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Parity Violation as a Tool to Perform Spectroscopy Inside Quantum Materials Using β-NMR

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Nuclear magnetic resonance exploits the delicate sensitivity of nuclear spin to characterise the local dynamics and structure of the surrounding chemical and magnetic environment inside materials. β-NMR is an extension of this technique, similar to muon spectroscopy, which relies on the detection of anisotropic beta emission produced by a polarised radioactive isotope such as ^{8}Li. This allows for the measurement of local magnetic susceptibility, electric field gradients, and ionic transport processes.

In the past, this technique was successfully deployed as a bulk probe of matter using the capture of polarised thermal neutrons at Grenoble [1]. More recently, low-energy spin-polarised beams have been prepared at TRIUMF, Canada, enabling depth profiling of thin films and surfaces at depths ranging from 1 to 100 nm [2,3]. The ability to study surfaces and buried interfaces makes low-energy β-NMR a local real-space probe that complements reciprocal space techniques like polarised neutron reflectometry, offering different sensitivity to low-moment magnetism and the inelastic regime of dynamics and fluctuations.

We present a specific example of β-NMR in antiferromagnetic epitaxial α-Fe_2O_3 [4] and and 2D antiferromagnet $FePS_3$. This study shows that the nuclear spin-lattice relaxation rate of the implanted ^{8}Li spin provides a sensitive measure of surface-localised spin dynamics and spin reorientation of the antiferromagnetic interface near the Morin transition. A variant of the technique using polarised neutron capture at ANSTO is also discussed.

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