LBL-33758
UC-413

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

Presented at the Ninth International Conference on Hyperfine Interactions, Osaka, Japan, August 17–21, 1992, and to be published in the Proceedings

Beta-NMR Detection of Beta-Emitting Fragment ^{43}Ti

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

August 1992

REFERENCE COPY
Does Not
Circulate
Bldg. 50 Library.
LBL-33758
Copy 1

Prepared for the U.S. Department of Energy under Contract Number DE-AC03-76SF00098

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. Neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or The Regents of the University of California and shall not be used for advertising or product endorsement purposes.

Lawrence Berkeley Laboratory is an equal opportunity employer.

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

LBL - 33758

BETA-NMR DETECTION OF BETA-EMITTING FRAGMENT ^{43}Ti

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

August, 1992

This work was supported in part by the Director, Office of Energy Research, Division of Nuclear Physics of the Office of High Energy and Nuclear Physics of the U.S. Department of Energy under Contract DE-AC03-76SF00098

Printed on recycled paper

BETA-NMR DETECTION OF BETA-EMITTING FRAGMENT ^{43}Ti

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

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.

AKNOWLEDGEMENTS

The present work was supported by the Grant in Aid for Scientific Research, the Monbusho International Science Research Program, and the special project for Isotope Beam Science from the Ministry of Education, Culture and Science, Japan. Support was also given by the U.S.A.-Japan Collaborative Research, funded by both the Japan Scientific Foundation, and the National Science Foundation, U.S.A. It was also supported in part by the US Department of Energy, under contract No. DE-AC03-76SF0098, and by the Kurata Research Grant from the Kurata Foundation.

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.

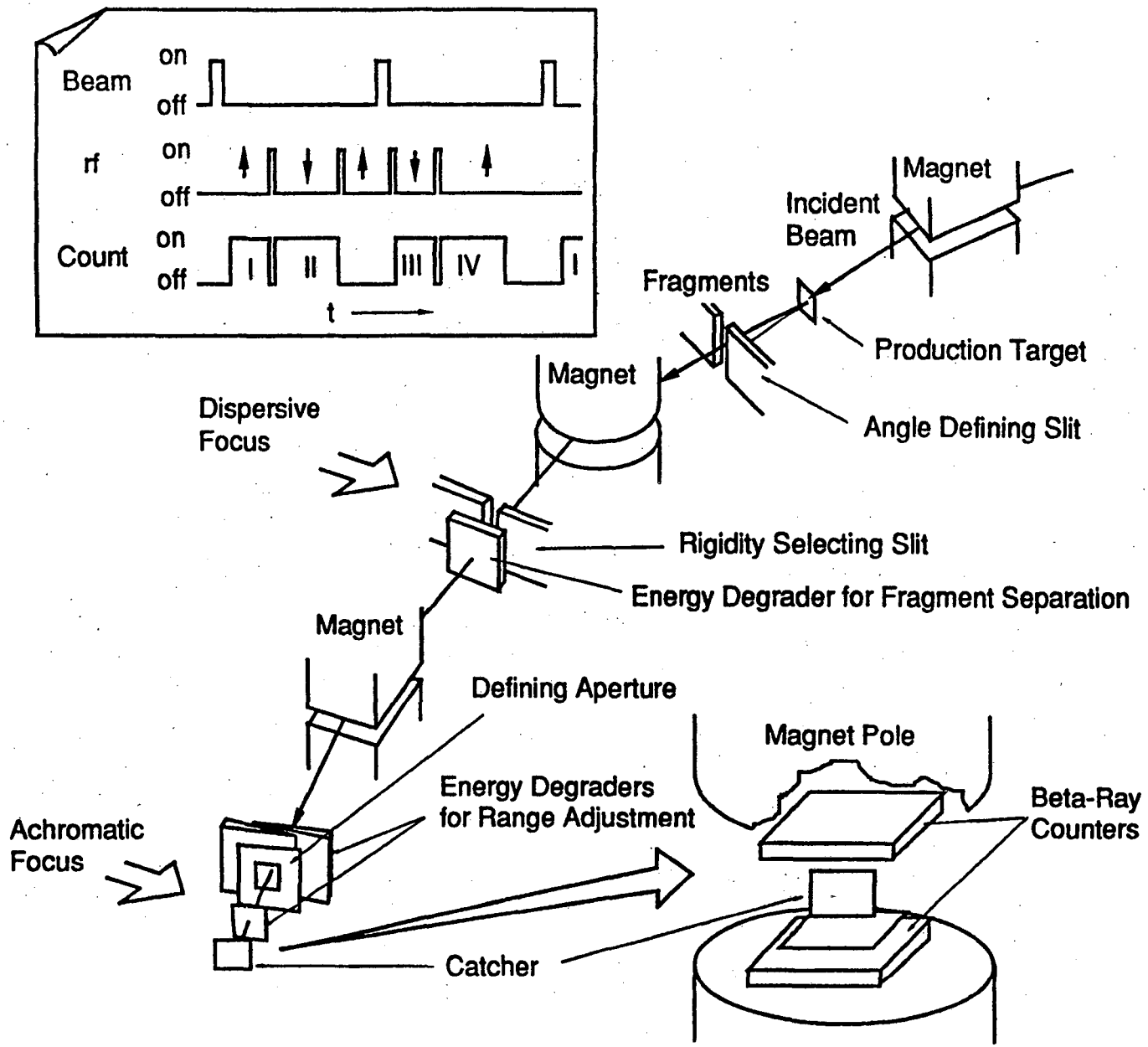

Fig. 1. Schematic view of experimental setup.

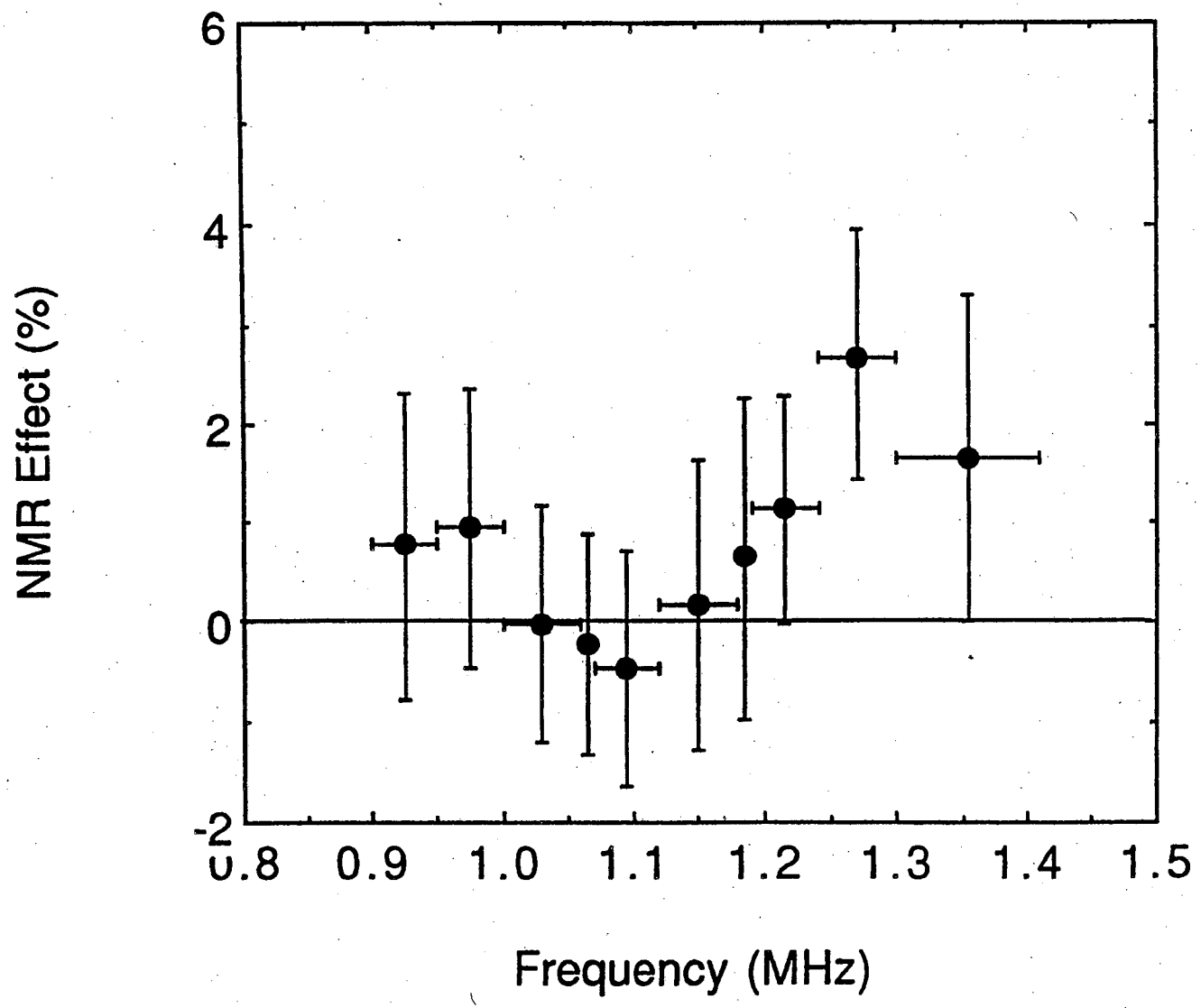

Fig. 2. NMR spectrum for ^{43}Ti in Pt at 90K.

The external field H_0 was 6.878 kOe.

LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
TECHNICAL INFORMATION DEPARTMENT
BERKELEY, CALIFORNIA 94720