with NV centers and carbon-based nanostructures, as well as phonon-mediated quantum information processing with spin qubits.
- This hybrid structure takes advantage of the unprecedented mechanical and electrical characteristics of carbon nanotubes, as well as the exceptional coherence properties of NV centers in diamond.
- We demonstrated that the physics of an NV center in diamond placed near a carbon nanotube with a dc current flowing through it can be well mapped to cavity quantum electrodynamics (QED).



(a) Schematic of a single NV center in a diamond nanocrystal located near a current-carrying nanotube. (b) Level diagram of the driven NV center.



Schematic of the nanotube-NV hybrid setup. (a) A current-carrying nanotube is suspended above a diamond sample, in which individual optically resolvable NV centers are implanted 5–10 nm below its surface. (b) A single NV defect hosted in a diamond nanocrystal with a size about 10 nm is positioned near the nanotube.

Publications

P.B. Li, Z.L. Xiang, P. Rabl, F. Nori, *Hybrid Quantum Device with Nitrogen-Vacancy Centers in Diamond Coupled to Carbon Nanotubes,* Phys. Rev. Lett. **117**, 015502 (2016).