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September 1963

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Our investigations are concerned primarily with the attenuation coefficient, G_2 , of free atoms or ions determined by integral α - γ directional correlations from Am^{243} under an applied magnetic field. The technique^{1,2} involves preparation of a very thin source of Am^{243} on a thin backing plate and detecting those α particles which pass through the plate. The recoil nuclei associated with the detected alpha particles are ejected from the backing plate into vacuum. After traveling some fraction of a millimeter in the vacuum system most of the Np^{239} recoils emit a 75 keV gamma ray. The pertinent part of the Am^{243} alpha decay scheme is shown in Figure 1. The principal correlation with which we are concerned is that between the most intense alpha group, α_{75} , and the intense 75 keV E1 gamma ray. This alpha group is composed principally of a mixture of L = 0 and L = 2 alpha waves. The alpha groups, α_{118} and α_{174} , are composed principally of L = 2 with small amounts of L = 4. By a simple approximation given by Bohr, Fröman and Mottelson³ (BFM) for transitions of these types it is easy to calculate the L = 2 contribution in the main group from the intensities of either α_{118} or α_{174} . The ratio of L = 2 to L = 0 in α_{75} is then $\delta^2 = 0.22$ (BFM)^{1,2} as determined from α_{118} . Comparison of α_{118} and α_{174} , and of similar groups in many the nuclei show a deviation in the approximation of ~ 30%. A discrepancy of this type also might extend to the main group, α_{75} . Chasman and Roemussen⁴ (CR) have analyzed this discrepancy in U^{233} as a function of the interaction of the nuclear quadrupole moment with the alpha wave. They have concluded for U^{233} that the L = 2 contribution in the main group should be increased by ~ 40%. The resulting theoretical anisotropies⁵ are

are 45.6% (EFM) and 50.5% (CR). This uncertainty will be reflected in all of our values of G_2 and will be in addition to the listed standard deviations.

In the early work^{1,2} it was found that the correlation $\alpha_{75} - \gamma_{75}$ with recoils going into vacuum was highly attenuated with a G_2 of 0.11 (EFM) where $W(\theta) = 1 + A_2 G_2 P_2 \cos \theta$. This attenuation was ascribed^{1,2} to the hyperfine interaction. With the sample reversed, such that the recoils travelled into the Ag backing plate rather than into vacuum, G_2 had a value of 0.5 (EFM).

In the present experiment⁵ with a sample about an order of magnitude thicker than in the early work, G_2 , for recoils going into vacuum, was found to be 0.17 ± 0.02 (CR) or 0.19 ± 0.02 (EFM). Our values are consistent with the hard core value of G_2 , 0.20. The vacuum anisotropy was studied as a function of an external magnetic field applied parallel to the path of the alpha particles. The magnet was designed by Professor Siebghahn and is shown in Fig. 2. It can operate continuously at a field of 11000 gauss. The field is constant to 10% over the surface of the sample. The observed anisotropies as a function of the applied magnetic field are shown in Fig. 3. It is seen that nearly all of the correlation is restored with 11000 gauss. Figure 4 shows the variation of $1 - G_2$ as a function of the applied magnetic field (CR). The indicated exponential dependence of $1 - G_2$ on H is very likely fortuitous because of the relatively large standard deviations.

The anisotropy was also measured with the alpha particles going directly into vacuum and the recoils going into the Ag backing plate. No increase in anisotropy was observed with an applied magnetic field. With and without an 11000 gauss magnetic field the respective values (CR) were 0.52 ± 0.05 and 0.59 ± 0.02 .

A Ag cover foil was placed about 0.005 cm away from the sample so that the recoils would strike the cover foil after spending $\sim 1.5 \times 10^{-10}$ sec in vacuum. With no applied magnetic field, the anisotropy was still highly attenuated ($G_2 \approx 0.2$). Under an applied magnetic field of 11000 gauss G_2 was restored to a

value of 0.62 (CR) or 7.70 (BFM). The significance of this experiment is that the vacuum perturbation of the correlation takes place is appreciably less than 1.5×10^{-10} seconds.

The correlation between α_{118} and α_{75} was measured with the recoils in an Mg environment. This was an attempt to determine the L = 2 and L = 4 admixtures in α_{118} . Figure 5 shows the gamma ray spectrum in coincidence with α_{118} . The energies and relative intensities of the observed gamma rays were 75 keV (~ 91%), 88 keV (~ 3%), and 118 keV (~ 6%). The observed anisotropy, after finite-size corrections, is 0.075 ± 0.023 . Figure 6 shows the theoretical values of the anisotropy as a function of various mixtures of L = 2 and L = 4 waves. The experimental value of the anisotropy was corrected by assuming $G_2 = 0.59$ (CR), the same value as found for α_{75} . The value of δ (L = 4/L = 2) is then -0.17 ± 0.10 , exclusive of the error in G_2 . For U^{233} favored alpha decay Chasman and Rasmussen deduced the L = 2 and L = 4 waves had the same sign. In earlier analyses of alpha decay transition probabilities of even-even nuclei, Rasmussen⁶ had deduced that the L = 4 wave would change sign in the vicinity of Cm (one atomic number higher than Am). Our negative value of δ may mean that the L = 4 wave has changed sign for Am^{243} favored alpha decay. With the standard deviations in our measurements, however, there is a 5% possibility that δ has a positive sign, exclusive of any error in G_2 . Finally the value of G_2 may be in error. If a substantial perturbation of the $\alpha_{75} - \gamma_{75}$ correlation occurs in $< 10^{-10}$ seconds due to a quadrupole interaction, then the perturbation will be smaller for the $\alpha_{118} - \gamma_{75}$ correlation since the quadrupole moment of the 118 keV rotational state should be much smaller than that of the 75 keV state. The probability that δ can be positive might then be as high as ~ 15%. Therefore our value for negative value of δ is suggestive but not conclusive.

FOOTNOTES AND REFERENCES

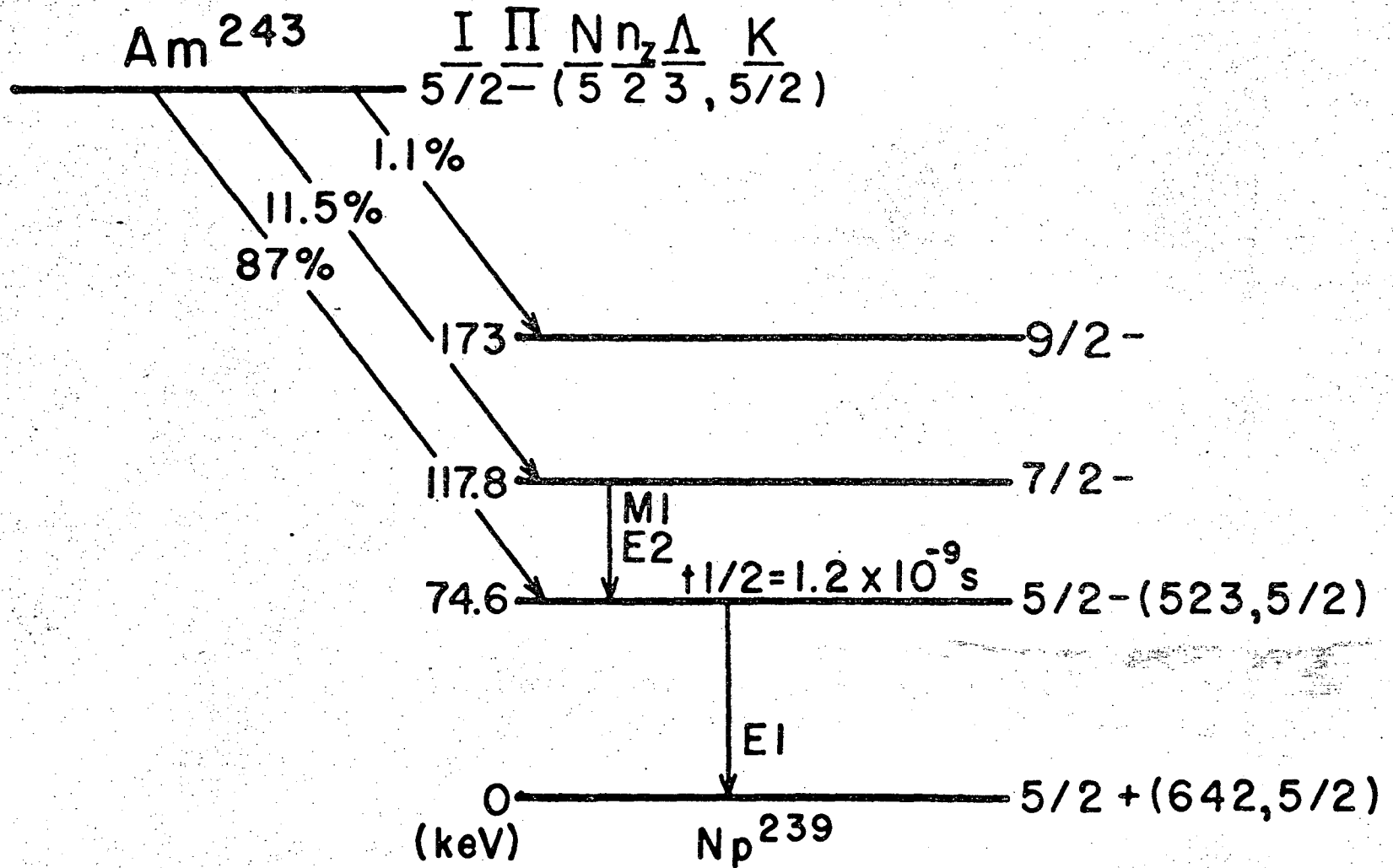
*Work performed under the auspices of the U.S. Atomic Energy Commission.

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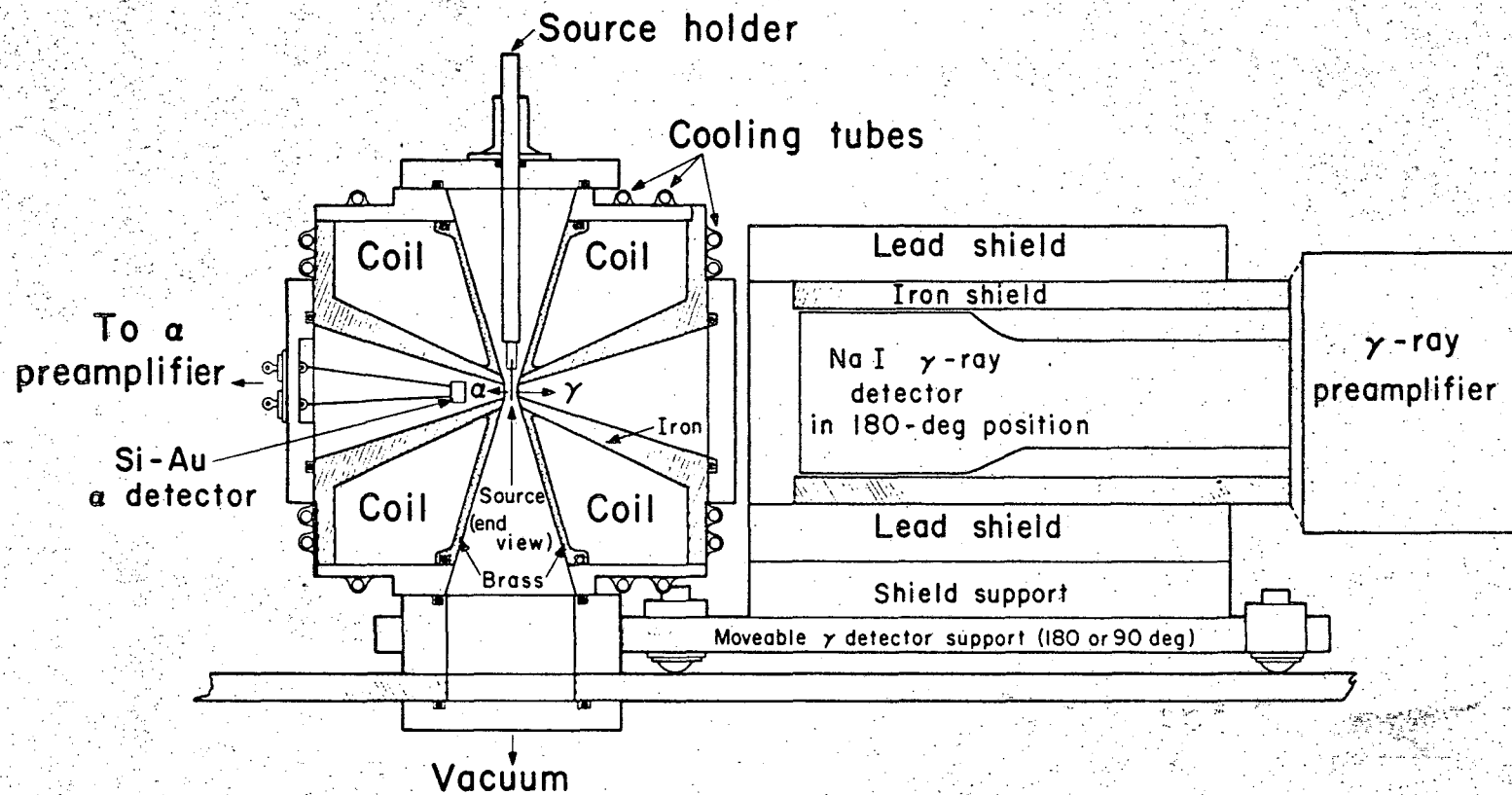
FIGURE CAPTIONS

- Figure 1. Partial alpha decay scheme of Am^{241} .
- Figure 2. α - γ angular correlation magnet and detector arrangement.
- Figure 3. $\text{Am}^{243} (\alpha_{75} + \alpha_{118}) - \gamma_{75}$ angular correlation as a function of an applied magnetic field. The recoiling nuclei are in a vacuum environment.
- Figure 4. The attenuation factor, G_2 , for the $\text{Am}^{243} (\alpha_{75} + \alpha_{118}) - \gamma_{75}$ correlation in a vacuum environment as a function of an applied magnetic field. The theoretical anisotropy was calculated with the correction of Chasman and Rasmussen. The dashed line, which is the best representation of the data from 1-12 kgauss can be expressed by the equation $1-G_2 = 0.7 \times 10^{-0.06H}$.
- Figure 5. Gamma ray spectrum in coincidence with $\text{Am}^{243} \alpha_{118}$.
- Figure 6. $\text{Am}^{243} \alpha_{118} - \gamma_{75}$ angular correlation anisotropy.



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Fig. 1.



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Fig. 2.

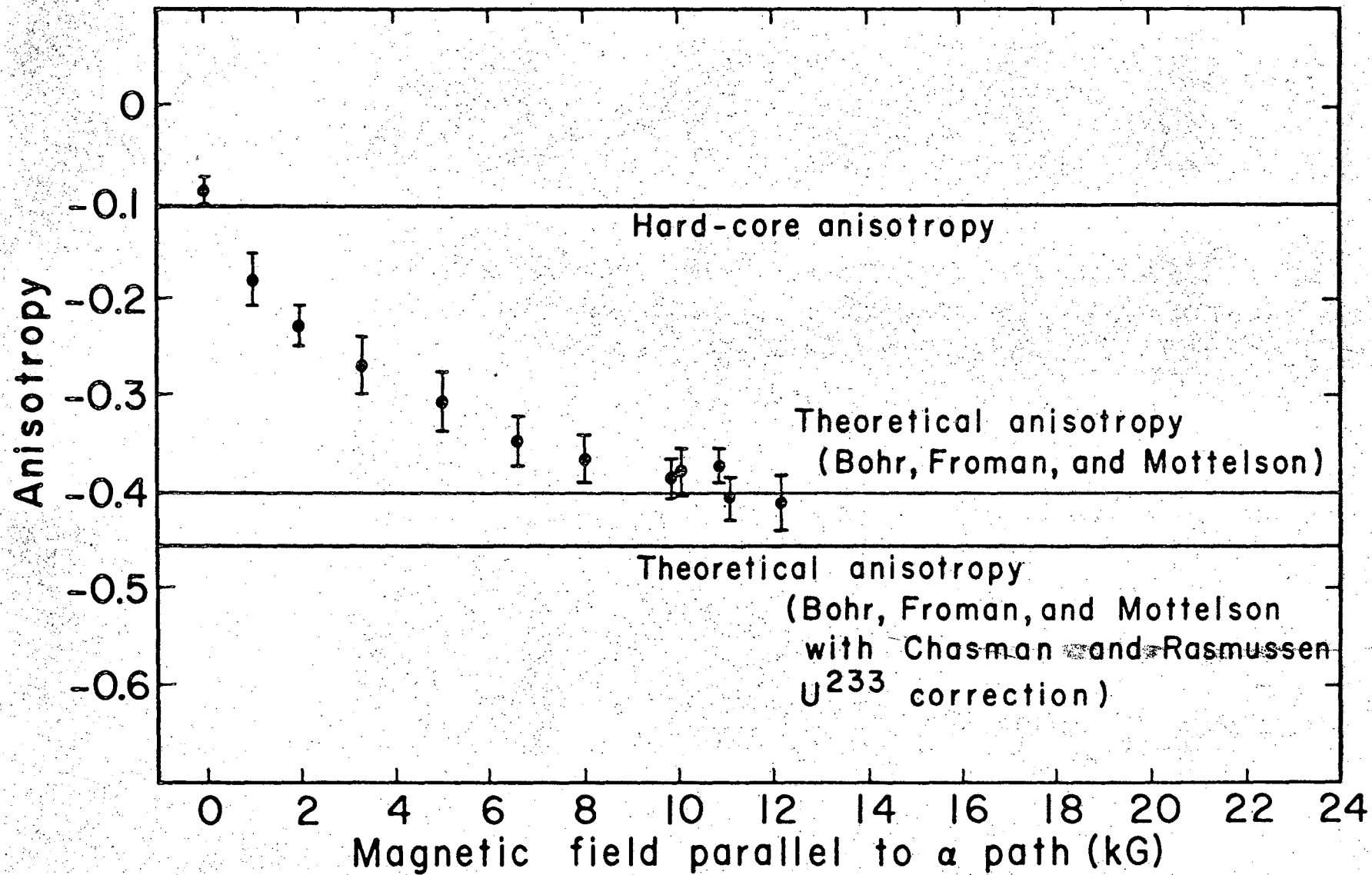


Fig. 3.

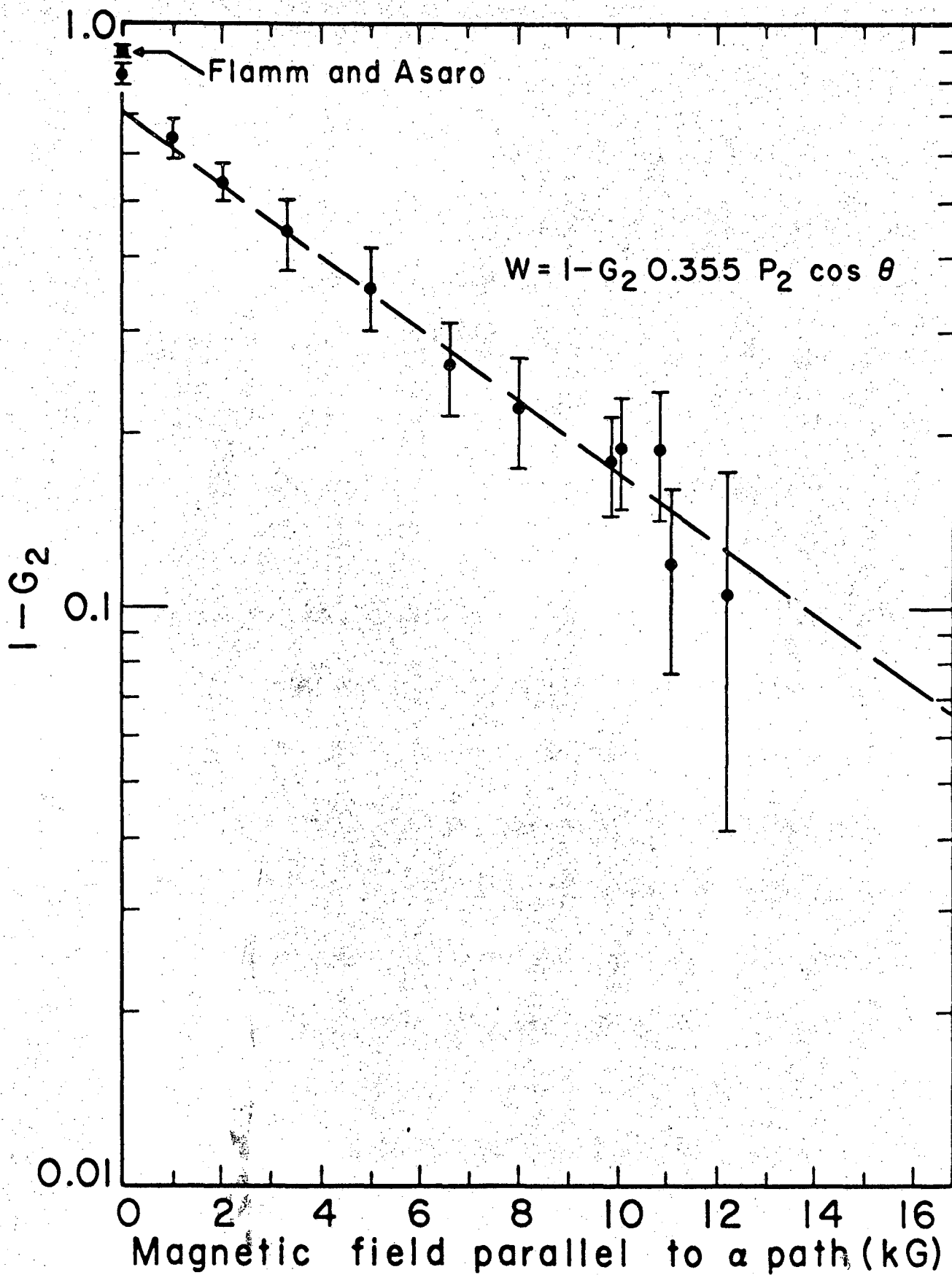
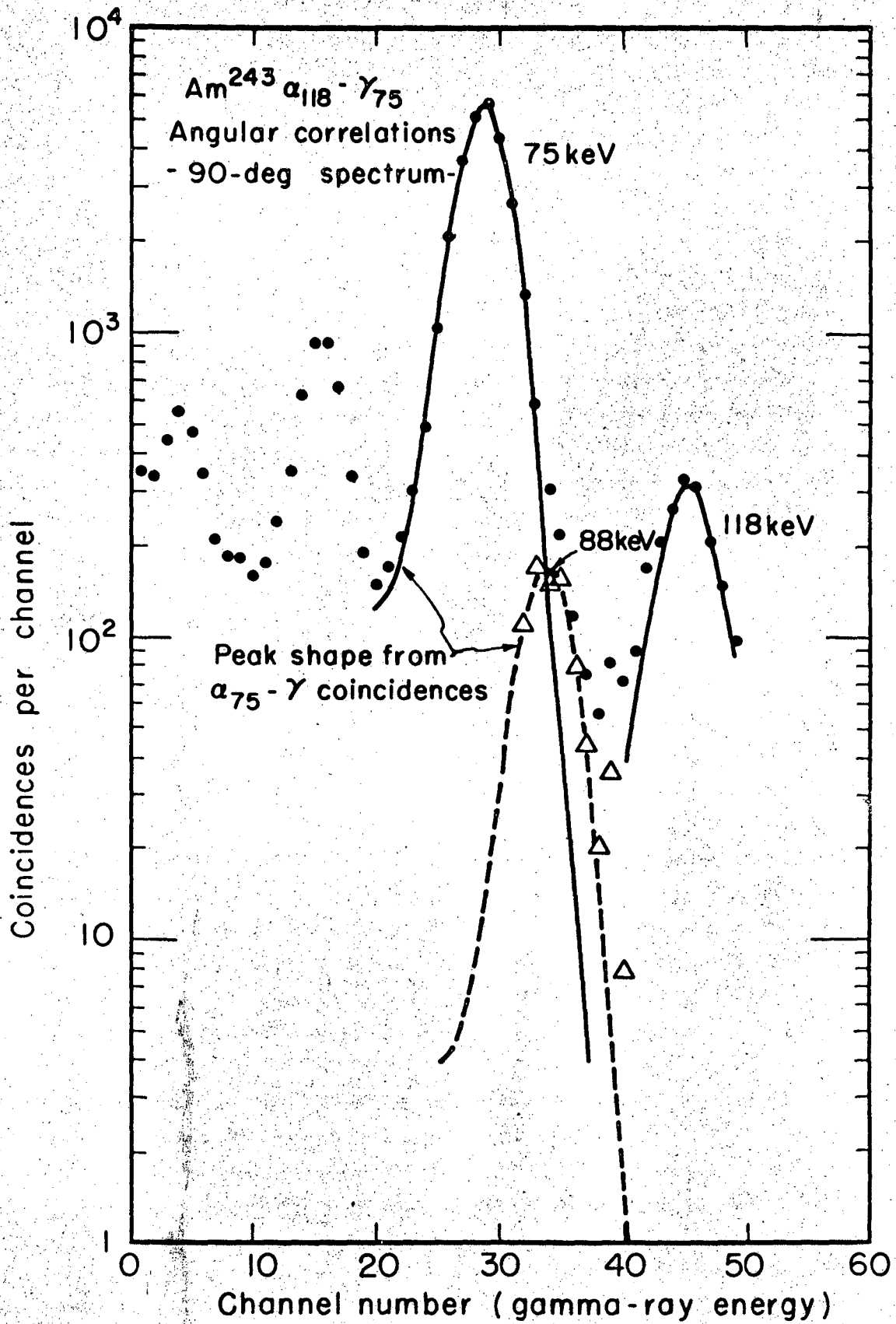


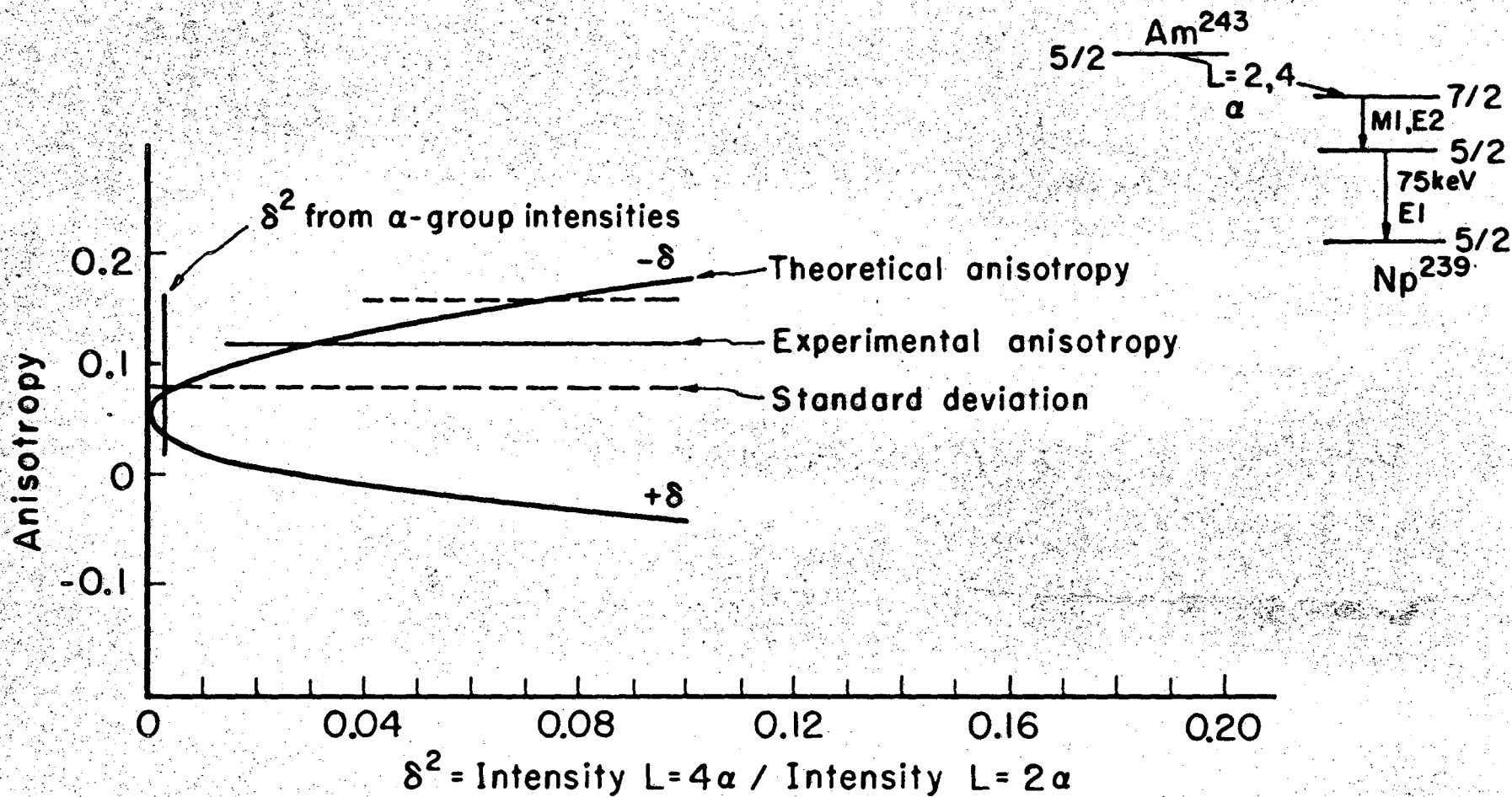
Fig. 4.



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Fig. 5.

$\text{Am}^{243} \alpha_{118} - \gamma_{75}$ angular correlation



MU-30568

Fig. 6.

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