

**Experiment title:**

Nuclear resonant forward scattering and phonon-assisted scattering on  $^{57}\text{Fe}$  complexes: Pilot studies for investigation of Fe proteins

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CH 114

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**Report:****Studies of dynamic molecular properties : temperature induced superparamagnetic relaxation**

Among the various dynamic properties of biomolecules we have selected for the present pilot studies the superparamagnetic relaxation behavior which is characteristic for the iron-mineral core in ferritins, the iron-storage protein in a variety of living systems including vertebrates. The goethite-like ( $\text{FeOOH}$ ) core in ferritins and in corresponding biomimetic analogies exhibits at low enough temperature a static magnetic moment giving rise to magnetic hyperfine interaction in the  $^{57}\text{Fe}$  nucleus (Trautwein et al., 1991) and therefore to a characteristic pattern in the NFS spectrum with high quantum-beat frequency (Fig. 1). At elevated temperature, depending on the site of the nanocrystalline  $\text{FeOOH}$  core, the magnetic moment undergoes temperature-induced directional relaxation (termed superparamagnetic relaxation). Because of the stochastic nature of this process coherent interference within the nuclear scattering process is no longer possible and, hence, the NFS intensity significantly decreases under these conditions (at ca. 35-40 K in Fig. 1 and 2). At high enough temperature, in the fast relaxation limit, where the time average of the magnetic hyperfine interaction becomes zero, the coherence condition is again preserved and the NFS intensity reappears.

we draw from our studies the general conclusion that the NFS intensity of  $^{57}\text{Fe}$  is sensitively influenced by dynamic molecular properties because of their stochastic nature.

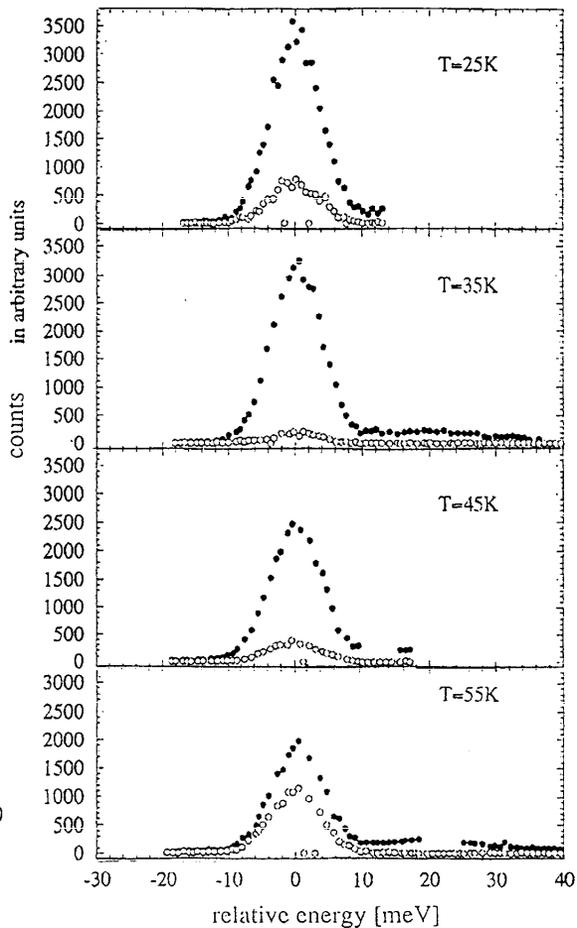
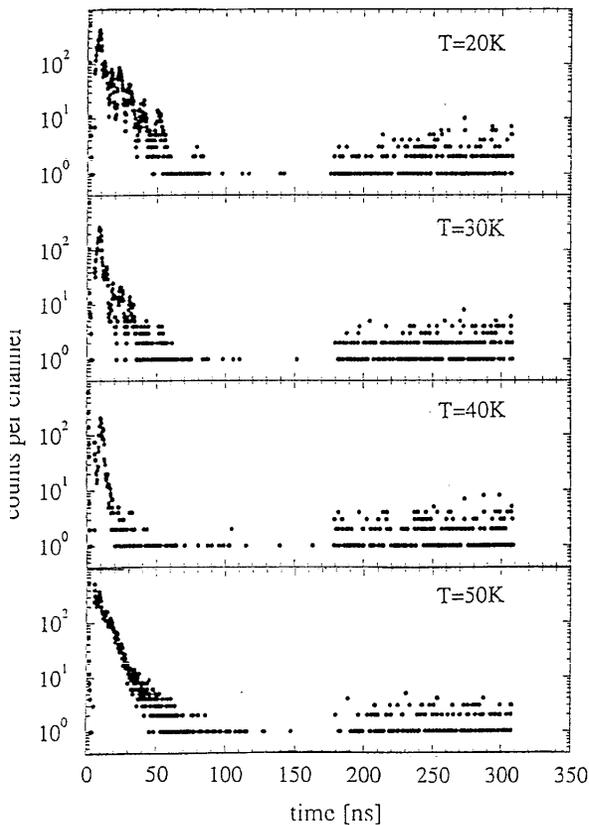


Fig. 1 (left): Nuclear resonant forward scattering spectra of nanocrystalline  $^{57}\text{FeOOH}$ , exhibiting superparamagnetic relaxation between 30 and 40 K.

Fig. 2 (right): Energy dependence of time-averaged scattering intensity (rocking curve) in forward scattering geometry (open circles) and in  $4\pi$  geometry (closed circles), normalized to single bunch current in hybrid mode.