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ELSEVIER

Spin dynamics in the commensurate antiferromagnet PrCo_2Si_2 probed by muon spin relaxation measurements

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Abstract

Muon relaxation measurements on the uniaxial commensurate antiferromagnet PrCo_2Si_2 show that whereas the relaxation rate probing the fluctuations along the c -axis has a strong maximum at T_N , the rate probing the c -plane fluctuations presents only a weak maximum which occurs at ~ 3 K below T_N .

The study of modulated magnetic structures with a period commensurate with the basic lattice has recently attracted some interest. Among the considerable number of such structures in rare-earth intermetallic compounds [1], the compounds with collinear magnetic structures are particularly interesting because it is now possible to understand their magnetic phase diagrams [2]. Up to now only their static magnetic properties have been investigated in details. In this report we present a muon spin relaxation study of the spin dynamics near the critical temperature from the paramagnetic to the commensurate uniaxial antiferromagnetic phase transition of one of the simplest compound in this family: PrCo_2Si_2 . This study has been motivated by the peculiar result of Ref. [3], where it was noticed that the muon spin lattice relaxation rate extracted from data recorded on a sample where the initial muon beam polarisation, P_μ , was parallel to the c -axis had a maximum below the Néel temperature, T_N , and not at T_N as expected.

The ternary intermetallic compound PrCo_2Si_2 crystallises in the tetragonal ThCr_2Si_2 type of structure. It exhibits three magnetic phase transitions [4]. For all the three phases the magnetic moments are aligned along the c -axis and are coupled ferromagnetically to each other in the c -plane. The propagation vector of the magnetic structures writes $(0, 0, k)$ where k is in units of $2\pi/c$. The phases are distinguished by the stacking of their ferromag-

netic layers along the c -axis. Of interest here is the transition from the paramagnetic region to the antiferromagnetic phase characterised by the long-period commensurate spin structure with $k = 7/9$.

In this preliminary report we only consider the spectra recorded at the ISIS surface muon facility (of the Rutherford Appleton laboratory in UK) in applied magnetic fields sufficiently large to decouple the effect of the spin dynamics of purely electronic origin from the effect of the electronically enhanced ^{141}Pr nuclear magnetic moments (an example of this effect is given in Ref. [5] for PrRu_2Si_2). The spectra have been recorded in the longitudinal geometry (see Ref. [6] for details) on two single crystals which differ by the orientation of P_μ relative to their c -axis. They are all well described by the simple exponential depolarisation functions. Therefore they are characterised by an initial asymmetry, a , and a damping rate, λ , which is a measure of the spin lattice relaxation rate. $a(T)$ and $\lambda(T)$ near T_N are presented in Fig. 1. When P_μ and the c -axis are perpendicular we observe the anticipated critical slowing down of the magnetic fluctuations when approaching T_N , i.e. λ is maximum at T_N . On the other hand, when P_μ and the c -axis are parallel we only detect a weak increase of λ which is maximum at ≈ 3 K below T_N and not at T_N as one would expect. This weak increase reflects the short range correlations of the ferromagnetic domains (c -plane). The behaviour of $a(T)$ is peculiar: it drops at T_N when P_μ and c are perpendicular (a large internal magnetic field at the muon can not be resolved at ISIS) and decreases slightly when P_μ and c are parallel. Although a reliable interpretation of the $a(T)$ behaviour must await a more detailed experimental study, we notice that this be-

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haviour can be understood if some of the muons probe regions in the sample where the internal field at the muon is perpendicular to the c -axis. This type of regions must exist in domain walls.

In Fig. 2 we present the critical paramagnetic region of $\lambda(T)$. We notice that whereas $\lambda(T)$ follows a power law with an exponent of $w = 1.10$ (5) at sufficiently high temperature, it is almost temperature independent near T_N . The strong increase of λ observed when approaching T_N from above reflects the slowing down of the fluctuations. This slowing down ceases very near T_N (at ~ 0.5 K above T_N) probably because the magnetic correlation length can

Fig. 1. Temperature dependence of the initial asymmetry and the exponential damping rate measured on single crystals of PrCo_2Si_2 . The measurements have been performed either on a sample with the c -axis parallel (empty symbol) or perpendicular (filled symbol) to the initial muon beam polarisation. The data have been recorded with a magnetic field of 0.4 T (empty symbol) or 0.2 T (filled symbol) applied along the initial muon beam polarisation. The values of the initial asymmetry for the two samples in the paramagnetic phase are different only because the two data sets have been recorded in different geometrical conditions.

Fig. 2. Logarithmic plot of the damping rate extracted from the data recorded near the Néel temperature, T_N ($T > T_N$). The measurements have been performed in an applied longitudinal field of 0.2 T on the sample with the c -axis perpendicular to the initial muon beam polarisation. The full line is a fit to the data with a power law of exponent w .

not be longer than the distance between the antiphase domains.

If we suppose that the fluctuations are characteristic of an antiferromagnet with $(d, n) = (3, 1)$ (d being the dimension of space and n the dimension of the order parameter), we calculate $w = 0.74$ [7]. This is not in agreement with the experimental result.

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