

# Excitations of the antiferromagnetic XXZ spin-1/2 spin chain - spinons and Bethe strings

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The antiferromagnetic spin-1/2 spin chain with Heisenberg-Ising (XXZ) anisotropy is a rich source of novel phenomena. Good physical realizations are the compounds  $\text{SrCo}_2\text{V}_2\text{O}_8$  and  $\text{BaCo}_2\text{V}_2\text{O}_8$  where the  $\text{Co}^{2+}$  ions have effective spin-1/2 and are coupled by antiferromagnetic interactions into chains while long-range magnetic order occurs at  $T_N = 5$  K due to weak interchain coupling. The excitations are spinons which become bound into pairs to form magnons below  $T_N$ . In a longitudinal magnetic field applied along the easy axis, the magnetic order is suppressed and using inelastic neutron scattering and optical spectroscopy we find the first evidence for complex bound states of magnetic excitations, known as Bethe strings [1,2]. Furthermore, the characteristic energy, scattering intensity and linewidth of the observed string states exhibit excellent agreement with precise Bethe ansatz calculations. Our results confirm the existence of the long-sought Bethe string excitations which were predicted almost a century ago [3], establish their role in the quantum spin dynamics of one-dimensional systems and reveal the effectiveness of new measurement and calculation techniques.

## References:

- [1] Z. Wang et al., Nature 554 219 (2018).
- [2] A. K. Bera et al., Nature Physics 16 625 (2020).
- [3] H. Bethe. Z. Phys. 71, 205 226 (1931).