Tunability of the spin reorientation transitions with pressure in $NdCo_5$ - supplementary material

Santosh Kumar,[1,a)] Christopher E. Patrick,[1] Rachel S. Edwards,[1] Geetha Balakrishnan,[1] Martin R. Lees,[1,b)] and Julie B. Staunton[1]

Department of Physics, University of Warwick, Coventry CV4 7AL, United Kingdom.

I. INTRODUCTION

The magnetic anisotropy constant, K_1, for the permanent magnet YCo_5 was estimated from magnetization data recorded at 200 and 265 K under different hydrostatic pressures. These data indicate that the magnetic anisotropy of the Co sublattice (Y is non-magnetic) decreases with pressure. This observation is supported by our calculations shown in Fig. 4(b) of the main text.

II. EXPERIMENTAL DETAILS

Single crystals of YCo_5, were grown using the optical floating zone technique.[1] For these experiments, a small single crystal of YCo_5 was isolated from the as-grown boule. The aligned crystal was loaded into a cylindrical PTFE sample holder with the *c*-axis either parallel or perpendicular to the direction of the magnetic field applied during the measurements. Care was taken to ensure the sample would not rotate in the sample holder when the applied field was perpendicular to the easy axis. The PTFE cylinder was filled with a pressure transmitting medium (Daphne oil) and placed in an easyLab Mcell 10 beryllium–copper piston clamp pressure cell. Hydrostatic pressure was applied at room temperature. The pressure in the cell was determined *in situ* from the superconducting transition temperature in a magnetic field of 1 mT of a small piece of high purity (99.9999%) tin placed alongside the sample.[2] Measurements were carried out at 200 and 265 K, close to the temperature of the spin reorientation transition in $NdCo_5$. Once the pressure is fixed, the pressure in the cell varies by less than 10% between 5 and 300 K.[3] Magnetization measurements as a function of applied field were carried out using a Quantum Design Magnetic Property Measurement System magnetometer.

III. MAGNETIC ANISOTROPY CONSTANTS ESTIMATED FOR YCO_5

The pressure dependence of the anisotropy constant K_1 in YCo_5 was investigated at 200 and 265 K, close to the temperatures at which the spin reorientation transition occurs in $NdCo_5$.

Figure S1(a) shows the magnetization versus field, $M(H)$, data recorded at $T = 200$ K and a pressure of 0.57 GPa with

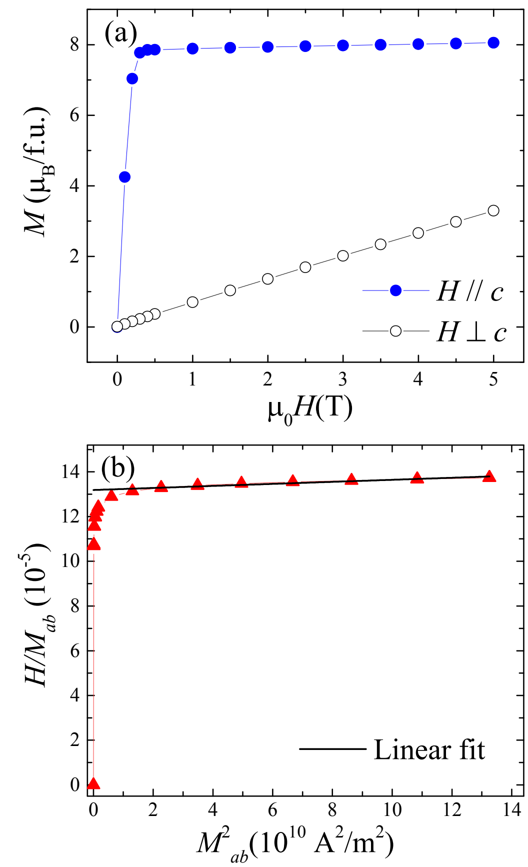

FIG. S1. (a) Isothermal dc magnetization versus applied magnetic field for a single crystal of YCo_5 at $T = 200$ K and a pressure of 0.57 GPa with $H \parallel c$ and $H \perp c$. (b) H/M_{ab} versus M^2_{ab} at the same temperature (200 K) and pressure (0.57 GPa). The line is a fit to the data made using Eq. S1.

the field applied parallel ($H \parallel c$) and perpendicular ($H \perp c$) to the easy axis of magnetization of YCo_5 and is typical of the data collected for this study. The Sucksmith-Thompson method[4] was used to determine the anisotropy constant K_1. The magnetization and applied field are related to the anisotropy constants K_1 and K_2 by

$$\frac{H}{M_{ab}} = 2K_1 + 4K_2(M_{ab}/M_0)^2, \quad \text{(S1)}$$

where M_{ab} is the magnetization in the *ab* plane (perpendicular to the easy axis) and M_0 is the saturated magnetization.

Figure S1(b) shows the variation of H/M_{ab} with M^2_{ab} at 200 K and 0.57 GPa obtained from the $M(H)$ curves in Fig. S1(a). H/M_{ab} is linear for higher values of M^2_{ab}. A linear fit to this portion of the curve yields the value of K_1 (intercept

a)Electronic mail: santosh.kumar595@gmail.com
b)Electronic mail: m.r.lees@warwick.ac.uk

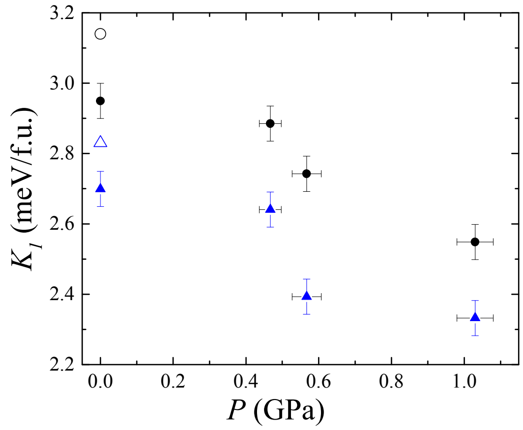

FIG. S2. Magnetic anisotropy constant K_1 versus pressure for YCo_5. The closed symbols show the experimental data collected under pressure at 200 (•) and 265 K (▲). The open symbols show K_1 at 200 (○) and 265 K (△) estimated from data collected at ambient pressure by Yermolenko.[5]

at $M_{ab}^2 = 0$). This method was used to determine the values of K_1 for YCo_5 at different pressures.

Figure S2 shows the K_1 values for YCo_5 as a function of pressure at two different temperatures (200 and 265 K). It is clear that K_1 decreases with pressure at both temperatures, and that at a given pressure K_1 falls with increasing temperature. A similar decrease in K_1 with temperature at ambient pressure is reported by several other authors who have studied YCo_5 including Yermolenko.[5] The decrease in K_1 with pressure observed here agrees with the calculations presented in Fig. 4(b) of the main text.

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