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Quantum sensing of the electron's electric dipole moment using ultracold Fr atoms

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The search for the fundamental physics using atoms and molecules have been widely investigated [1]. The discovery of the electron's electric dipole moment (EDM) sheds light on new physics beyond the standard model. The upper limit of EDM has been reported [2]. We propose a novel experimental technique to measure the electron EDM using ultracold Fr atoms based on the combined principles of quantum sensing and optical lattice [3]. Our method enables a search for the electron EDM at a level below 10−30 ecm. Fr isotopes with relatively long lifetimes show increasing nuclear octupole deformation with more neutrons, further enhancing Schiff moments in addition to the electron EDM. We produce two Fr isotopes using distinct methods: Fr-210 via nuclear fusion reactions with an accelerator and Fr-221, with strong octupole deformation, via radiochemical techniques using Ac-225 as its generator. Laser beams were delivered from the laser room to the Fr room via 400-m optical fibers [4]. Fr was generated [5], neutralized [6], laser cooled and trapped [7]. We demonstrated Faraday rotations by Rb and Cs trapped in an optical lattice, to measure Zeeman and vector light shifts simultaneously which are the systematic errors in EDM measurements. We also report the experiment of an atomic vapor magnetometer, and measurement of Ramsey resonance using ultracold atoms for the EDM measurement.

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Primary author: AOKI, Takatoshi (The University of Tokyo)

Co-authors: GABTENI, A. B.; CHAKRABORTY, A.; HATAKEYAMA, A.; KASTBERG, A.; SAHOO, B. K.; DAS, B. P.; ARORA, Bindiya; . HABA, H.; NAGAHAMA, H.; NISHINO, H.; ABE, K.; NAKAMURA, K.; KAJITA, M.; NAKAZAWA, M.; OKAMOTO, N.; OZAWA, N.; SREEKANTHAM, R.; TSUSUI, R.; KUMAHARA, S.; NAGASE, S.; TANAKA, S.; TOJO, S.; NAKASHITA, T.; ONO, T.; . NEZU, Y.; ISHII, Y.; MATSUO, Y.; SAKEMI, Y.; TORII, Y.

Presenter: AOKI, Takatoshi (The University of Tokyo)

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