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Rabi-oscillation spectroscopy : high precision time-domain analysis applied to muonium hyperfine resonance

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Muonium (Mu), an exotic atom composed of a positive muon and an electron (μ^+e^-), is a suitable probe for precise tests of bound-state QED as well as for searching for new physics beyond the Standard Model. MuSEUM collaboration at J-PARC has so far succeeded in measuring the ground-state hyperfine splitting (HFS) of the muonium atom under the zero magnetic field, and is now aiming at a precision of 2 ppb under strong magnetic fields to determine the magnetic moment and the mass of the muon.
We have developed a new spectroscopic technique named "Rabi-oscillation spectroscopy", in which the resonance frequency can be determined directly from the time evolution of the Rabi oscillation at a fixed frequency of the applied electromagnetic wave (i.e. microwave or laser). In contrast to standard spectroscopy, this new technique does not require any frequency scanning, any drawing of resonance curves nor any Fourier transform in the analysis.

Rabi-oscillation spectroscopy has not only found application to our HFS microwave resonance studies of muonium [1] and muonic helium (μ^-He) atoms, but it can also be applied in principle to other exotic and ordinary atoms and molecules.

Reference
[1] S. Nishimura, H. A. Torii et al., "Rabi-oscillation spectroscopy of the hyperfine structure of muonium atoms", Phys. Rev. A 104, L020801 (2021).

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