Test of Lorentz Invariance at the Amundsen - Scott South Pole Station
Marc Smiciklas1, Andrew Vernaza2, Michael Romalis1

1 Physics Department, Princeton University
2 Antarctic Support Contract, Lockheed Martin

This work supported by NSF grant PHY-1142032

PRINCIPAL LORENTZ VIOLATION LIMITS
• Most stringent limits on vector and tensor Lorentz violation for fermions
• Vector limit set using K-3He
• Tensor limit set using K-Rb-21Ne

LORENTZ VIOLATION
• Standard-Model Extension (SME): a framework for Lorentz violation searches
• Co-magnetometer experiment constrains vector (f) and tensor (g) couplings
• 1st harmonic sidereal response when measuring f coefficient
• 1st and 2nd harmonic sidereal response when measuring g coefficient


• 1st harmonic sidereal response when measuring f coefficient

ALKALI-NOBLE GAS CO-MAGNETOMETER
• Circularly polarized pump light polarizes alkali atomic spins
• Noble gas polarized by spin exchange collisions with alkali atoms
• Operated at a compensation field $B_c = -2/3 \kappa (\hbar / \omega_{\text{L}}} + M_{\text{had}})

SOUTH POLE LORENTZ INVARIANCE TEST (SPLIT)

SOUTH POLE LORENTZ INVARIANCE TEST (SPLIT)

The current status of the experiment is that it’s in its first year of a planned two year deployment at the South Pole. Data collection is currently underway.

Continued work is being conducted at Princeton and in coordination with the wintering over Research Associate at the South Pole to evaluate and identify necessary improvements to reduce systematic effects and improve statistical performance.

Future plans include returning to the South Pole during the 2013-2014 Austral Summer to implement improvements to automation and various environmental controls.

Circularly polarized pump light polarizes alkali atomic spins
Noble gas polarized by spin exchange collisions with alkali atoms
Operated at a compensation field $B_c = -2/3 \kappa (\hbar / \omega_{\text{L}}} + M_{\text{had}})$

Atomic spin co-magnetometers are among the most sensitive devices for testing Lorentz symmetry. However, gyroscope pickup of Earth's rotation represents a large limiting background.

So, we moved our experiment...

In Princeton, Earth's signal is 2.6 μT –10,000 times larger than the current Lorentz-violating limit.
Now located ~100 to 200 m from the geographical South Pole, Earth’s signal = 0.1 ft

Preliminary analysis indicates ~0.3 T uncertainty for 1 day of data taking, roughly the same uncertainty of the current Lorentz Violation limit.

• Experimental apparatus mounted on a precision air-bearing rotary table
• Signal modulated by rotating the apparatus (data collected at stationary position)
• Lorentz-violating signal corresponds to a 1st and 2nd harmonic sidereal frequencies

Depicted and quadrupole SME Lorentz violating coefficients constrained by operating in 2 different configurations