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Searches for Lorentz violation in 3He/129Xe clock comparison experiments

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We discuss the design and performance of a very sensitive low-field magnetometer based on the detection of free spin precession of gaseous, nuclear polarized 3He or 129Xe samples with a SQUID as magnetic flux detector. Characteristic spin precession times of up to 60 h were measured in low magnetic fields (about 1μT) and in the regime of motional narrowing. The achieved signal-to-noise ratio of more than 5000:1 leads to an expected sensitivity level (Cramer-Rao Lower Bound) of (100 Zeptotesla) after one day [1].
With the detection of the free precession of co-located 3He/129Xe nuclear spins (clock comparison), the device can be used as ultra-sensitive probe for non-magnetic spin interactions, since the magnetic dipole interaction (Zeeman-term) drops out in the weighted frequency difference, i.e., dw=w_He- g_He/g_Xe*w_Xe . We report on searches for Lorentz violating signatures by monitoring the Larmor frequencies of co-located 3He/129Xe spin samples as the laboratory reference frame rotates with respect to distant stars (sidereal modulation) [2].
[1] C.Gemmel, W.Heil, S.Karpuk, et al., Eur. Phys. J. D, 47, 303-320, (2010)
[2] C. Gemmel, W. Heil, S. Karpuk, et al., Phys. Rev D 82, 111901(R) (2010)

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