DISORDERED, LOW ENERGY COMPONENT OF THE MAGNETIC RESPONSE IN BOTH ANTI-
FERROMAGNETIC AND SUPERCONDUCTING Y-Ba-Cu-O SAMPLES

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INTRODUCTION

Neutron scattering lends itself as a prominently powerful and direct tool to the investigation of magnetic phenomena, under the assumption that the magnetic scattering effects can be unambiguously identified and separated from an often stronger background of non-magnetic signal. This is the case in particular with relatively small magnetic effects, such as in high Tc superconductors. Magnetic Bragg peaks and excitations around them can be well identified by their localized character in the reciprocal space. On the other hand, the hardly q dependent diffuse scattering from magnetic disorder can only be identified by the use of polarization analysis, which implies a dramatic loss of neutron intensity, i.e. sensitivity. This latter kind, much more limited studies performed by now are complementary to the single crystal work described in other contributions in this volume and they provide evidence for the existence of a disorder type, relatively low frequency range contribution to the total magnetic response in Y-Ba-Cu-O compounds. This "impurity" kind magnetism is expected to also manifest itself in µSR and NMR experiments.

EXPERIMENTAL

As of today the best neutron flux conditions in neutron spin polarization analysis can be achieved at relatively long neutron wavelengths (4-6 Å, i.e. low neutron energies of 5-3 meV) by the application of supermirror optical devices as opposed to the conventional magnetic crystals. The main feature of these devices is that, in contrast to the crystals, they are not energy selective. This allows us, on the one hand, to use a relatively broad wavelength band to increase the flux, but, on the other hand, it makes us lose most information on the inelasticity of the scattering, i.e. on the frequency of the observed magnetic fluctuations. Thus, similarly to neutron diffraction work without energy analysis, we have a "constant scattering angle" situation (cf. Fig. 1) as opposed to the more familiar and favourable "constant momentum transfer q" situation of triple-axis spectroscopy. In the detector (which also includes the polarization analyser device) we record simultaneously various outgoing neutron momenta $k'$, consequently various q vectors and neutron energy changes. The uncertainty of the direction of q essentially influences the interpretation of the polarization analysis data, since in a "paramagnetic", i.e. macroscopically magnetically isotropic sample (e.g. a polycrystalline antiferromagnet) the polarization $P'$ of the magnetically...
Fig. 1. "Constant scattering angle" experimental configuration showing a few possible scattering triangles with different $q$ vectors.

Fig. 2. Choice of reference directions in "three directional polarization analysis" in order to check the inelasticity of the scattering.

The scattered beam is parallel to $q$, as given by the well known Halpern-Johnson relation:

$$P' = -q(Pq)/|q|^2 = P'(P)$$  \hfill (1)

where $P$ is the incoming beam polarization. The polarization of the scattered beam is independent of the direction of $q$ for nuclear or nuclear spin scattering. The characteristic $q$ dependence (1) is used to identify magnetic scattering effects. However, since in our case the incoming beam direction and the position of the detector only determines the scattering plane (say horizontal) but not the direction of $q$ within this plane, we have to apply a special trick, the so-called "three directional polarization analysis" method, which has been first introduced by the Leningrad group\textsuperscript{2} and somewhat later, independently, at the Institut Laue-Langevin (ILL) in Grenoble\textsuperscript{3}. This method consists of determining the spin flip (sf) and non-spin-flip scattering intensities for 3 mutually perpendicular incoming beam polarization $P$ directions $x$, $y$ and $z$. It is preferable to make one of these, say $y$, vertical, i.e. in any case perpendicular to $q$. Thus in view of (1) $P'(y)=0$. Now, if the angle between $q$ and $x$ is named $\alpha$, we have $|P'(x)|=\cos^2 \alpha$ and $|P'(z)|=\sin^2 \alpha$. Thus the sum of the scattered beam polarizations measured in the 3 directions is $-I$, independently of the direction of $q$. If, in addition, we choose e.g. $z$ to be the bisector of the scattering angle $\delta$, (cf. Figs. 1 and 2) we also can obtain some information on the inelasticity of the scattering purely from the polarization analysis measurement, as first pointed out by Maleev\textsuperscript{4}. Namely, for purely elastic scattering now $q \parallel x$, and hence $P'(x)=0$, while inelastic scattering contributes to both $P'(x)$ and $P'(z)$, cf. Fig. 2, and the ratio $|P'(x)|/|P'(z)|$ is related to the effective inelastic linewidth. (More details can be found in Refs. 3 and 5.)

Another experimental aspect is particularly relevant for the present case. The two strongest contributions to the elastic non-magnetic