Master 2
INTERNSHIP PROPOSAL
2022-2023

Laboratory name: LKB – Laboratoire Kastler Brossel
CNRS identification code: UMR 8552
Internship director'surname: Tastevin G. / Nacher P.-J.
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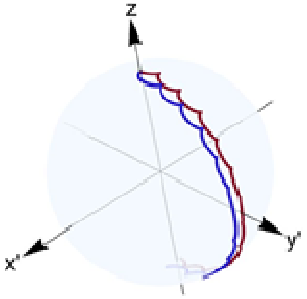
Internship location: ENS Physics Department, 24 rue Lhomond, 75005 Paris
Thesis possibility after internship: YES Funding: NO

Study of Rabi oscillations using optically detected NMR in polarised helium gas

Context: Pulses of resonant ac fields are generically used to control the internal state of 2-level systems. In magnetic resonance of spin-1/2 nuclei (NMR) elaborate sequences of rf pulses provide powerful tools for numerous applications in spectroscopy and imaging, for instance. Similar accurate manipulation of the internal state of various other 2-level quantum systems through controlled travel on the Bloch sphere is also needed, in particular for those which may be used as Qubits in the context of quantum technologies.

Travel on the Bloch sphere induced by a (near-) resonant pulse is a standard textbook item, but the presence of additional off-resonant or longitudinal oscillating field components, which are often unavoidable in practice, may deeply modify spin trajectories and therefore the spin response to complex trains of rf pulses.

NMR in low magnetic fields is a versatile test bench for a variety of behaviours of spin response to well-controlled pulsed excitation, as recently demonstrated in our group.[1] In particular, conditions for operating outside the range of validity of the well-known rotating wave approximation are easily met.



Internship project: Relying on the team's experience in (i) low-field NMR and (ii) optical pumping/probing of ^{3}He in gas discharges, studies of Rabi oscillations driven by rf pulses will be performed. These oscillations of the nuclear spin state of the atomic ground state will be monitored by optical polarimetry involving a suitable atomic excited state. Thanks to the strong hyperfine coupling and a fast spin exchange enforced by collisions, the optically measured longitudinal and transverse time-dependent orientations will accurately reflect the 3D travel of pre-polarised nuclear spins on the Bloch sphere during rf pulses.

Initial tests have shown the feasibility of such measurements. A new dedicated setup is being constructed. Different kinds of complex travel paths will be explored. Corresponding numerical simulations and theoretical studies will be performed.

[1] Bidinosti et al., J. Magn. Reson. 345 (2022) 107306, "Generating accurate tip angles for NMR outside the rotating-wave approximation" [arXiv:2209.03754]

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Quantum Physics: YES