

# Coupling a single spin to the motion of a carbon nanotube

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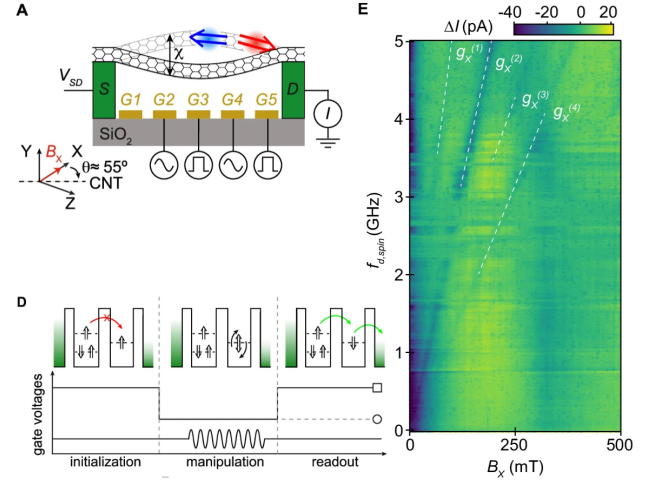
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The ability to couple a solitary spin to high-frequency motion is a crucial advancement for a range of applications, including quantum sensing, intermediate and long-distance spin-spin coupling, and quantum information processing. Although proposed theoretically over a decade ago, experimental demonstrations have remained elusive. Here [1] we report the observation of spin-mechanical coupling in a carbon nanotube device. We demonstrate this coupling in two configurations: off-resonant, with spin and mechanics excited by separate tones, and resonant, driven by a single tone. The coupling manifests as a shift and broadening of the electric dipole spin resonance (EDSR), respectively. Our theoretical model, which accounts for the tensor character of the coupling and mechanical non-linearity, reproduces the data with very good agreement. Our results demonstrate a previously unobserved spin-mechanical coupling, offering versatile tools for exploring macroscopic quantum phenomena, quantum thermodynamics, and quantum simulation.

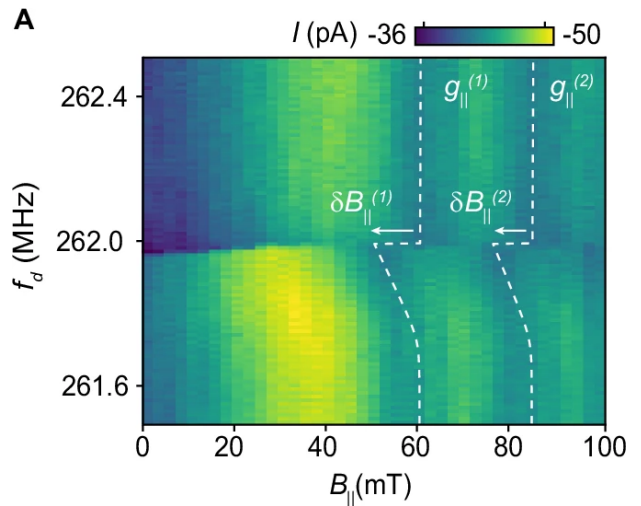
## References

- [1] Fedele, F., Cerisola, *et al.* "Coupling a single spin to the motion of a carbon nanotube". *Nature Communications* **16**, 11454 (2025). [doi.org/10.1038/s41467-025-66331-5](https://doi.org/10.1038/s41467-025-66331-5)

## Figures



**Figure 1:** The CNT is suspended between source and drain contacts, and over five gate electrodes. A DQD confined along the CNT (red and blue arrows) allows us to define a qubit and enables readout via Pauli spin blockade. Panel E shows  $\Delta I$  as a function of drive frequency and magnetic field, showing the EDSR resonances.



**Figure 2:** Measured EDSR signal as a function of the applied parallel field  $B_{||}$  and drive frequency  $f_d$ . At  $f_d$  slightly below  $f_m = 261.9$  MHz, which coincides with the CNT mechanical frequency, the resonances shift significantly towards lower values of  $B_{||}$ . This shows how turning on the mechanical motion affects the two-level system resonant frequency.