INSTITUT DE PHYSIQUE ET CHIMIE DES MATERIAUX DE STRASBOURG
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Séminaire AXE 1 - Sciences et Matériaux Quantiques

Mardi 05 Mai 2026 | ~~11:00~~ 14:00 | Auditorium de l'IPCMS

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Probing Landau–Zener transitions of a single Ho atom qudit with spin-polarized STM

Nuclear spins are promising candidates for quantum bits owing to their long lifetimes and robustness against environmental noise [1-3]. However, reliable initialization and readout of individual nuclear spins in solid-state systems remain challenging [2,3]. Using spin-polarized scanning tunnelling microscope, we demonstrate all-electrical initialization, single-shot readout and long-lived storage of the nuclear spin state of a single Ho atom on MgO. Strong hyperfine coupling between the electron and nuclear spins enables high-fidelity state preparation (> 95% polarization) at 50 mK and allows nuclear spin populations to be detected through Landau–Zener transitions at avoided crossings of the electronic spin states [4]. We resolve an unprecedented avoided-crossing gap of 10 peV—the smallest ever measured for spins on surfaces—and observe nuclear spin polarization exceeding 90 % at 50 mK. Using a pump–probe protocol based on double magnetic-field sweeps across an avoided level crossing, we extract a nuclear spin relaxation time (T1) of approximately 60 s for Ho on 2 ML MgO, increasing to several minutes on 3 ML MgO. These results establish controllable and long-lived nuclear spin states at the single-atom limit and provide a pathway toward atomically engineered nuclear-spin qudits.

References

[1] R. Vincent et al., Nature **488**, 357–360 (2012)
[2] J. P. Jarryd et al., Nature **496**, 334–338 (2013)
[3] E. W. Stolte et al., Nat. Commun. **16**, 7785 (2025)
[4] P. R. Forrester et al., Phys. Rev. B **100**, 180405(R) (2019)

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