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Prolongation of Nuclear Exciton Lifetime by Switching Off the Coherent Decay	HE-183

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Names and affiliations of applicants (*indicates experimentalists):

Yu.V. Shvyd'ko*, E. Gerdau*,
Universität Hamburg, II. Institut für Experimentalphysik, D-22761 Hamburg, Germany

U. van Bürck*, P. Schindelmann*, W. Potzel*, T. Hertrich*
Physik-Dep.E15, TUM, 85748 Garching, Germany

V.G. Kohn
RRC "Kurchatov Institute", 123182, Moscow, Russia

A.I. Chumakov*
ESRF, Grenoble Cedex 9, BP 220, F-38043, France

Report:

The experiment was aimed at continuing our studies of fast 90" switching of the magnetisation during coherent nuclear excitation by synchrotron radiation (SR) [1,2]. In particular, it was intended to improve the conditions of the initial switching off and the later recovery of the coherent scattering by a new switching geometry, where instead of transverse switching with respect t,o t,he beam [2] the magnetisation was switched into a direction almost along the beam. In addition, the switching was now to be performed by two alternating, mutually perpendicular magnetisation signals, where one wa.s produced by a small coil, and for steric reasons the other by a stripeline. The different geometry and the different switching mode required a new magnetisation cell and new pulse electronics.

The time dependences of the perturbed nuclear scattering in the X-ray allowed Bragg geometry reflection (222) of a perfect single crystal of $^{57}FeBO_3$ were measured. At the arrival of the SR flash, the crystal was magnetized in the way that only the nuclear $\Delta m=0$ transitions were excited. At, time t_1 aft,er the excitation the magnet,isation was switched by 90" into the longitudinal direction. After a pulse duration T the magnetisation was switched back. The time spectra of the Bragg reflection were studied as a function of t_1 and T. The analysis of the experimental results by means of a new computer programme developed for t,hat purpose [3] still under way. In the following we shall give prelimina.ry results only.

The alternating switching worked satisfa.ctorily. The change to the longitudinal switching geometry essentially improved the suppression of t.he integral scattered intensit,y during time T (I_{pT}), yielding now a reduction of I_{pT} with respect to the unperturbed intensity in the same t,ime window (I_{oT}) by almost a factor of 10. In the scattered intensity after switching back $(I_{pB}(t))$ well resolved $\Delta m=0$ quantum beats were observed (compare Fig.1), demonstrating the high quality of the switching process. In the course of the experiment, however, the crystal was obviously getting stressed due to heating by the magnetisation currents. The rocking curve width increased from initial 4" to final 10", and t,he reduction factor I_{oT}/I_{pT} decreased from about 10 to 4.

For the determination of the optimal position of the first switching point the dependence of I_{pT} on t_1 was measured. In analogy to previous results [1,2] it was expected to find minima of I_{pT}, when the magmetisation is switched at the times of the minima of the quantum beat with period of about 14 ns. By contrast, the observed first three minima were separated by about 7 ns only. This important result is not yet understood.

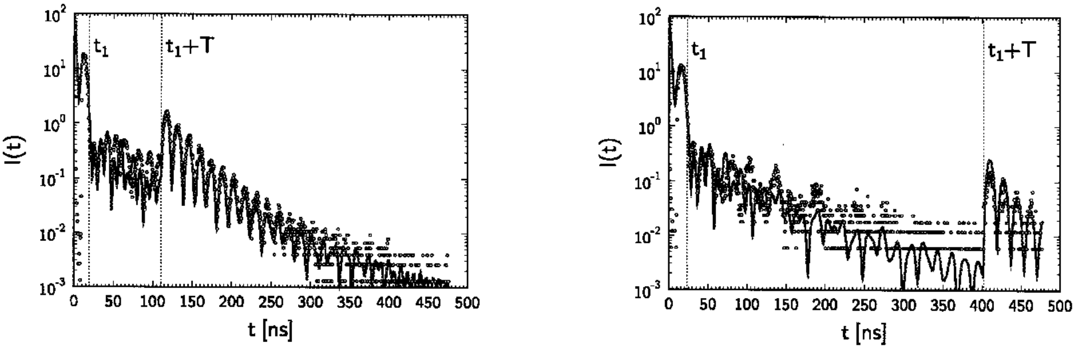

Fig.1 Typical time spectrum of the scattered intensity $^{57}FeBO_3(222)$ perturbed by switching forth at t_1 and back at t_1+T.

For the study of the dependence of $I_{pB}(t)$ on the pulse length T, the first switching was fixed at that time t_1 which corresponded to the second, most pronounced minimum of I_{pT}. The integral scattering after switching back (I_{pB}), normalized to the total intensity of the unperpurbed spectrum (I,), was found to decrease with a natural decay law. thus confirming the main result of [2]. This time, however, a pronounced oscillatory dependence of I_{pB} on the pulse length T was observed (see Fig.2). The modulation period increased with pulse duration T, because the heat load of the stripe line was increasing. leading to a rise of the crystal temperature and a corresponding reduction of the hyperfine splitting. The rise in temperature with T was independently registered by means of unperturbed spectra. which were measured alternatingly each second SR pulse. The observed modulation is in principle expected from a necessary periodicity in the rearrangement of the excitation currents after switching forth and back, and it was also predicted by the theoretical calculations [3]. However, it was not yet. possible to give a detailed interpretation of this effect, in particular to establish a satisfactory relation between the modulation period of about 30 ns and the hyperfine splitting.

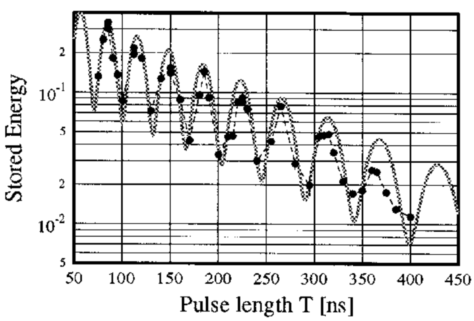

Fig.2 Dependence of the normalized integral scattered intensity I_{pB}/I_o on the pulse length T.

/1/ Yu.V. Shvyd'ko, A.I. Chumakov, G.V. Smirnov et al., Europhys. Lett. 26 (1994) 215.
/2/ Yu.V. Shvyd'ko, T. Hertrich, U. van Bürck et al.. Phys. Rev. Lett. 77 (1997) 3232.
/3/ V.G. Kohn and Yu.V. Shvyd'ko, to be published.