Dependence of the Electric Field Gradient of Ir in Fe on the Direction of Magnetization with Respect to the Crystallographic Axes ◇

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1. Motivation

It is known since long that a small electric quadrupole interaction exists in dilute alloys of nd elements in Fe, fcc-Co and Ni, despite of the cubic symmetry of these lattices. This has been ascribed to an electric field gradient (EFG) which originates from an unquenched orbital momentum at the impurity site. Until now it was generally assumed that this EFG is invariant with respect to the crystallographic axes. Experimental results in the literature seemed to prove this feature. Several of our experiments performed in the last years – especially the observed magnetic-field dependence of the effective quadrupole interaction – pointed to a noninvariance of this EFG. Therefore measurements were performed with an Fe single crystal sample.

2. Experimental Method and Results

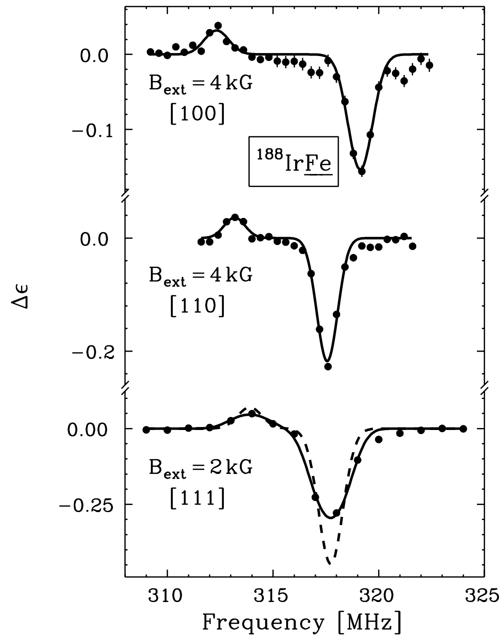

Fig. 1: NMR-ON resonance of ^{188}IrFe$^{(sc)}$ measured for magnetization parallel [100] (top), [110] (middle), and [111] (bottom).

Radioactive ^{188}Hg which is a precursor of ^{188}Ir was implanted at ISOLDE/CERN into an Fe single crystal. With a ^{3}He-^{4}He-dilution refrigerator the samples were cooled to temperatures of $\sim$ 5 - 10 mK. Then QI-NMR-ON (quadrupole-interaction-resolved NMR) and MAPON (modulated adiabatic passage on oriented nuclei) measurements were performed for magnetization parallel to the crystallographic [100], [110], and [111] axes. The results are shown in figs. 1 and 2.

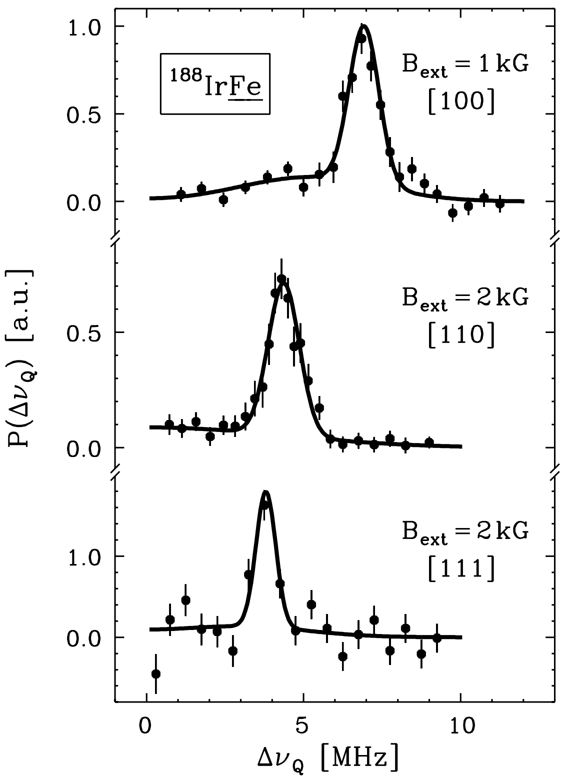

Fig. 2: Derivatives of the MAPON spectra for ^{188}IrFe$^{(sc)}$, which represent the distribution of the quadrupole splitting $P(\Delta\nu_Q)$.

Both methods yield consistently that the quadrupole interaction depends strongly on the direction of magnetization with respect to the crystallographic axes. The final results for the EFGs are $-0.394(6) \times 10^{17}$, $-0.249(4) \times 10^{17}$, and $-0.216(5) \times 10^{17}$ V/cm^2 for the [100], [110], and [111] directions, respectively. Thus, contrary to all previous experiments, a strong dependence of the electric field gradient on the direction of the magnetization with respect to the crystallographic axes was observed for the first time. A full description of this work is given in ref. [1].

References

[1] G. Seewald, E. Hagn, E. Zech, D. Forkel-Wirth, A. Burchard and ISOLDE Collaboration, Phys. Rev. Lett., in press

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