Experimental report

08/05/2019

Proposal: 4-05-700 **Council:** 4/2018

Title: Investigating Bethe String Excitations in a Spin-1/2 antiferromagnetic XXZ chain under magnetic field

Research area: Physics

This proposal is a new proposal

Main proposer: Bella LAKE

Experimental team: Bella LAKE

Local contacts: Jacques OLLIVIER

Samples: SrCo2V2O8
Ca10Cr7O28

Instrument	Requested days	Allocated days	From	To
THALES	0	8	08/10/2018	16/10/2018
ORIENTEXPRESS	0	1		
IN5	6	8		

Abstract:

A longitudinal field applied parallel to the easy access of an XXZ spin chain shows exotic physics. Above a critical field, the long-range antiferromagnetic order is destroyed and the system enters a gapless critical regime. As well as spinon-pair excitations (known as psinons), bound states of magnons can also be excited, these are known as Bethe strings and were first predicted by Hans Bethe in 1931 but have only been verified very recently using terahertz spectroscopy measurements on the model magnet SrCo2V2O8. These excitations are also expected to be observeable by inelastic neutron scattering which would be able to measure the longitudinal excitations (inaccessible to terahertz spectroscopy) and provide information about the wavevector dependence of these excitation (terahertz spectroscopy is confined to the gamma point). The goal is this proposal is to perform a thorough investigation of the excitations in the field-induced critical state of SrCo2V2O8 using inelastic neutron scattering and make a comparison to theory.

Title: Determination of the Spinon Confining Potential in a 1D spin-1/2 XXZ Antiferromagnet.

Proposal number 4-05-700
Thales Spectrometer of ILL.
08.10.2018 until 16.10.2018.

Introduction:

$SrCo_2V_2O_8$ is a quasi-one-dimensional, Spin-1/2 antiferromagnet with XXZ anisotropy. Weak interchains coupling gives rise to long-range magnetic order at a suppressed but finite temperature. A spinon continuum is observed above the Neel temperature while below T_N a series of resolution-limited sharp modes are found. The modes are due to spinons bound into pairs by the interchain coupling which acts as a confining potential [1]. In a magnetic field applied along the anisotropy (c-axis) direction, the long-range magnetic order is suppressed for a field of 3.8T and for higher fields exotic excitations such as Psinons, antispinon and the long sought after Bethe string modes that were first predicted by Hans Bethe in 1931 [2] are expected. These excitations were observed very recently in this compound using ESR measurements [3]. However ESR is not able to measure all excitations, it is only sensitive to excitations with transverse polarisation, on the other hand neutrons can measure both longitudinal and transverse excitation. The aim of this experiment was to measure the exotic excitations present at high magnetic field in SrCo2V2O8.

[1] A. K. Bera *et al. Phys. Rev. B* 96 054423 (2017).
[2] H. Bethe *Z. für Phys*. **71** 205 (1931).
[3] Z. Wang *et al.Nature* 554 219 (2018).

Experimental setup:

We used the IN14 triple axis spectrometer at ILL and the 15T vertical magnet. The magnet was operated using a Berillium filter with Kf=1.5A-1 and with doubly focusing monochromator and analyser. The sample was oriented with the c-axis vertical and was cooled to 1.8K. Measurements took place at the wavevectors (2.3,2.3,0) and (3.25,0,0) which corresponds to the antiferromagnetic zone center. These wavevectors were chose to highlight specific modes and an energy scan was measured at each for different fields between 0 and 14.5T.

Results:

We successfully observed a series of different excitations including the psinon and antipsinon modes as well as the 2-particle Bethe string modes as a function of field see the figure.

Conclusion

This experiment was highly successful and gave a clear picture of the exotic excitations found at high magnetic fields in an anisotropic chain. The data is currently being compared to DMRG calculations and a publication is in progress.

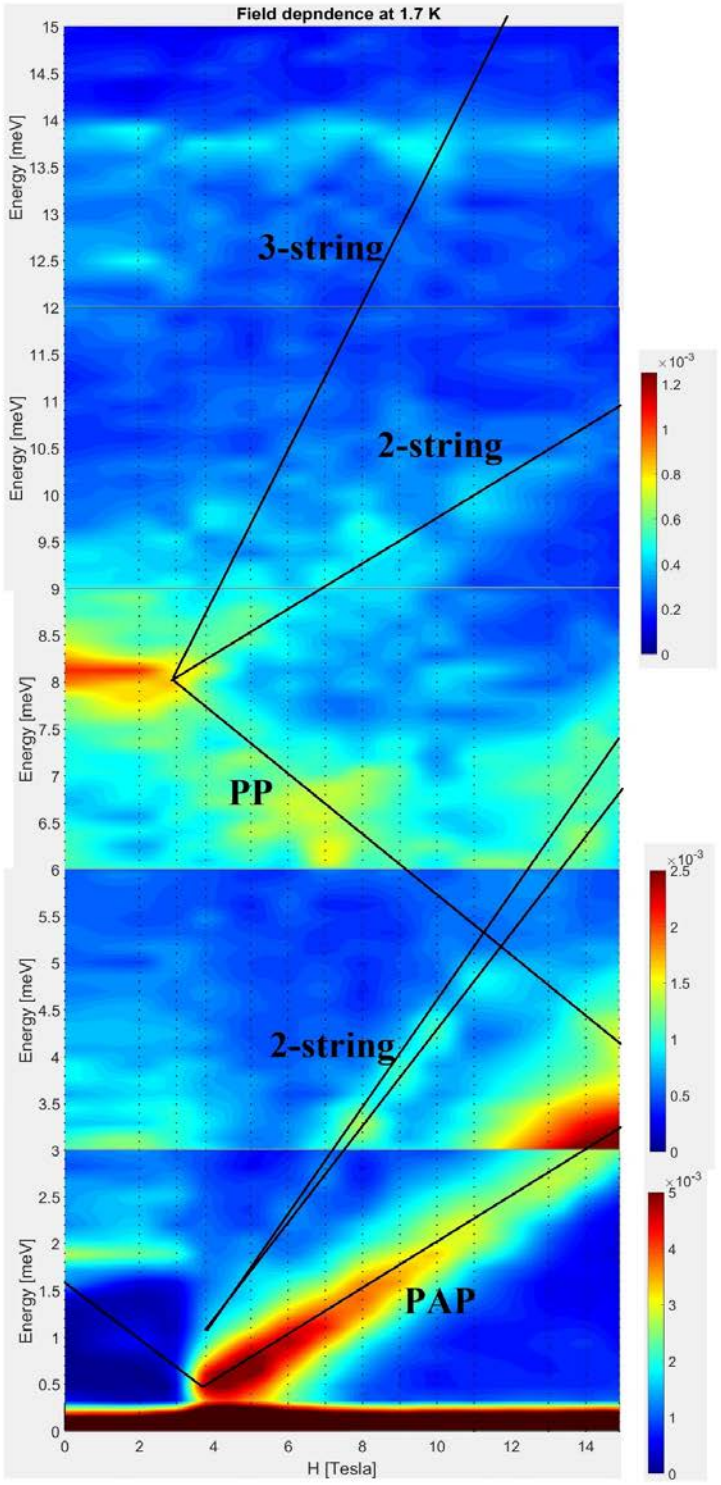

Figure 1: Inelastic Neutron scattering as a function of energy for different magnetic fields applied along the c-axis. The data shows the evolution of the excitations with field.