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Fundamental physics with precision magnetometers

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Symmetries and conservation laws determine the interactions between particles and the structures in which matter organizes itself. Some of the most fundamental symmetries in physics are the space-time symmetries of Lorentz transformations - where the laws of physics are unchanged under boosts and rotations - and CPT - the combination of charge conjugation (C), parity inversion (P) and time reversal (T). Precision measurements using "atomic clocks"have flourished in recent years as attempts to find cracks in the well established Standard Model of particle physics by searching for tiny violations of empirical symmetry laws. Polarized 3He and 129Xe are ideally suited for pushing the limits of sensitivity due to the extraordinarily long phase-coherence time of their precessing spins of about 100h. A resulting spin clock would be about 6 orders of magnitude more sensitive than modern Cs-fountain clocks and could access frequency shifts in the pHz range. This sensitivity gain will open a new area for precision experiments where the observables are tiny changes in the clock transition filtered out by the symmetry properties of the relevant interaction potential.

The talk discusses the benefits of long spin coherence times in searching for fundamental symmetries in nature and some practical applications in ultra-sensitive magnetometry.

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