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Coherent microwave control of muonium

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We demonstrate the most fundamental coherent control techniques by excitation of microwave spin transitions in muonium, namely driven Rabi oscillations and Ramsey fringes upon free evolution. Unprecedented performance is achieved by triggering microwave pulses by a single implanted muon, which enables coherent spin manipulation of individual muonium atoms.

As a first example, we suppress extrinsic line broadening with the Ramsey experiment on strongly coupled muonium in SiO_2 (Fig. 1). As a second example, we retrieve the electron g-factor of bond-centered muonium in Si using the double electron-muon resonance (DEMUR) technique and decouple the system from its environment by strong driving of the electron-muon double quantum transition.

Overall, we expect that this capability will provide a powerful tool to investigate the effect of the environment on isolated coupled spins, uncover the details of coupled electron-muon systems in matter and validate quantum electrodynamics in the context of (vacuum) muonium spectroscopy.

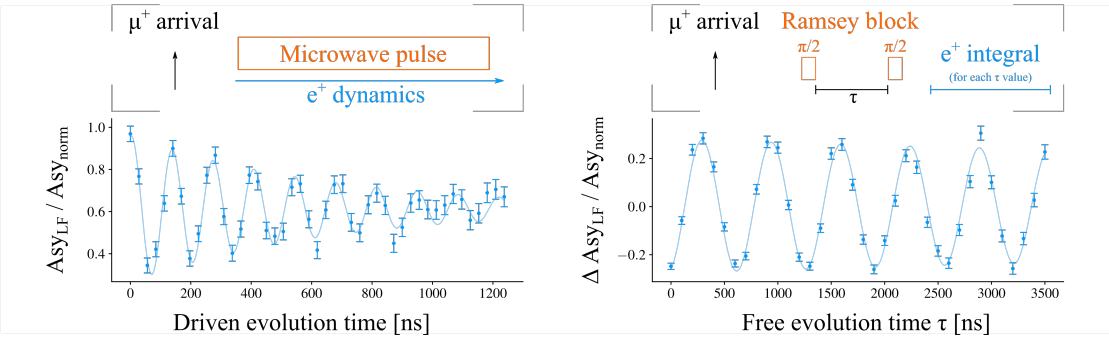

Figure 1: Microwave experiments with muonium formed in SiO_2 at 280 K, showing Rabi oscillations excited by 3.6 GHz microwaves (left) and phase-coherent Ramsey fringes excited by 30 ns pulses (right). The upper schemes depict the timing of the experiment.

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