Magnetic Raman scattering in quasi-one-dimensional antiferromagnets

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Since its description almost five decades ago, the quantum spin liquid (QSL) state has eluded concrete experimental realization. 'Smoking gun' experimental signatures of QSLs are rare, and detection of fractionalized, spin-$1/2$ quasiparticles known as spinons via inelastic neutron scattering (INS) remains the gold standard [1]. However, spinons are generic features of one-dimensional antiferromangets, and ambiguous dimensionality can lead to spinons of one-dimensional origin posing as exotic spinons originating from QSL physics [2]. Consequently, there remains a demand for both theoretical and experimental methods for the detection and classification of spinons in low dimensional antiferromagnets.

Magnetic Raman scattering (MRS) is a complementary spectroscopic technique to INS, in which the magnetic excitations are caused by inelastically scattered photons in place of neutrons. We explore a description of MRS in quasi-one-dimensional antiferromagnets using first order perturbation theory from the two-spinon approximation on a single antiferromagnetic chain. Employing the Loudon-Fleury formalism [3] in conjunction with the one-dimensional eigenstates given by the Bethe ansatz, we derive an expression for the Raman intensity valid in the regime of weakly coupled chains. We find three unique classes of solutions that contribute distinct spectral features to the Raman intensity with comparable magnitudes: the spinonic solutions, the one-triplon solutions, and the two-triplon solutions. The triplon is an exotic excitation of some low dimensional antiferromagnets that allows for coherent transport of spinon pairs transverse to the dominant chain axis. The two-triplon solutions are found to dominate the Raman intensity at low and intermediate scattering energies, displaying an intensity peak at a Raman shift value of $\pi J_{\parallel}$, where $J_{\parallel}$ is the nearest neighbour exchange coupling on the dominant axis. We believe this peak to be a generic feature in the magnetic Raman signature of low dimensional antiferromagnets that realise triplons.

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[3] Fleury, P. A., & Loudon, R. (1968) *Physical Review*, 166(2), 514.