# Experimental report

12/06/2019

**Proposal:** **4-05-711** **Council:** 4/2018

**Title:** Multi-particle excitations in a coupled spin-1 antiferromagnetic chain material.

**Research area:** Physics

**This proposal is a resubmission of 4-05-667**


**Main proposer:** **Rafal WAWRZYNCZAK**

**Experimental team:** Michel KENZELMANN
Rafal WAWRZYNCZAK

**Local contacts:** Mechthild ENDERLE


**Samples:** RbNiCl3

| Instrument | Requested days | Allocated days | From | To |
|---|---|---|---|---|
| IN20 | 14 | 7 | 28/06/2018 | 05/07/2018 |


**Abstract:**

The S= 1 antiferromagnetic chain, also called Haldane chain, in the absence of inter-chain interactions exhibits a gapped spin-liquid ground-state, with characteristic S= 1 triplet excitations. In RbNiCl3 chains of Ni2+ (S=1) ions form a triangular array and coupling between those leads to the onset of long range magnetic order at TN= 12 K. In preliminary studies, apart from well defined, expected gapped excitations we have observed a broad continuum of multi-particle scattering. This continuum is more pronounced than the one predicted for processes involving multiple Haldane triplets. However, there is a strong resemblance of this feature with the one expected for the presence of S= 1/2, paired quasi particles (spinons). We suspect that the inter-chain frustration, due to their triangular arrangement, causes surprising appearance of those fractionalized excitations. Therefore we propose to investigate the extent of measured continuum at wave-vectors covering the inter-chain interactions and its temperature dependence.

# Multi-particle excitations in a coupled spin-1 antiferromagnetic chain material.

R. Wawrzyńczak,[1] M. Kenzelmann,[2] M. Enderle,[1] and K. Krämer[3]

[1] *Institut Laue Langevin, FR-38042 Grenoble, France*

[2] *Laboratory for Neutron Scattering, PSI, CH-5232 Villigen PSI, Switzerland*

[3] *Departement für Chemie und Biochemie, Universität Bern, Freiestrasse 3, CH-3000 Berne 9, Switzerland*

IN20 tirple-axis neutron spectrometer with longitudinal polarization setup was employed for investigation of scattering continuum of multi-particle excitations in $RbNiCl_3$ spin-1 antiferromagnetic Heisenberg chain. Excess scattering weight intensity, in form of broad feature, was observed above the well-defined branches of magnetic excitations at the anitferromagnetic point ($Q_l = 1$) of intrachain dispersion. This coincides with the region where multi-particle continuum scatterin was observed in closely related $CsNiCl_3$. The observed continuum constitutes 5(3)% of the inelastic magnetic scattering at $\boldsymbol{Q} = (1/3, 1/3, 1)$.

A single-crystal sample in form of rod with length $l \sim 45$ mm and diameter $\phi \sim 5$ mm was aligned with $[hhl]$-crystallographic plane lying in the horizontal scattering plane (Fig. 1). It was enclosed in Al can filled with helium gas serving as a protective atmosphere, due to the sample's hygroscopic character.

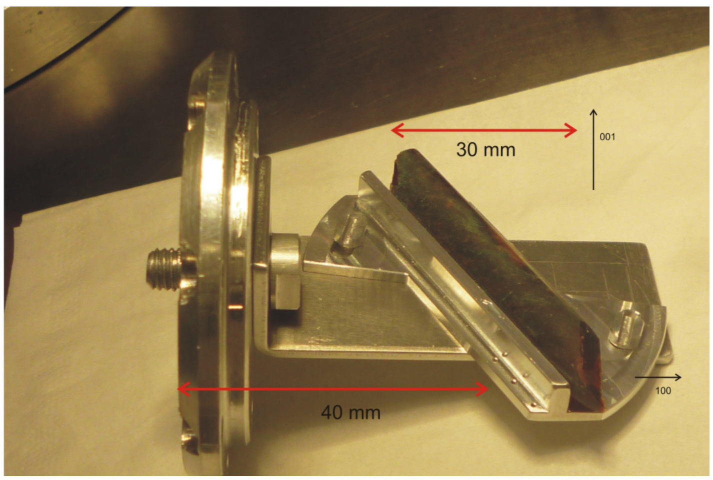


FIG. 1. Single crystal sampleo f $RbNicL_3$ on an aluminium sample mount.

Sample was cooled down to $T = 2$ K, well beyond the Néel temperature $T_N \sim 11$ K, and constant-$\boldsymbol{Q}$ scans at three positions ($(2/3, 2/3, 1/2)$, $(1/3, 1/3, 1)$ and $(2/3, 2/3, 0)$) were performed. $x$, $y$ and $z$ spin flip scattering channels were measured to allow for separation of magnetic scattering $|\boldsymbol{M}_\perp|^2$.

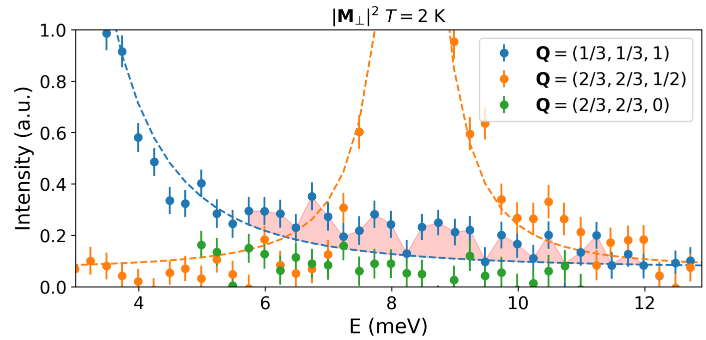


FIG. 2. Separated magnetic scattering intensities in constant-$\boldsymbol{Q}$ scans. The dashed lines are fits to the peaks of magnetic excitations with antisymmetrized Loretzian wighted with Bose factor. The shaded are marks the excess scattering weight.

Peaks of well-defined magnetic excitations were fitted with antisymmetrized Lorentzian weighted with Bose factor. Scatteirng intensity measured in scan at $\boldsymbol{Q} = (2/3, 2/3, 0)$ does not seem to be affected by any magnetic scattering. The averaged intensity of this scan was used as a flat background in the fitting procedure.

Excess magnetic scattering wieght was observed above the well-defined magnetic excitation branches in the energy range $E = 5 - 12$ meV at magnetic zone center $\boldsymbol{Q} = (1/3, 1/3, 1)$ (Fig. 2). The observed feature takes form of broad continuum similar to the one observed in $CsNiCl_3$ (Keznelmann et. al. PRL **87** 017201). It constitutes the 5(3)% of inelastic magnetic scattering weight at $\boldsymbol{Q} = (1/3, 1/3, 1)$, which is much smaller than 9(2)% observed in $CsNiCl_3$ at $\boldsymbol{Q} = (0.81, 0.81, 1)$.