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Spin excitations and magnon fractionalization in a quantum spin ladder[1]

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The quantum spin ladder is arguably the most prototypical model system in theoretical quantum magnetism. Recent progress in the field was triggered by the development of efficient theoretical methods for simulations of relatively large finite-size systems (DMRG, ED); on the other hand, experimental work was for decades limited by the sparse number of model materials. The compound $(C_5H_{12}N)_2CuBr_4$ [1-3], representing the limit of exceptionally weak magnetic exchange realised in metal-organic materials, is a rare exception. It is well-suited for studies of the elementary excitations and the phase diagram of the quantum spin ladder. The phase diagram of quasi–1D arrays of quantum spin ladders in temperature and magnetic field is particularly rich: quantum disordered, quantum critical, spin Luttinger–liquid, BEC, and classically saturated phases can be studied and their characteristic excitations explored. We measured by inelastic neutron scattering the spin excitation spectra in $(C_5H_{12}N)_2CuBr_4$ as a function of applied magnetic field across these phases and the two intrinsic quantum critical points. Discrete magnon modes at low fields in the quantum disordered phase and at high fields in the saturated phase contrast sharply with a spinon continuum at intermediate fields characteristic of the spin Luttinger–liquid phase. By tuning the magnetic field, we drive the fractionalization of magnons into spinons and, in this deconfined regime, observe both commensurate and incommensurate continua.

[1] Ch. Rüegg *et al.*, Phys. Rev. Lett. **101**, 247202 (2008).
[2] B. Thielemann *et al.*, Phys. Rev. B **79**, 020408(R) (2009).
[3] B. Thielemann *et al.*, Phys. Rev. Lett. **102**, 107204 (2009).

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