



Contribution ID: 46

Type: Talk

Pressure Tuned Magnetism in the 3D Frustrated Antiferromagnet $K_2Ni_2(SO_4)_3$

Monday, 11 May 2026 11:10 (20 minutes)

$K_2Ni_2(SO_4)_3$ is a three dimensional frustrated antiferromagnet in which $Ni^{2+}(S=1)$ ions occupy two interpenetrating trillium sublattices that together form a unique tetra-trillium network. Recent thermodynamic, inelastic neutron scattering, and muon spin relaxation (μ SR) studies show that, at ambient pressure and zero magnetic field, $K_2Ni_2(SO_4)_3$ hosts a highly dynamic, correlated ground state with features reminiscent of a quantum spin liquid (QSL), coexisting with a very small static ordered component —behavior that places the system close to a quantum critical regime [1-3]

To investigate how this dynamic state evolves when magnetic interactions are tuned, we performed detailed μ SR experiments on $K_2Ni_2(SO_4)_3$ under hydrostatic pressure up to 23 kbar. At low pressures (below about 8.6 kbar), the ZF- μ SR spectra measured at millikelvin temperatures show predominantly dynamic relaxation, consistent with persistent spin fluctuations. At and above approximately 9.5 kbar, pronounced oscillations appear in the ZF μ SR time spectra, providing clear evidence for the development of static internal magnetic fields and indicating that pressure drives the system toward a more static, magnetically ordered regime. The evolution of the internal field strength with pressure and temperature highlights a systematic suppression of spin fluctuations and increasing stabilization of static correlations under compression.

These results demonstrate that hydrostatic pressure is a powerful tuning parameter in $K_2Ni_2(SO_4)_3$, transforming the magnetic ground state from a dynamic, frustration dominated regime toward static magnetism. This behavior underscores the sensitivity of three dimensional frustrated spin networks to small perturbations and establishes pressure as a promising route for exploring competing quantum phases and proximate QSL behavior in 3D frustrated magnets.

[1] I. Živković et al., Phys. Rev. Lett **127**, 157204 (2021).

[2] M. G. Gonzalez et al., Nat. Commun. **15**, 7191 (2024).

[3] W. Yao et al., Phys. Rev. Lett **131**, 146701 (2023).

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