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**Polarisation dependence of the spin-density-wave excitations in
single-domain chromium**

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A polarised neutron scattering experiment has been performed on a single-Q, single domain sample of Cr in a magnetic field of 4 T in the transverse spin-density-wave phase. It is confirmed that the longitudinal fluctuations are enhanced for energy transfers $E < 8$ meV similarly as in the longitudinal spin-density-wave phase. The spin wave modes with δS parallel and perpendicular to Q are isotropic within the E-range investigated.

Keywords: Antiferromagnetism, incommensurate, itinerant, polarised neutrons

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1. Introduction

Chromium is a very fascinating magnetic material [1]. At $T_N = 311$ K it undergoes a transition from a paramagnetic phase to a transversely polarised spin-density-wave phase (TSDW) characterised by incommensurate wave vectors $Q_{\pm} = (1 \pm \delta \ 0 \ 0)$. At the spin flip temperature $T_{sf} = 121$ K a transition to a longitudinally polarised phase (LSDW) occurs. The magnetic excitations exhibit many unusual features, in particular, the spin wave branches originating from the magnetic satellite positions are extremely steep and very difficult to resolve.

Measurements using unpolarized neutrons have shown unambiguously that the longitudinal excitations are enhanced for $E < 8$ meV in the LSDW phase [2,3]. In the TSDW phase, the fluctuations perpendicular to Q are also enhanced below 8 meV [2], however, it was not clear, which modes are enhanced because at least three different modes (L, T_1 , and T_2 , see Fig. 1b) contribute to the scattering cross section. A clear separation is only possible with polarised neutrons on a single- Q , single-domain sample (Fig. 1c).

The neutron scattering experiments were performed using the IN20 polarised-neutron triple axis spectrometer at the Institut Laue-Langevin in Grenoble. The crystal was cooled through T_N in a magnetic field of 20 T in order to induce a single- Q state. During the experiments, a vertical field $H = 4$ T was applied along $[001]$ in order to enforce a single-domain state with the magnetic moments lying in the $(h \ k \ 0)$ scattering plane (Fig. 1c). The flipping ratio at $(1-\delta \ 0 \ 0)$ was 12 indicating that essentially all moments are aligned in the $(h \ k \ 0)$ plane. The constant- Q scans were conducted at the $(1-\delta \ 0 \ 0)$

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and $(\delta \ 1 \ 0)$ satellite positions (Fig. 1a). Table 1 lists the fluctuation modes that can be measured at these positions with the spin flipper on and off. The background has been determined by measuring the spin-flip and non-spin-flip scattering at $(0.7 \ 0.7 \ 0)$. It has not been subtracted from the data.

2. Results

The data in Fig. 2 shows clearly that the longitudinal fluctuations are enhanced below 8 meV, similarly as in the LSDW phase [2,3]. In contrast, the spin wave modes T_1 and T_2 are essentially independent of E (Figs. 2 and 3). The increase of the intensity of the T_1 mode at $(1-\delta,0,0)$ and $(\delta,1,0)$ for $E < 5$ meV is most likely due to the increasing background and not due to magnetic scattering. The transverse fluctuations seem to be stronger above $E \cong 10$ meV than the longitudinal fluctuations, in contrast to the situation in the LSDW phase [3].

We have performed similar measurements at 299 K at the allowed and silent satellite positions [4]. The intensity of the allowed peaks decreases monotonically with increasing E . In particular, at $(1-\delta \ 0 \ 0)$, the T_1 mode approaches the longitudinal mode and the enhancement for $E < 8$ meV is lost. The magnetic intensity of the T_1 and T_2 mode at $(1 \ \delta \ 0)$ decreases also with increasing E , however, the overall intensities are larger maybe due to a resolution effect. The scattering at the silent satellite positions is substantial. Finally, we have investigated the polarisation dependence of the Fincher-Burke mode. Our results are in agreement with previous measurements by Pynn et al. [5] and confirm that the 4 meV commensurate mode at $(1 \ 0 \ 0)$ is of longitudinal origin.

Summarising, our measurements in the TSDW phase show that the spin wave modes T_1 and T_2 are essentially identical. At low T , the longitudinal mode is enhanced below $E \cong 8$ meV, similarly as in the LSDW phase. Close to T_N , this enhancement vanishes, i.e. the phase transition to the paramagnetic phase is driven by the longitudinal and the spin wave modes.

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3. References

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Table 1: Polarisation and selection rules for the magnetic fluctuation modes in single-domain Cr.

momentum transfer	non spin flip	spin flip
$(1-\delta,0,0)$	T_1	L
$(\delta,1,0)$	T_1	T_2

4. Figure Captions

Fig. 1: a) Brillouin zone of bcc Cr. The squares and circles represent chemical Bragg peaks and magnetic satellites, respectively. The filled circles indicate the visible satellites in the single-Q state. b) Definition of the three different polarisation modes. c) Schematics of a single-domain TSDW.

Fig. 2: Polarisation dependence of magnetic fluctuations at $(1-\delta \ 0 \ 0)$ in the TSDW phase. The longitudinal mode is enhanced below 8 meV, when compared with the T_1 mode. The backgrounds for the spin-flip (sf) and non-spin-flip (nsf) scattering are given by the solid lines.

Fig. 3: Polarisation dependence of the spin wave modes T_1 and T_2 at $(\delta \ 1 \ 0)$ in the TSDW phase. The spin-flip and non-spin-flip backgrounds are given by the solid lines.

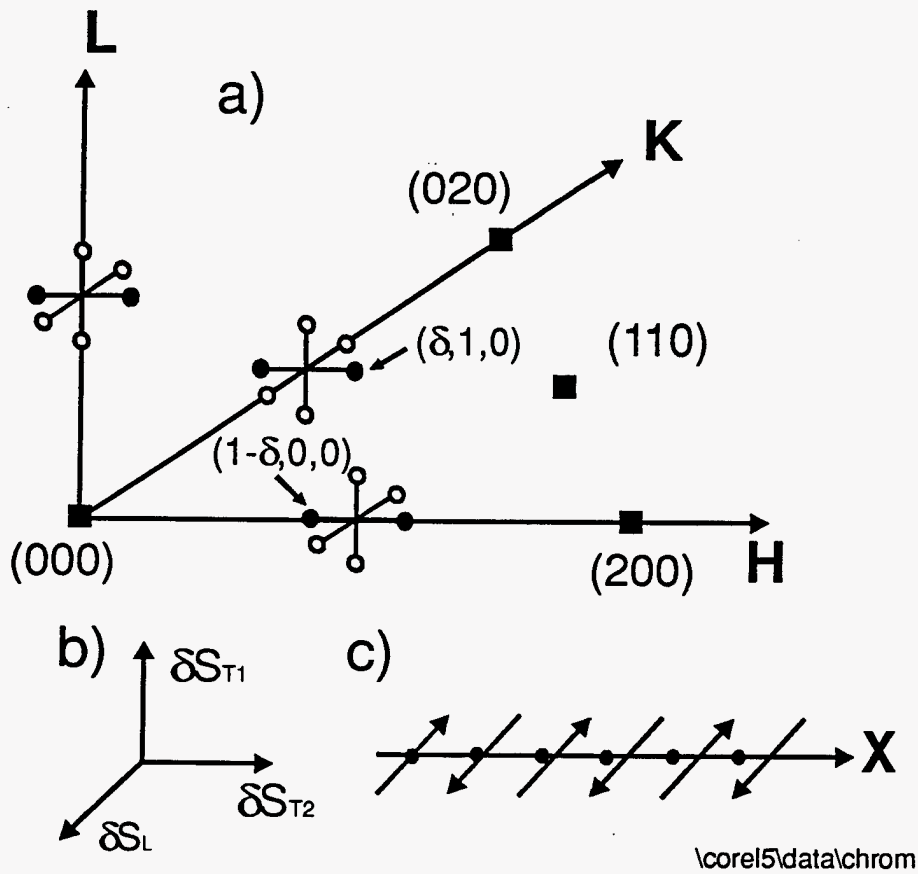


Fig. 4
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Cr

Cr (#10) (1- δ 0 0) T=136K

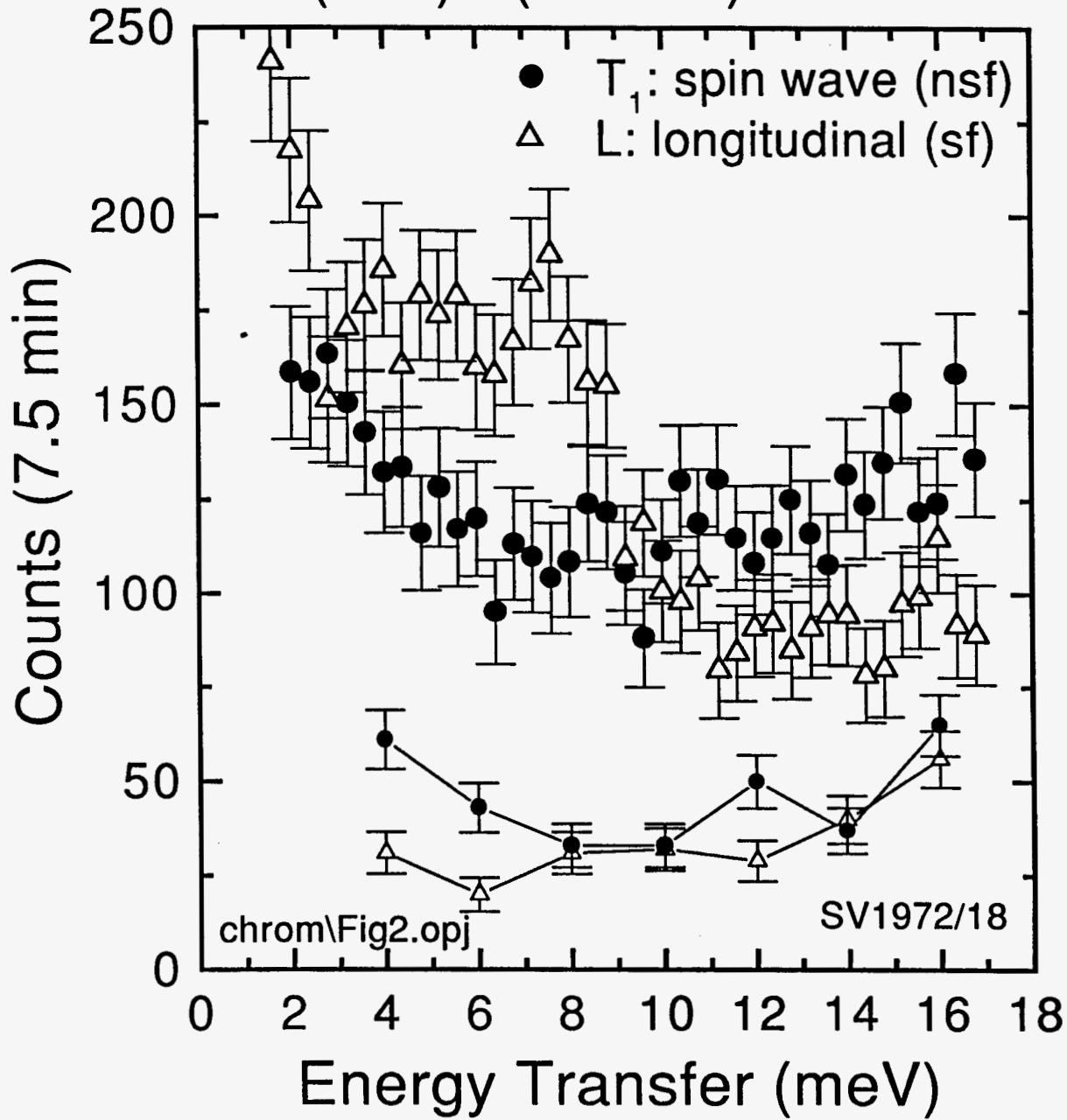
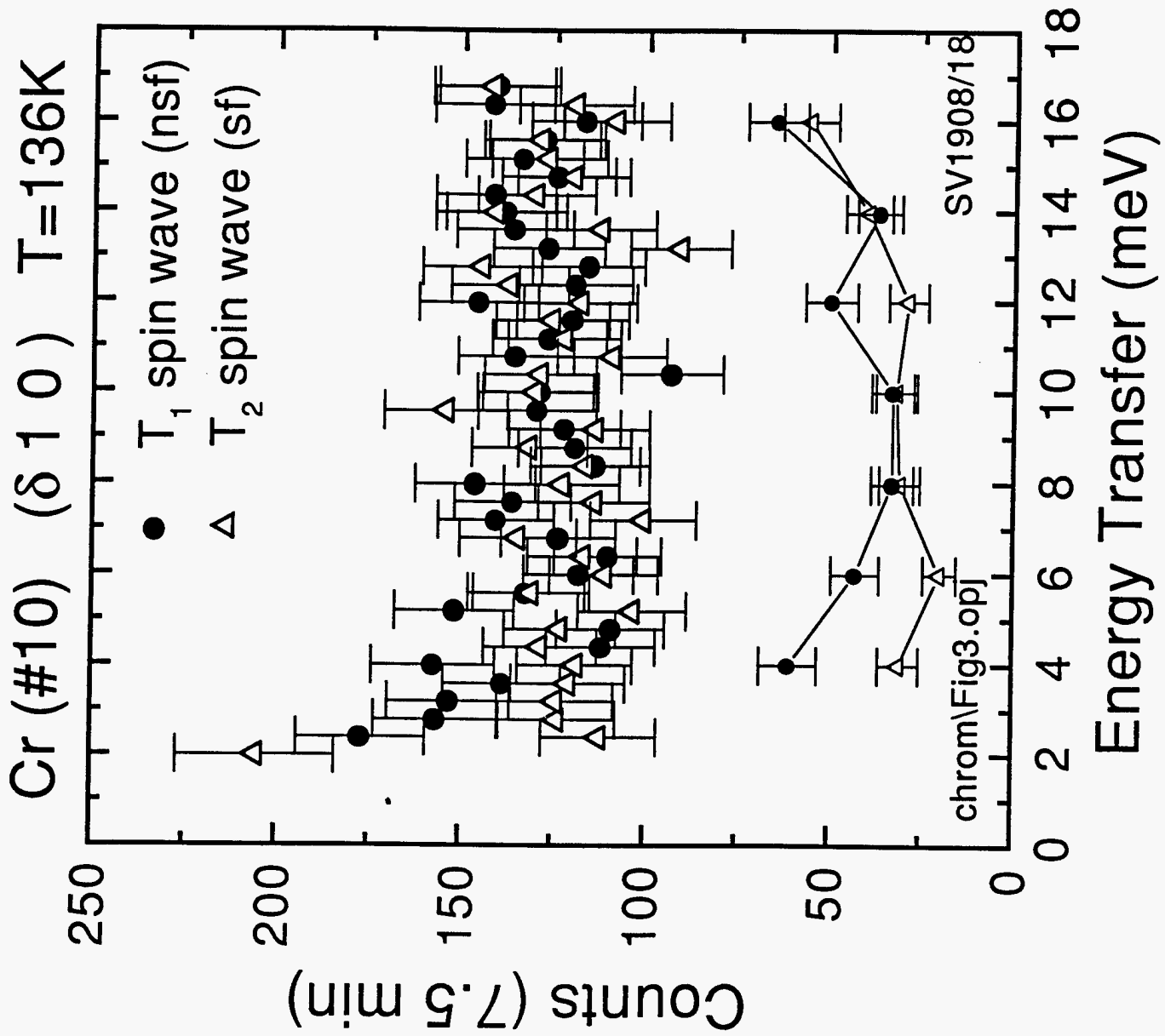


Fig. 2
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Cr

Fig. 3
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