Test of Lorentz Invariance with a ^{3}He/^{129}Xe co-magnetometer

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In the framework of the so-called Standard Model Extension (SME) [1], Lorentz- and CPT violating terms should cause measurable effects in high-precision experiments at low energies. One test is to look for a periodic variation of the Larmor precession frequency of polarized noble gas atoms (^{3}He, ^{129}Xe) during a sidereal day as the laboratory reference frame rotates with respect to a relic background field which permeates the universe and points in a preferred direction in space-time. In our setup we use co-located, nuclear spin polarized ^{3}He and ^{129}Xe atoms and measure their free spin precession frequencies around a homogeneous magnetic guiding field of about 400 nT using LT_C SQUID detectors which have a sensitivity of ≈ 3 fT/$\sqrt{\text{Hz}}$. The whole apparatus is housed in a magnetically shielded room at the Physikalisch Technische Bundesanstalt (PTB) in Berlin [2]. To search for these effects or to give new upper limits, long transverse spin-relaxation times ($T_2^* \approx \mathcal{O}(\text{day})$) are mandatory as well as very good signal-to-noise ratios (SNR). The latter requirement is fulfilled since the field of the precessing spins in the spherical sample cells reaches some tenths of pT at SQUID position, resulting in a SNR of > 1000 . In order to reach a long T_2^*, one has to work in the so-called motional narrowing regime [3] at low gas pressures ($p \approx \mathcal{O}(\text{mbar})$) and low magnetic fields ($\approx \mu$T), where spin-dephasing due to field gradients is strongly suppressed [4] and T_2^* is dominated mainly by wall relaxation and relaxation due to the formation of Van-der-Waals molecules (only for ^{129}Xe). For the ^{3}He/^{129}Xe co-magnetometer, T_2^* times of up to 4 hours for ^{129}Xe and 25 hours for ^{3}He were measured.

In the talk we report on our measurement results from October 2007. The status of data analysis is discussed and a comparison is made with ^{3}He/^{129}Xe Zeeman maser experiments [5], which bound violations of CPT and Lorentz symmetry of the neutron (Schmidt model) at the 10^{-31} GeV level.

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