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Influence of Time-Windows on NMR-PAC Line Shapes in Pulsed-Beam Experiments

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Spectroscopy of long-lived isomers populated by nuclear reactions requires pulsed beams in order to free the delayed decay from the intense prompt radiation. The time-windows introduced by the beam width, t_b, and the observation interval, $t_2 - t_1$, between the beampulses drastically change the resonance behavior compared to time-integral line shapes. The perturbation factor for the simplest geometry

$$G^{00}_{\lambda\lambda} = \frac{\int_0^{t_b} dt' \int_{t_1}^{t_2} \sum_p e^{-(t-t')(ip\omega_e+\tau^{-1})} d^{(\lambda)}_{0p}(\beta)^2 \, dt}{\int_0^{t_b} dt' \int_{t_1}^{t_2} e^{-(t-t')/\tau} \, dt}$$

contains oscillating terms in $p\omega_e t_1, p\omega_e t_2, p\omega_e(t_2 - t_b)$ and $p\omega_e(t_1 - t_b)$ which superimpose to patterns which have nothing in common with integral double-resonance shapes.[1] Here, ω_e is the precession frequency about the effective field in the rotating frame which is tilted by the angle β against the dc-field axis. Three facts emerge from the detailed calculation:

(1) The amplitude of the resonance effect can be enhanced by a factor 1.5, compared to the time-integral effect.
(2) Attenuation of the resonance amplitude due to relaxation effects can be partly compensated.
(3) In time-integral resonances the width is determined entirely by the rf-amplitude H_1. Proper time-settings can reduce the width of or splittings between individual components of the resonance structure to about the natural line width.

Four experimental examples of such time-window effects are shown in the figure. The resonances belong to the 120 μs (181 keV, $I = 4$) level in ^{78}Br, which was populated by a ^{78}Se(p, n)^{78}Br reaction. Parameters were: 1. beam width: 7 μs; 2. relaxation time for ^{78m}Br in liquid SeTl: 100 μs; 3. $H_1 = 12$ Gauss; 4. $|g| = 1.025$; 5. Frequency 101.37 KHz.

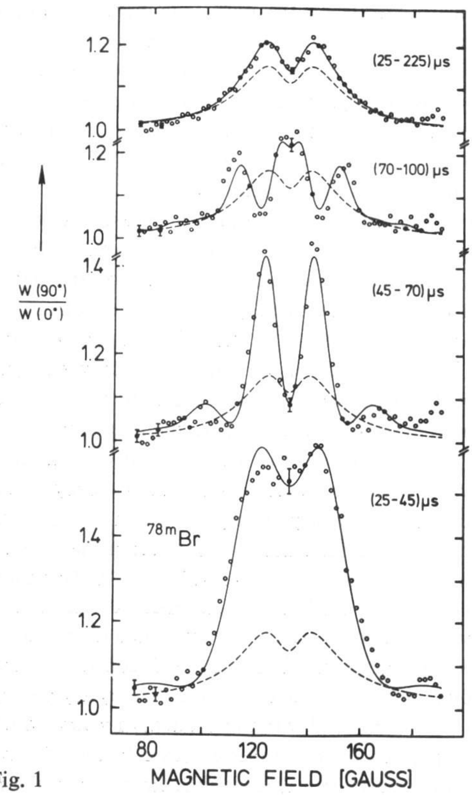

Fig. 1

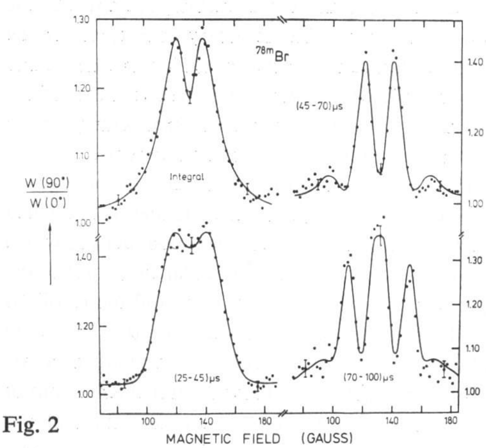

Fig. 2

Reference

1) E. Matthias *et al.*: Phys. Rev. **A4** (1971) 1626.