Probing a Purported Spin Nematic State Utilizing the World Record 32T All-Superconducting Magnet

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The quantum spin-nematic state (SN) was theoretically predicted over 30 years ago, but has yet to be experimentally found in condensed matter systems, due to the complex nature of this exotic spin-state. Analogous to a type of order found in liquid crystals, this frustrated magnetic state, if real, is predicted to be an avenue for developing quantum information devices. However, scientists are presently limited by the small number of potential experimental observables for a SN state. *Nuclear magnetic resonance (NMR) is currently the only feasible measurement technique that is sensitive to local, microscopic magnetism. It can be naturally combined with the high magnetic fields necessary to prove the SN state's existence.*

MagLab users performed NMR measurements on the material β-$TeVO_4$, a promising SN candidate, in both the 36T Series Connected Hybrid (SCH) magnet and, most recently, the world-record all-superconducting 32T magnet. The experiment is ongoing, but initial results on the 32T magnet are consistent with the ^{125}Te spectral shifts measured in the SCH. *Future experiments will require long times at high fields to establish whether the purported SN state is real.*

These initial results indicate the game-changing nature of the new 32T HTS user magnet and its unique measurement capabilities.

Facilities and instrumentation used: DC Field Facility: SCM4 (The new 32 Tesla all superconducting magnet)

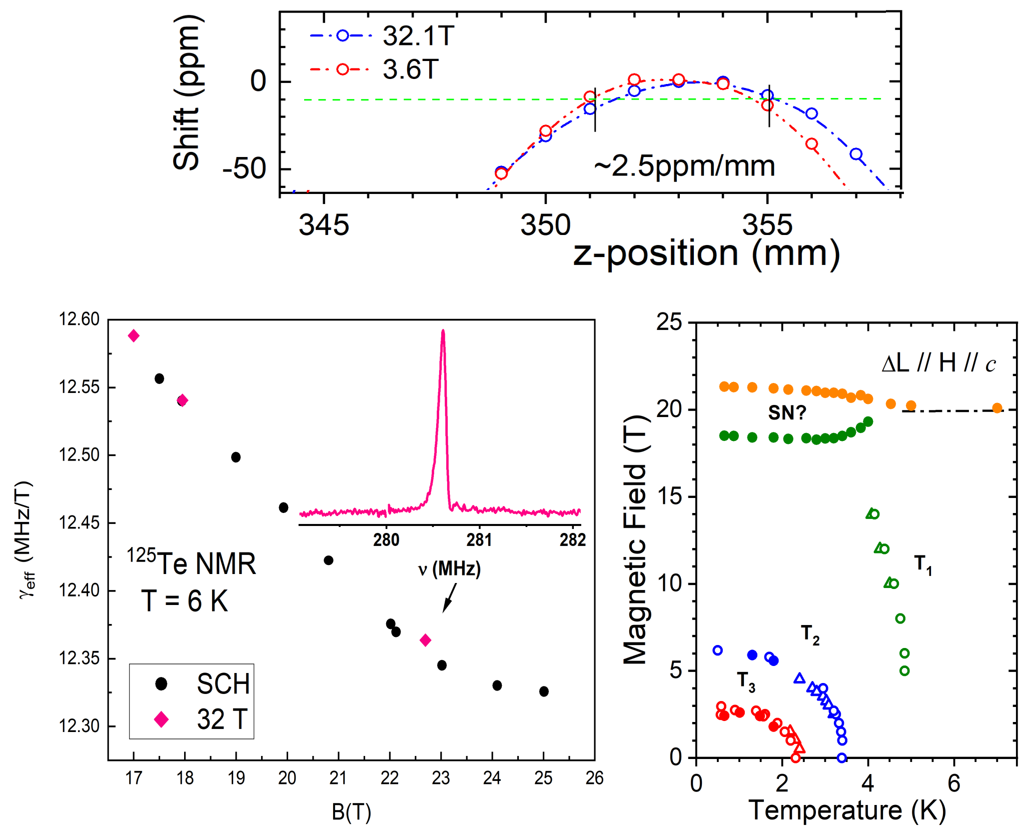

Figure: **(Top)** Magnet field profile of the new magnet along the z-axis at 32.1T and 3.6T measured with 63Cu NMR. **(Left)** ^{125}Te spectral line and effective gamma with respect to magnetic field. Black circles are from the 36T Series Connected Hybrid while the pink diamonds are from the new HTS 32T magnet. **(Right)** Phase diagram for H//c highlighting the possible spin-nematic state. [PRB **94** 064403 2016] Solid circles are from magnetostriction. Open circles from magnetostriction and thermal expansion. Open triangles from magnetization.