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Authors
Matsuta, K.
Ozawa, A.
Nojiri, Y.
et al.

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K. Matsuta, A. Ozawa, Y. Nojiri, T Minamisono, M. Fukuda, S Momota, T. Ohtsubo, S. Fukuda, K. Sugimoto, I Tanihata,[A] K. Yoshida,[A] K. Omata,[B] J.R. Alonso,[C] G.F.Krebs,[C] and T.J.M. Symons[C]

Department of Physics, Osaka Univ., Toyonaka, Osaka 560, Japan

(A) RIKEN, Wako, Saitama 351-01, Japan

(B) INS, The Univ. of Tokyo, Tanashi, Tokyo 188, Japan

(C) Lawrence Berkeley Laboratory, Berkeley, CA 94720, USA

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Department of Physics, Osaka Univ., Toyonaka, Osaka 560, Japan

(A) RIKEN, Wako, Saitama 351-01, Japan

(B) INS, The Univ. of Tokyo, Tanashi, Tokyo 188, Japan

(C) Lawrence Berkeley Laboratory, Berkeley, CA 94720, USA

NMR on the beta emitter ^{43}Ti has been observed by use of the β-NMR technique. From the observed NMR spectrum, the magnetic moment of ^{43}Ti was determined to be $|\mu| = (0.85 \pm 0.02)\ \mu_N$. The value is significantly quenched from the single particle value -1.91 μ_N, which shows a strong effect resulting from meson-exchange currents and configuration mixing.

1. INTRODUCTION

Magnetic moments of mirror nuclei have been an important testing ground of nuclear models and a probe for the non-nucleonic degrees of freedom in the nucleus, such as meson-exchange effects and quark effects. Although almost all the mirror moments in the p and sd shells have been measured, the measurement for $f_{7/2}$-shell mirror nuclei is very scarce because of the difficulty in producing such nuclei. In fact, only ^{41}Sc has been studied so far among the beta-emitting mirror nuclei in the $f_{7/2}$ shell. Meanwhile, the projectile fragmentation process in high-energy heavy-ion collisions is found to be a good tool to provide us with such unstable nuclei in a high production rate. We have been studying magnetic moments utilizing this production technique with the β-NMR technique. In the present experiment, NMR has been detected for beta-emitting ^{43}Ti (I^{π}=7/2^{-},$T_{1/2}$=0.50 sec) produced through the projectile fragmentation process to study magnetic moments of mirror nuclei and the reaction mechanism of the process.

2. EXPERIMENTAL PROCEDURE

The experimental method and equipments are essentially the same as the previous experiment on fragment polarization [1]. A schematic view of the present experimental setup is shown in Fig. 1. The ^{43}Ti nuclei were produced through the projectile fragmentation of ^{46}Ti at an effective energy of (116 ± 8) MeV/nucleon on a 260 mg/cm^2 thick C target. The ^{43}Ti nuclei emerging from the target to a deflection angle of 1.5° were purified and momentum analyzed by a fragment separator at the Bevatron of Lawrence Berkeley Laboratory. After a suitable energy degradation, the ^{43}Ti nuclei were implanted into a Pt foil cooled down to 90 K to maintain the polarization created in the collision during its lifetime. At this temperature, a spin-lattice-relaxation time T_1 was expected to be longer than 1.3 sec, which was estimated from the known T_1 of Sc and V in Pt considering the small g factor expected for ^{43}Ti. From the prior experiment, it was known that the degree of polarization reaches about 3% at the optimum momentum of ^{43}Ti fragment under the present conditions. An external magnetic field H_0= 6.878 kOe was applied to the Pt catcher region for maintaining the polarization and for NMR. Polarization of the ^{43}Ti was detected by means of asymmetric beta decay. A radio frequency (rf) magnetic field H_1 of about 20 Oe was applyed for 20 msec in the direction perpendicular to the external magnetic field to invert the spin ensemble by the Adiabatic Fast Passage (AFP) method in the NMR technique, in order to compare the resultant beta-decay asymmetry with that without spin inversion. A typical beta-ray counting rate was about 40 counts per beam-count cycle (4 sec).

3. RESULTS AND DISCUSSION

NMR effects for ^{43}Ti were observed as a function of rf frequency as shown in Fig. 2. A resonance was found at a frequency f= (1.27 ± 0.03) MHz in the NMR spectrum. From the resonance frequency, the magnetic moment of ^{43}Ti was deduced to be $|\mu|$ = (0.85 ± 0.02) μ_N. The value is significantly quenched from the single particle value -1.91 μ_N, which shows a strong effect resulting from meson exchange currents and configuration mixing. A shell model calculation with first order configuration mixing predicts - 0.754 μ_N [2], and the semi-empirical odd-nucleon model predicts - 0.784 μ_N [3], both of which reproduce the observed value fairly well.

For a more detailed discussion, the isoscalar and the isovector moments of the mirror pair were deduced to be $\mu^{(0)}$= 1.89(2) μ_N and $\mu^{(1)}$= -2.74(2) μ_N, respectively, from the measured moment of ^{43}Ti and the known moment of ^{43}Sc. While the isoscalar moment is very close to the single particle value, the isovector moment is strongly quenched as usually expected for the mirror pairs in the middle of a nuclear shell. The shell model calculation [2] with first order configuration mixing predicts $\mu^{(1)}$= -2.71 μ_N, which agrees with the present value very well. However, this may not be an indication that the meson exchange effect is negligible, but that the second order configuration mixing effect almost cancels the meson exchange effect, as is in the case of the mass A=40±1 system.

Thus, the present technique has been proven its effectiveness to the magnetic moment study of the $f_{7/2}$-shell-mirror nuclei.

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REFERNECES

[1] K. Matsuta, A. Ozawa, Y. Nojiri, T. Minamisono, M. Fukuda, A. Kitagawa, S. Momota, T. Ohtsubo, Y. Matsuo, H. Takechi, S. Fukuda, I. Minami, K. Sugimoto, I. Tanihata, K. Omata, J.R. Alonso, G.F. Krebs, and T.J.M. Symons, Phys. Lett. B 281 (1992)214.

[2] H. Miyatake, K. Ogawa, T. Shinozuka, and M. Fujioka, Nucl. Phys. A470 (1987) 328.

[3] S.M. Perez, Phys. Rev. C 36 (1987) 1202.

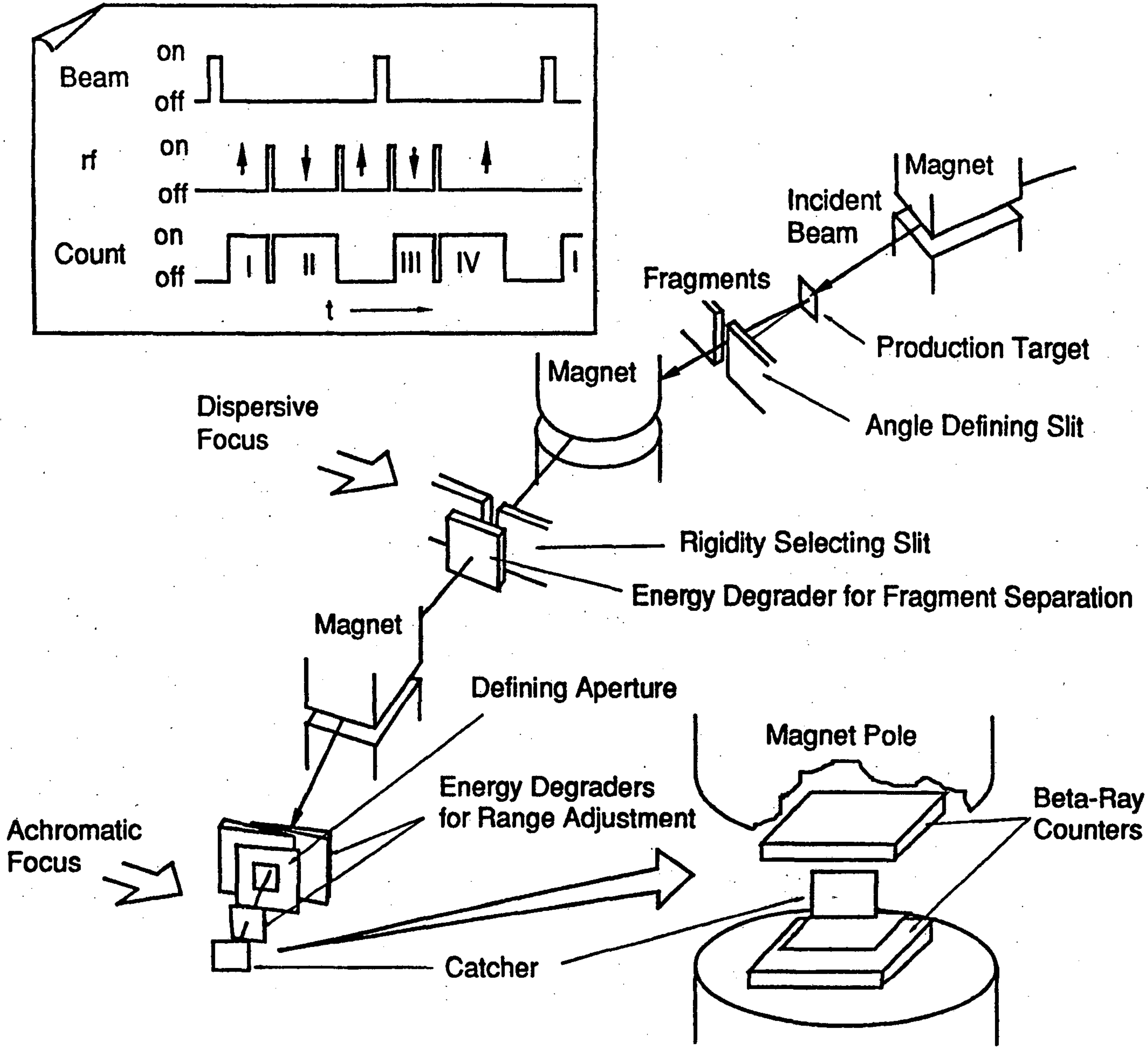

Fig. 1. Schematic view of experimental setup.

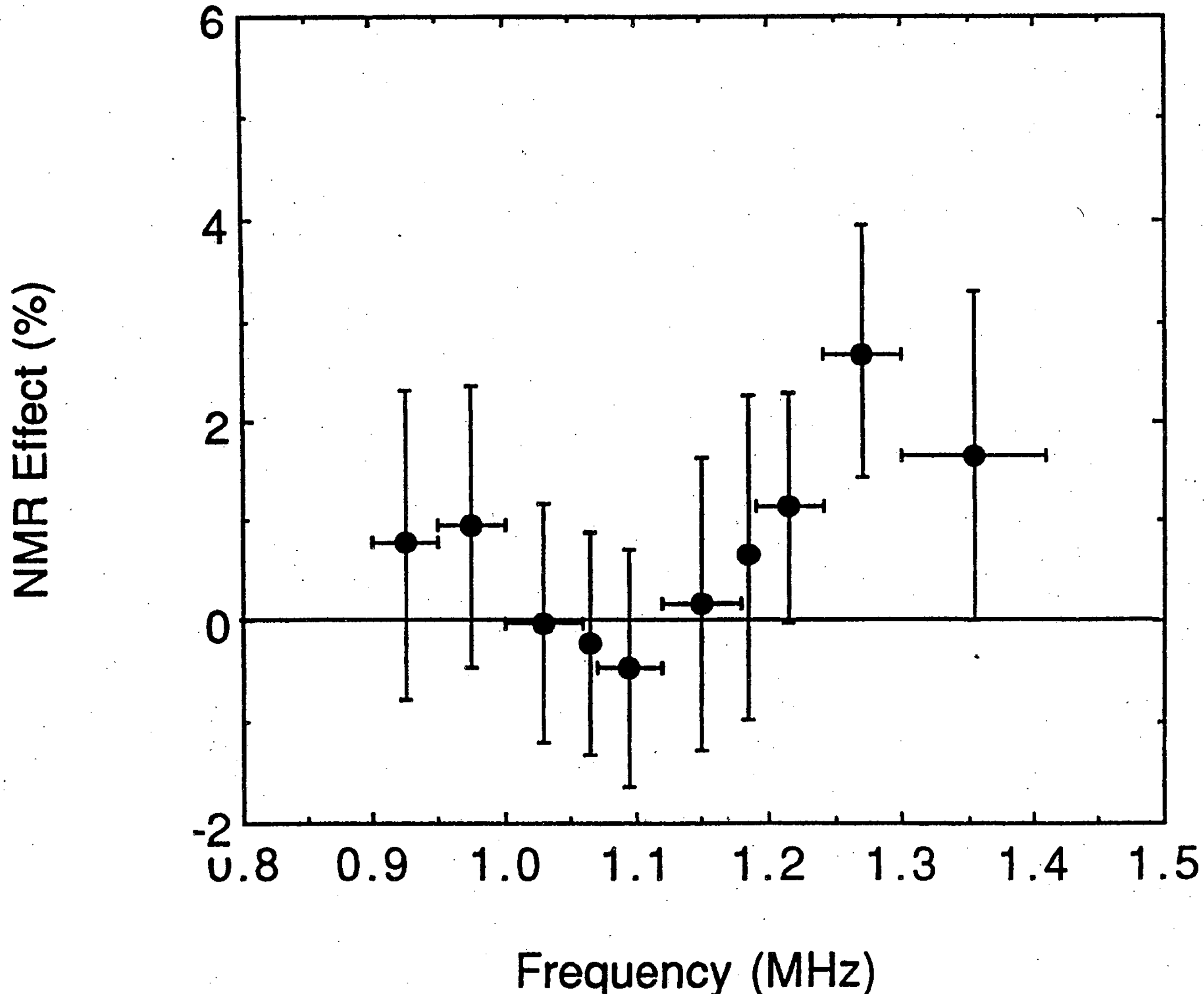

Fig. 2. NMR spectrum for ^{43}Ti in Pt at 90K.

The external field H_0 was 6.878 kOe.

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UNIVERSITY OF CALIFORNIA
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BERKELEY, CALIFORNIA 94720