SELECTIVE ADDRESSING OF NUCLEAR SPINS THROUGH PULSED LASER EXCITATION

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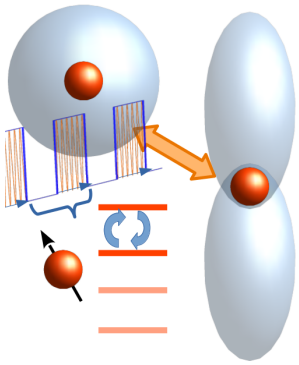

Nuclear electric resonance (NER) spectroscopy is currently experiencing a revival as a potential tool for quantum computing based on nuclear spins. Access to nuclear spin states via electric fields is provided by the nuclear quadrupole moment, a common feature of many standard isotopes, caused by the non-spherical shape of their nuclei.

Based on an in-depth analysis of the underlying coupling mechanism, we investigate the possibility of coherent spin control in atoms or molecules via nuclear quadrupole interaction from first principles. A general, time-dependent description is provided, which entails and reflects on commonly applied approximations often found in recent literature. This formalism is then used to propose a new method we refer to as 'optical' nuclear electric resonance or 'ONER'.

Our protocol takes advantage of time-modulated optical excitations via UV/visible light, e.g. realized by a pulsed laser, to control the electric field gradient at the position of a specific nucleus by periodic changes of the surrounding electron density. The proposed method is theoretically investigated for the $^1S \rightarrow {}^1P$ transition in ^{9}Be as well as the $^1X\Sigma^+ \rightarrow {}^1A\Sigma^+$ transition in ^{7}Li^{23}Na as first atomic and molecular benchmark systems, respectively.[ab] Our findings suggest that it might be possible to shift complicated spin manipulation tasks in atomic, molecular or solid-state systems into the time domain by pulse-duration encoded laser signals.

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[a] Johannes K. Krondorfer and Andreas W. Hauser. Nuclear electric resonance for spatially resolved spin control via pulsed optical excitation in the uv-visible spectrum. Phys. Rev. A, 108:053110, Nov 2023.

[b] Johannes K Krondorfer, Matthias Diez and Andreas W Hauser, Optical Nuclear Electric Resonance in LiNa: Selective Addressing of Nuclear Spins through Pulsed Lasers, Physica Scripta (submitted)