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Pulsed Laser Spectroscopy of Xe¹²⁹ for a Co-magnetometer in the TRIUMF Neutron Electric Dipole Moment Experiment

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Construction is underway at TRIUMF by an international collaboration on a high-density ultra-cold neutron source. Its primary experiment will be a measurement of the neutron electric dipole moment (nEDM). The experiment uses an NMR technique known as Ramsey resonance to detect electric-field correlated shifts in the precession frequency of ultra-cold neutrons. Previous-generation nEDM experiments add spin-1/2 Hg¹⁹⁹ atoms as a co-magnetometer in the same volume with ultra-cold neutrons to perform a cross-check on magnetic field drifts.

Xe¹²⁹ is another spin-1/2 species sensitive to magnetic field drifts. We are developing magnetometry using Xe¹²⁹ atoms excited via two-photon transitions at 252 nm and detecting the laser-induced fluorescence (LIF). Combining both Hg¹⁹⁹ and Xe¹²⁹ co-magnetometers will make it possible to measure and correct for geometric phase effects which currently limit the accuracy with which field instabilities are measured.

Xe¹²⁹ has been studied in the past using the spin exchange optical pumping technique, which hyperpolarizes the gas orders of magnitude greater than achievable in Boltzmann distributions alone, but requires Rb for optical interaction. Our goal in investigating the two-photon transition is to optically pump and probe a spin state of Xe¹²⁹ directly. One of the hyperfine transitions is sensitive to the excitation light's polarization and suitable for optical pumping. While a narrow-linewidth CW laser is the ideal for measuring this sensitivity, intensity requirements for TPA necessitate use of (broadband) pulsed nanosecond lasers. We will present results from Doppler-free studies of the 252 nm transition and polarization dependence, as well as observed coherent emission of LIF radiation.

Author: MILLER, Eric R (The University of British Columbia)

Co-authors: JONES, David J. (The University of British Columbia); ALTIERE, E.E. (The University of British Columbia); WIENANDS, Joshua N. (The University of British Columbia); MADISON, Kirk W. (The University of British Columbia); MOMOSE, Takamasa (The University of British Columbia)

Presenter: MILLER, Eric R (The University of British Columbia)

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