

# Experimental report

13/09/2024

**Proposal:** CRG-2969

**Council:** 10/2022

**Title:** Magneto-elastic coupling in the “Faraday-rotator” KTb3F10

**Research area:** Physics

**This proposal is a new proposal**

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**Samples:** KTb3F10

Instrument	Requested days	Allocated days	From	To
IN22	5	5	31/03/2023	06/04/2023

**Abstract:**

The abstract is in the scientific case pdf file.

**Experimental report on  
Magneto-elastic coupling in the “Faraday-rotator”  $\text{KTb}_3\text{F}_{10}$   
@IN22**

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**Scientific context:** As is well known for non-Kramers ions, the crystal-electric field (CEF) splits the  $(2J+1)$ -fold degenerate  $J$ -multiplet into a series of doublets but also singlets. The class of magnetic materials whose CEF ground state is *such a singlet*, like in  $\text{KTb}_3\text{F}_{10}$  is quite remarkable. Depending on the precise value of the gap to the excited states, the singlet state could be either well protected, or much more subtle, (so called “induced magnetism”) [1 -8].

In  $\text{KTb}_3\text{F}_{10}$ , the Tb ions occupy the vertices of a network of corner-sharing octahedra (cubic  $Fm-3m$  space group, see Ref [7]). Its CEF scheme encompasses a singlet ground state  $|O\rangle = |J=6, J_z=0\rangle$  and an excited doublet  $|\pm\rangle = |J=6, J_z=\pm 1\rangle$  at about 2.7 meV. Importantly, the  $z$  quantification axis changes from site to site, being one of the cubic axes [2]. Our modelling of the CEF levels leads to the fact that any field induced magnetic moment appears within the plane perpendicular to this local  $z$  quantification axis. Depending on the site, this plane is perpendicular to the local  $a$ ,  $b$  or  $c$  axis of the cell.

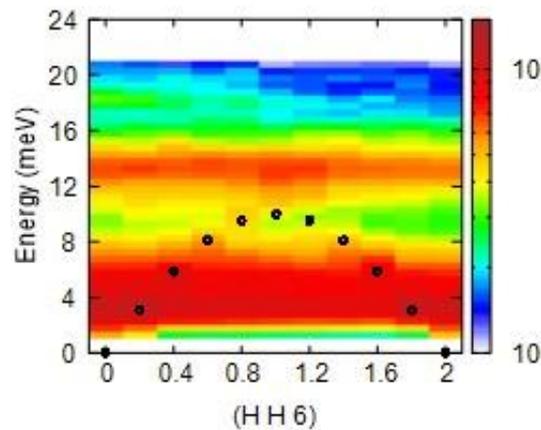


Figure 1 : Evolution of the first CEF mode as a function of  $Q$

A preliminary experiment carried out on IN8 (Figure 1) proved the measurement of any phonon intensity anomaly very challenging, as the low energy CEF levels in  $\text{KTb}_3\text{F}_{10}$  are very intense, making very difficult the extraction of the phononic signal. It was possible to determine approximately the dispersion (in various Brillouin zones and different condition, longitudinal and transverse), yet the careful estimation of the spectral weight was not possible. A nice way, however, to resolve this issue is to consider inelastic neutron scattering with polarization analysis. The SF and NSF channels (in  $P_x$  mode) indeed offer a simple possibility to disentangle the magnetic and lattice response.

The IN22 spectrometer was operated at  $k_f = 2.662 \text{ \AA}^{-1}$ . A high-quality single crystal ( $5 \times 5 \times 5 \text{ mm}^3$ , commercial, Northrop-Grumman) was oriented with  $[1-10]$  vertical.

Representative results of the 6 days spent at ILL are shown in Figure 2 where phonons were studied in the vicinity of the first excited CEF mode (2.7 meV).

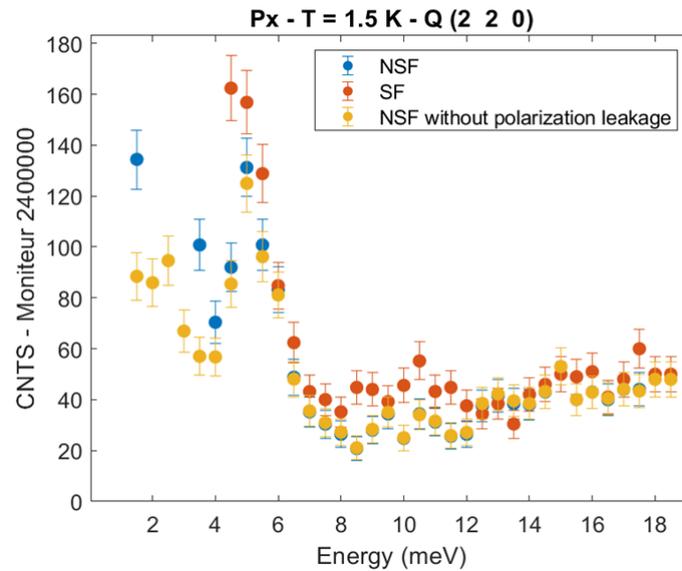


Figure 2 : Evolution of a transverse phonon

During the beam time, we tried to measure a magnetic signal from a phonon excitation (Spin Flip channel) as well as a lattice excitation response from a CEF excitation (NSF channel). The measurements show that the first excited mode of CEF can be observed in both SF and NSF channels.

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