Observation of a Nuclear-Magnon Contribution to the Nuclear Spin-Lattice Relaxation of ^{191}Pt in Ferromagnetic Cobalt ◇

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The nuclear spin-lattice relaxation (NSLR) of impurity nuclei in the ferromagnetic host lattices Fe, Co, and Ni has been the subject of many investigations both experimental and theoretical. Nevertheless, not all mechanisms which are responsible for the relaxation process are understood in detail. The strength of the NSLR is described by a relaxation rate

$$R = 1/C_{\mathrm{K}}, \tag{1}$$

where C_{K} is a specific constant for each impurity-host system, analogous to the Korringa constant. At present, it is an open question whether an electronic spin-wave mechanism yields an appreciable contribution to the relaxation rate.

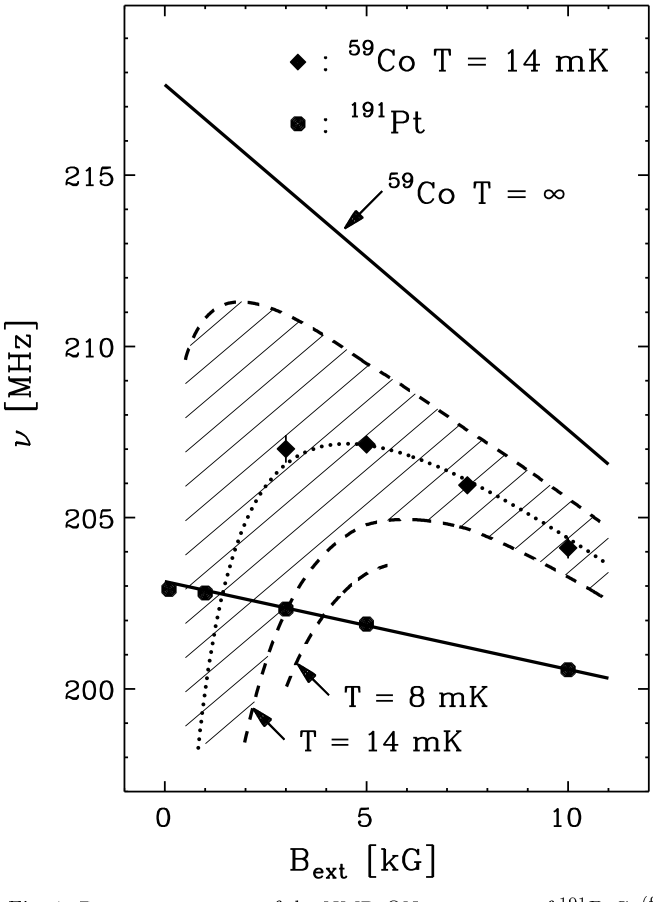

Fig. 1: Resonance centers of the NMR-ON resonances of ^{191}PtCo$^{(fcc)}$ (circles) and ^{59}CoCo$^{(fcc)}$ (rhombs) for $T = 14(1)$ mK. The shaded area enveloped by the dashed curves represents the 2σ frequency region in which 95% of the rf absorption by the $k = 0$ nuclear-magnon excitations takes place. In addition, the calculated lower bound for the 95%-absorption region for $T = 8(1)$ mK is shown by a dashed curve. It is evident that the overlap region between the ^{191}PtCo$^{(fcc)}$ resonance and the $k = 0$ nuclear-magnon excitation mode shifts to a higher value of B_{ext} with decreasing temperature.

Here we have addressed the question whether *nuclear* spin waves have an influence on the nuclear spin-lattice relaxation (NSLR) of impurity nuclei in the ferromagnetic host lattice fcc-Co. The nuclear spin waves are due to a collective coupling of the ^{59}Co nuclear spins via the long-range Suhl-Nakumura interaction. The nuclear-magnon dispersion relation can be influenced experimentally via the external magnetic field *and* the temperature, as has been shown recently for hcp-Co with calorimetric detection of NMR (CD-NMR) [1]. The hyperfine interaction of ^{59}Co and ^{191}Pt in fcc-Co were measured with calorimetric detection of NMR and nuclear magnetic resonance on oriented nuclei (NMR-ON), respectively. The result is shown in Fig. 1. It is evident that the ^{191}PtCo$^{(fcc)}$ resonance overlaps with the ^{59}Co $k = 0$ nuclear-magnon excitation mode for small external magnetic fields B_{ext} and that the overlap region depends on the temperature T. For this overlap region the rate of the NSLR and the rf-enhancement η^2 increase by about two orders of magnitude. This is illustrated in Fig. 2.

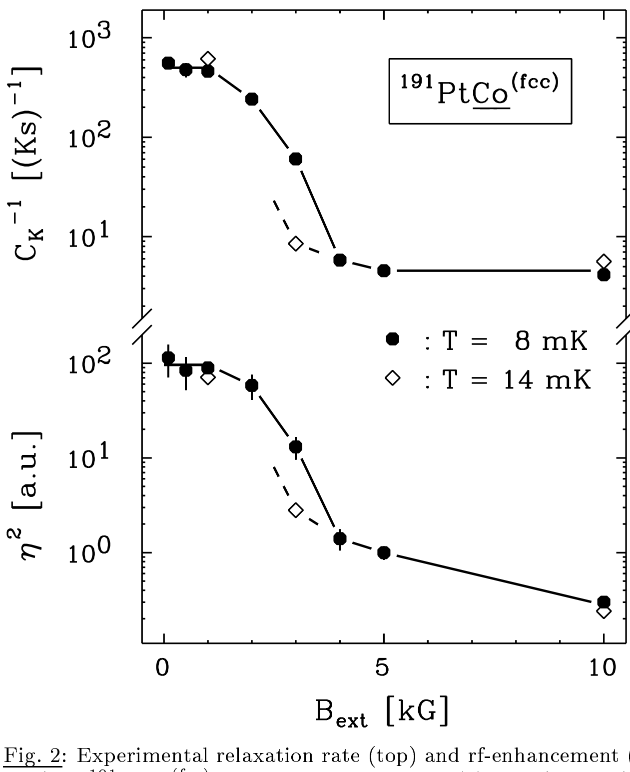

Fig. 2: Experimental relaxation rate (top) and rf-enhancement (bottom) of ^{191}PtCo$^{(fcc)}$ versus B_{ext} for $T = 14(1)$ mK (rhombs) and 8(1) mK (circles). The transition from "normal" to fast relaxation is shifted to a higher external magnetic field for lower temperature.

A full description of this work is given in [2].

References

[1] G. Seewald, E. Hagn, E. Zech, Phys. Lett. A **220** (1996) 287
[2] G. Seewald, E. Hagn, E. Zech, Phys. Rev. Lett. **78** (1997) 5002

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