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Atomic Magnetometers for the TUCAN EDM experiment

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The TUCAN (TRIUMF Ultra-Cold Advanced Neutron) collaboration seeks to measure the neutron electric dipole moment (nEDM) with a sensitivity of 10^{-27} e·cm, a factor of 10 better than present world's best. This measurement involves monitoring the spin precession frequency of ultracold neutrons subjected to an electric field. The experiment requires a constant and uniform magnetic field (B_0) of 1~μT, and searches for changes in the precession frequency of neutrons as the relative direction of the electric and magnetic field is reversed. A major challenge is minimizing systematic errors arising from magnetic field non-uniformities. To address these issues, we employ 20 cesium-based optical magnetometers to map and control spatial gradients within the magnetic field. These magnetometers, operating with sensitivities of 3.9~pT (in one measurement requiring about 200~ms) and drift stabilities of 90~fT (averaging over 150~s), are optimized for the low-field environment and will provide critical insight into gradient-induced frequency shifts. My work involves characterizing magnetic field gradients via multipole decomposition techniques and tuning shim coils within the magnetically shielded room to minimize both statistical and systematic errors in the EDM measurement. For the TUCAN EDM experiment, the goal is to achieve a neutron T_2 longer than 10,000 seconds so that the statistics of the EDM measurement are preserved. To reach this target, we must attain a homogeneous magnetic field with:
$\Delta B_z < 140$ pT, $\sigma(B_z) < 40$ pT and $\langle B_T^2 \rangle < 0.1$ nT^2.
In this presentation, I will discuss the Cs sensors and ongoing experiments to characterize both the magnetic environment at TRIUMF and the sensors themselves. This will include upcoming efforts to integrate the ^{199}Hg comagnetometer system with the Cs sensors.

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