ate values of eV by both the single[23] and multiple[24] phonon (magnon) terms in the expansion of $\exp[Q(\tau)]$ in Eq. (5a).

The authors are indebted to Dr. I. Giaever for suggesting that loss mechanisms in junctions could account for the zero-bias anomalies and for discussions of his unpublished data, to Dr. J. W. Conley, both for the use of unpublished data and for pointing out the small magnitude of TA zone-boundary phonon energies, and to Dr. G. D. Mahan for discussions.

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STATIC QUADRUPOLE MOMENT OF THE 2^+ STATE IN ^{114}Cd DETERMINED BY COULOMB EXCITATION*

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(Received 21 June 1967)

Recent measurements of the ratios of Coulomb excitation probabilities for two different projectiles, which have been interpreted in terms of the reorientation effect,[1] are unable to give verification of the mechanism involved.[2-4] We have measured the reorientation effect and thus the quadrupole moment of the 0.558-MeV 2^+ state in Cd^{114} by observing the angular distribution of 25-MeV oxygen ions inelastically scattered off Cd^{114} nuclei. The shape of the angular distribution gives conclusive evidence of the presence of the reorientation effect. The scattered ions were detected in coincidence with the de-excitation gamma radiation over an angular range from 50° to 160° in the laboratory.

The advantages of this technique are these: (1) Only a single type of projectile is required.

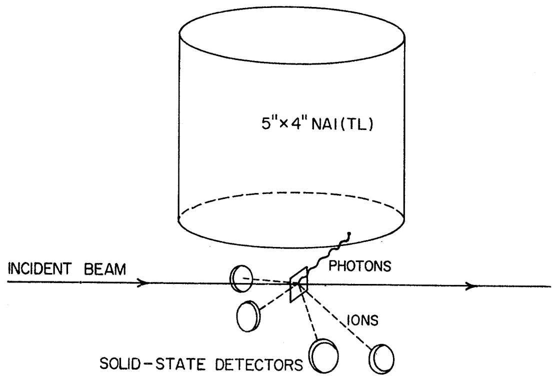

FIG. 1. Detector-beam geometry.

Consequently possible penetration by the lighter projectile is eliminated. (2) With our particular geometry, favorable counting rates are obtained by operating several detectors simultaneously. (3) Because of the favorable counting rates, the experiment can be executed at lower bombarding energy, where the uncertainties in the theoretical interpretation are considerably reduced.[5] (4) The angular distribution can aid in distinguishing the reorientation effect from excitation via the giant dipole resonance.[6]

The experimental geometry is shown in Fig. 1. A 5-in.×4-in. NaI(Tl) crystal is centered over the target position. The face of the gamma-ray detector is $1\frac{1}{4}$ in. from the target and parallel to the scattering plane defined by the beam and scattered-particle directions. Four silicon surface-barrier detectors are arrayed at the various scattering angles. Because it is not necessary to resolve the energy of the inelastic and elastic ions, large (0.5%) solid angles and thicker targets may be used.

The signals from the four particle detectors are fed to a time-sharing electronics system where they are placed in coincidence with that from the gamma-ray detector. The random events were measured simultaneously by a circuit developed by Simms.[7] These signals together with the individual particle detector rates were stored in a multichannel analyzer.

The separated-isotope Cd^{114} targets were prepared by vacuum depositing 200-μg/cm^2 Cd^{114} metal on a 75-μg/cm^2 Cu backing. A thin (20-μg/cm^2) Cu evaporation shield was deposited on top of the Cd metal. The enrichment was 97 %.

The 25-MeV oxygen ions were produced by the Argonne National Laboratory tandem accelerator. The gamma-ray detector spectrum is shown in Fig. 2. One gamma-ray window was set on the 0.558-MeV photopeak. A second gamma-ray window was operated above the 0.558-MeV photopeak.

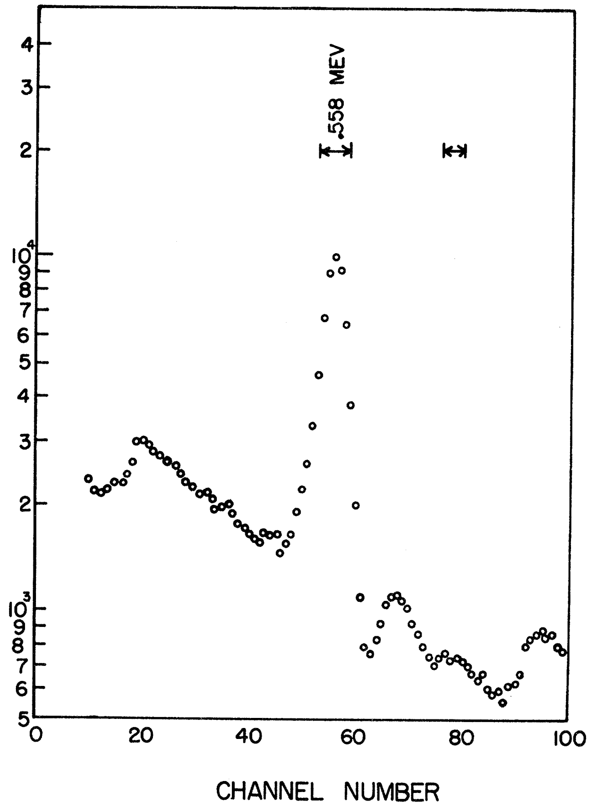

FIG. 2. Coulomb excitation γ-ray spectrum with windows.

Because the oxygen ions scattered off Cd and Cu could not be resolved at all scattering angles, both the Cd and Cu ion peaks were accepted by the electronics. A fifth particle detector located at 160°, where the Cd and Cu peaks were clearly resolved, served as a beam current normalization and target monitor. Raw coincidence data were corrected for random and background events and then divided by the Cd elastic counting rate. The Cd elastic counting rate was scaled from the individual rates with the help of the monitor counter. In a separate experiment we measured the Cd elastic angular distribution and found no deviation from Rutherford scattering.

Following Alder *et al.*,[8] the ratio of inelastic to elastic Coulomb scattering is given by

$$\frac{d\sigma_i/d\Omega}{d\sigma_e/d\Omega}=P(\theta),$$

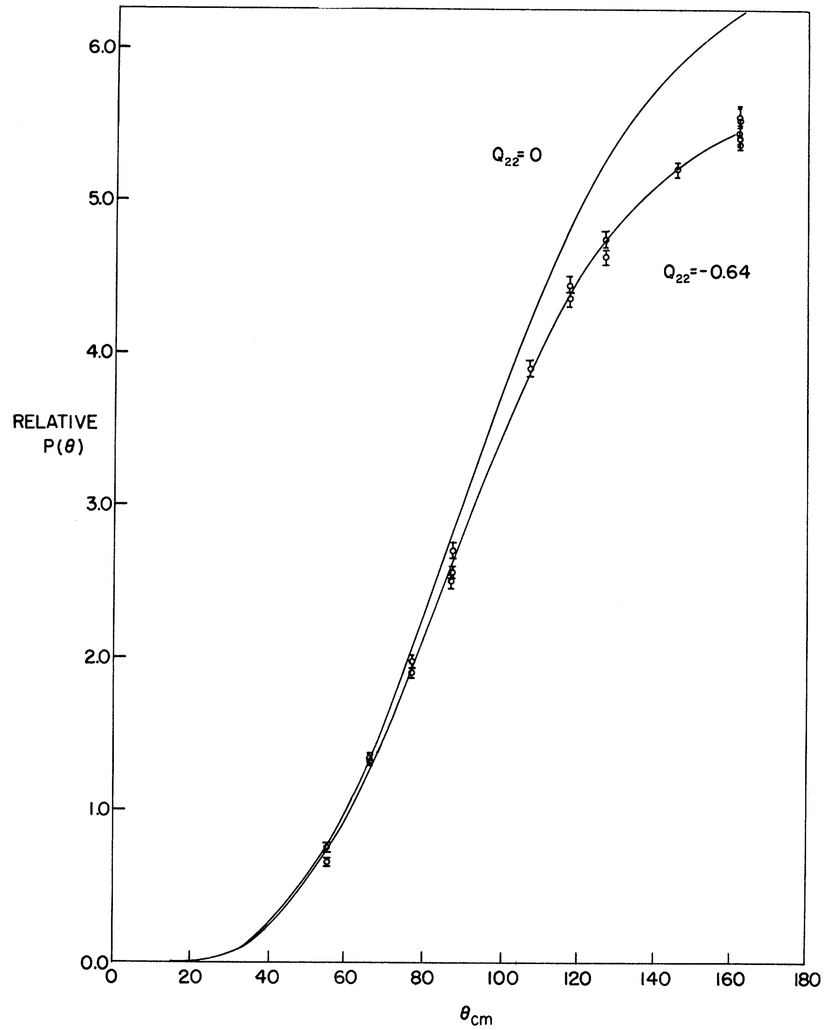

FIG. 3. Differential excitation probability of the 0.558-MeV state of Cd^{114}.

where $P(\theta)$ is the probability of excitation. We can apply this expression to the experiment if the variation of the gamma-ray angular distribution with ion scattering angle θ is taken into account. This is possible because of the insensitivity of the gamma-ray angular distribution to the reorientation effect. We have measured the relative photopeak efficiency with respect to the symmetry axis of the crystal. This efficiency is folded with the gamma-ray angular distribution obtained from the semiclassical theory.[5] Thus a "gating efficiency" can be determined for the various scattering angles. In addition we measured the gamma-ray angular distribution with respect to the incident beam direction and found it unperturbed.

The experimental excitation probabilities are shown in Fig. 3. A marked deviation from first-order Coulomb excitation theory is evident.

We have investigated the magnitude of higher order effects compared to the reorientation effect. We used the semiclassical theory and the the $B(E2)$ values measured by Stelson and McGowan.[9] We find: (1) The population of the 0.558-MeV 2^+ state is changed by only 0.15 % by de-excitation from higher states. (2) The uncertainty in theoretical interpretation of the reorientation effect due to virtual excitation of higher levels is insensitive to the magnitude of the reorientation effect and varies rapidly with the bombarding energy. For 25-MeV oxygen ions the effect of the higher levels introduces a ±1 % uncertainty in the excitation probability at 162° in the center-of-mass system.

We have fitted the experimental data with the function

$$P(\theta) = A(\theta) + M_{22}B(\theta),$$

where $A(\theta)$ and $B(\theta)$ are obtained from the two-level semiclassical theory using M_{22} values which straddle the data. A maximum-likelihood fit gives $M_{22} = 0.85 \pm 0.15$. If we include the uncertainties introduced by the higher levels $M_{22} = 0.85 \pm 0.25$. Since

$$-eQ_{22} = \frac{4}{5}\left(\frac{2\pi}{7}\right)\frac{1}{2}M_{22},$$

we obtain

$$Q_{22} = -0.64 \pm 0.19 \times 10^{-24}\ \mathrm{cm}^2$$

for the quadrupole moment of the 0.558-MeV 2^+ state of Cd^{114}, in agreement with ratio measurements.[2-4] This value of the quadrupole moment is in striking contrast with the vanishingly small quadrupole moments predicted by the pure vibrational model.

This analysis neglects the possibility of excitation via the giant dipole resonance, which is believed to be small.[10] The observed angular distribution is in good agreement with the reorientation-effect mechanism and suggests experimentally that the giant dipole resonance effects are very small.

The authors would like to express their appreciation for the excellent support by the Argonne National Laboratory tandem laboratory.

*Work supported by the U. S. Atomic Energy Commission under Contract No. AT(11-1)1420 (Chicago Operations Office).

†Work performed in partial fulfillment of the requirements for the Ph. D. degree, Case-Western Reserve University.

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COUPLING BETWEEN (d,p) and (d,n) CHANNELS AND THE SPECTROSCOPIC FACTOR IN (d,n) REACTIONS LEADING TO ANALOG STATES*

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The spectroscopic factor of $^9Be(d,n)^{10}B$ leading to the $T=1$ state is increased by about a factor of 2 by considering the $\mathbf{t}\cdot\mathbf{T}$ interaction, and becomes consistent with shell-model predictions.

Sometime ago, Siemssen et al.[1] pointed out a serious inconsistency in several single-particle-transfer reactions in light nuclei. Namely, they found that the values of the spectroscopic factors $S_>$ derived from $(^3He,d)$ and (d,n) reactions on the same target and to a given final state differed considerably from each other when that final state was an isobaric analogous state, i.e., a state with isospin $T=T_> = T_t + \frac{1}{2}$, where T_t is the isospin of the target.

Previously,[2] we argued that a difficulty of somewhat related nature, namely the difficulty of too large $S_>$ in neutron pick-up reactions,