

# 15th International Conference on Muon Spin Rotation, Relaxation and Resonance



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## Studying spin diffusion and quantum entanglement with LF- $\mu$ SR

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LF- $\mu$ SR studies of spin diffusion started with mobile solitons [1] and polarons [2] in conducting polymers. Spin 1/2 antiferromagnetic chains can also support diffusive spin excitations in a certain parameter range of the XXZ model [3], showing either diffusive [4] or ballistic transport [5]. Recent LF- $\mu$ SR studies of layered triangular lattice quantum spin liquid materials such as 1T-TaS<sub>2</sub> [6] and YbZnGaO<sub>4</sub> [7] have shown spin dynamics that is extremely well described by a 2D spin diffusion model, fitting much better than previously proposed models for spin correlations. In YbZnGaO<sub>4</sub> the diffusion rate shows a clear crossover between classical and quantum regimes as  $T$  falls below the exchange coupling  $J$ . That the spin diffusion approach works well in the high  $T$  classical region might be expected, but it is found that it also works equally well in the low  $T$  quantum region. This allows a  $T$  dependent length scale to be derived from the data that can be assigned to a quantum entanglement length  $\xi$ . Another entanglement measure, the Quantum Fisher Information  $F_Q$  [8] can also be obtained from the LF- $\mu$ SR data and compared with  $\xi$ .

[1] K. Nagamine et al, Phys. Rev. Lett. 53, 1763 (1984); [2] F.L. Pratt et al, Phys. Rev. Lett. 79, 2855 (1997); F.L. Pratt et al, Physica B 326, 34 (2003); [3] B. Bertini et al, Rev. Mod. Phys. 93, 025003 (2021); [4] F.L. Pratt et al, Phys. Rev. Lett. 96, 247203 (2006); F. Xiao et al, Phys. Rev. B 91, 144417 (2015); [5] T. Lancaster et al, Phys. Rev. B 85, 184404 (2012); B.M. Huddart et al, Phys. Rev. B 103, L060405 (2021); [6] S. Manas-Valero et al, npj Quantum Mater. 6, 69 (2021); [7] F.L. Pratt et al, Phys. Rev. B 106, L060401 (2022); [8] P. Hauke et al, Nat. Phys. 12, 778 (2016).

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