Angular dependence of the quantum beat of nuclear Bragg scattering

Takaya MITSUI, Yasuhiro KOBAYASHI[1], Makoto SETO[1], X.W.ZHANG[2]
Japan Atomic Energy Research Institute, 1-1-1 Kouto Mikazuki- cho
Sayo-gun Hyogo 679-5198, Japan
[1]Res. Reactor Institute, Kyoto Univ., Kumatori, Sennan, Osaka 590-0494, Japan
[2]KEK-PF, Tsukuba, Ibaraki 305-0801, Japan

Introduction

The (1 1 1) lattice planes of $^{57}FeBO_3$ (Iron borate) offer the unique possibility to study nuclear Bragg diffractions of quite different character. Especially, the (h h h) reflections allow for h=2n+1 purely nuclear reflections. It is due to the antiferromagnetic structure of iron borate. In addition the reflections with h=4n+2 should be nearly pure nuclear because of accidental cancellation of electric scattering amplitude of the unit cell. In pure nuclear reflections, all hyperfine transitions can be observed by contrast to the antiferromagnetic superlattice reflections, so that the quantum beat of Mössbauer time spectra are constructed by only the $m=\pm1$ transitions. On the other hand, for the reflections with h=4n+2, time spectrum may show the strong Bragg angular dependence for the spin alignments parallel or perpendicular to the scattering plane. In order to demonstrate the angular dependence of the quantum beat of nuclear Bragg scattering experimentally, Mössbauer time spectra in the reflections (2 2 2) {θ_B=10.266°} and (10 10 10) {θ_B=63.014°} were measured under the two different conditions; (Hex ⊥ Scattering plane and Hex // Scattering plane).

Experimental

The experiments performed at the NE3 undulator beam line of KEK. The experimental set-up is shown in Fig.1. A 4-bounce precision monochromator produced the σ-polarized X-ray with the energy width of 6.4meV at 14.4KeV nuclear resonance in ^{57}Fe. The static magnetic field (12Oe) were applied parallel to $^{57}FeBO_3$ single crystal surface and parallel or perpendicular to the scattering plane. Mössbauer time spectra of (2 2 2) refection and (10 10 10) refrection were measured by fast detector (APD).

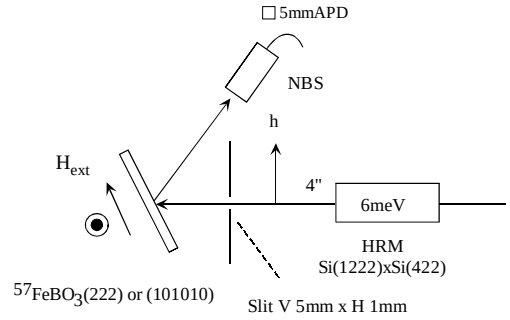

Fig.1:Schematic view of experimental setup

Results

The measured time spectra of reflections (10 10 10) and (2 2 2) are shown in Fig.2 (a),(b) and Fig.2 (c),(d) respectively; [(a),(c);H_{ex} ⊥ scattering plane, (b),(d);H_{ex} // scattering plane]. The time spectra of (2 2 2) reflection show the short periods of quantum beat related to $\Delta m=\pm1$ transitions [See Fig.2 (c),(d)]. On the contrary, the time spectra of (10 10 10) reflection show the obvious dependence for the external magnetic field conditions [See Fig.2 (a),(b)]. Especially, in the case of H_{ex} ⊥ scattering plane, only $m=0$ transitions contribute to the quantum beat of the time spectrum [See Fig.2 (a)]. Essentially, it is due to the Bragg angle dependence of polarization factors of nuclear Bragg scattering amplitudes. {Theoretical detail is described in Ref. [1].}

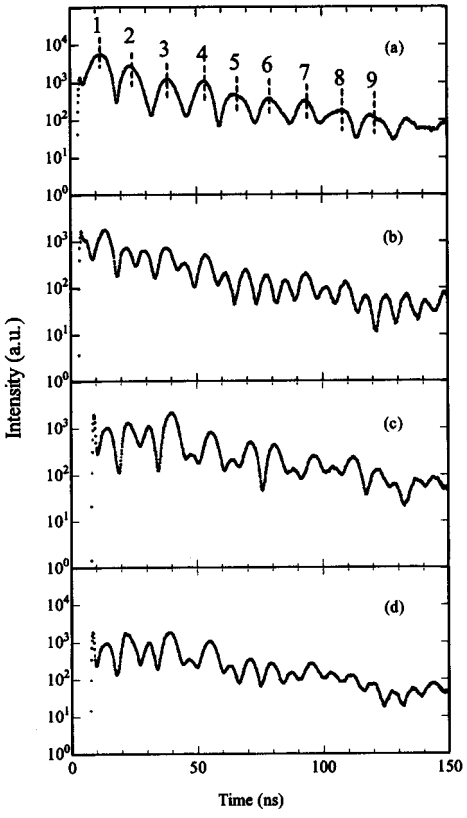

Fig.2: Time spectra of nuclear Bragg scattering of $^{57}FeBO_3$ in (10 10 10) and (2 2 2) reflections. [(a),(c);H_{ex} ⊥ scattering plane, (b),(d);H_{ex} // scattering plane]

References

[1] U.V.Bürck et al., J.Phys.C:Solid St.Phys.**13**, 4511 (1980).