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Toward Measuring the Neutron Electric Dipole Moment

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The existence of the neutron electric dipole moment (nEDM) is a violation of time reversal (T), and parity (P) symmetries. It is also a violation of Conjugate-Parity (CP) symmetry if CPT is invariant. The Standard Model prediction for the nEDM, which is suppressed to third order loop corrections, is $\approx 10^{-32}$ ecm. The current world experimental limit is 1.3×10^{-26} ecm, from Paul Scherrer Institute. This difference allows a large parameter space for a measurement of new CP violating interactions beyond the Standard Model. The discovery potential is significant, since the Sakharov conditions require a new larger source of CP violation for the observed matter anti-matter asymmetry in the present universe. These CP violating interactions would lead to a larger nEDM than the Standard Model's prediction. There are various approaches to measure the nEDM. The majority of experiments use the Ramsey resonance technique to measure the phase accumulation in the Larmor precession of the neutrons versus applied E-field. Alternatively if polarized ^{3}He are introduced with the polarized neutrons then the ^{3}He can be used as a neutron phase detector due to their spin dependent reaction. Free precession and spin dressed measurements of the relative phase between the neutron and the ^{3}He can be acquired during the duration of the measurement, improving the statistical reach over the Ramsey resonance technique.

Regardless of the measurement technique, due to the motion of the neutrons through the E-field and imperfections in the B field a systematic frequency shift arises that is proportional to the E-field. The nEDM signal is also proportional the the E field, which is why all nEDM experiments go to great lengths to understand and mitigate this effect.