strength of the field fulfills the condition that the Zeemann splitting of the atomic levels be large compared with the hyperfine splitting of the intermediate nuclear state.

In the case of Cd^{111}, calculation of the hfs from disturbed angular correlation and the known half-life of the intermediate state indicates that a field of 20 000 gauss should be sufficient to restore the undisturbed correlation. In our experimental arrangement we used a magnet with bored polefaces with which we could apply a very homogeneous field up to 20 000 gauss to the source placed in the center of the magnet gap. The detectors consisted of NaI(Tl) crystals[7] and 1P21 photomultipliers and were placed in front of the bored holes. For every source we measured the ratio $\delta = W(180°, H)/W(180°, 0)$ and in addition the anisotropy A without magnetic field (in an arrangement without magnet). Then the anisotropy B with magnetic field may be easily calculated from A and δ.

Two different groups of sources were used. One group consists of the so called "double stream" sources prepared by simultaneous evaporation of the active In^{111} atoms and the embedding material. The other group consists of chemically prepared indium compounds in solutions and in crystalline form. All the decoupling experiments with about 20 different sources gave no appreciable effect although in some cases the anisotropy was increased by a few percent. From these results we draw the conclusion that the large attenuation of the angular correlation observed in most of the sources cannot be explained with the magnetic interaction.

An analogous "electric decoupling experiment" would decide if the interaction is electric or not, but this experiment cannot be carried out because it is not possible to produce an artifical inhomogeneous electric field of sufficient strength. One can, however, make use of the high electric fields in crystals with lower symmetry than cubic. If one uses single crystals with axial symmetry one expects a dependence of the correlation function on the orientation of this axis respective to the detectors.

For this experiment we prepared metallic indium single crystals (tetragonal face centered) containing active In^{111}. The single crystals were examined by x-ray methods. The ratio of the coincidence rates in the 90° and 180° positions was measured for different orientations of the c axis (Fig. 1). Figure 2 shows the result when the c axis lies in the plane defined by the direction of the fixed counter and the normal to the plane of the two counters as a function of the angle α between the c axis and the fixed counter (experiment 1). Figure 3 shows the result when the c axis lies in the plane of the two counters as a function of the angle β between the c axis and the fixed counter (experiment 2). A phase shift in the correlation depending on α and β has also been observed.

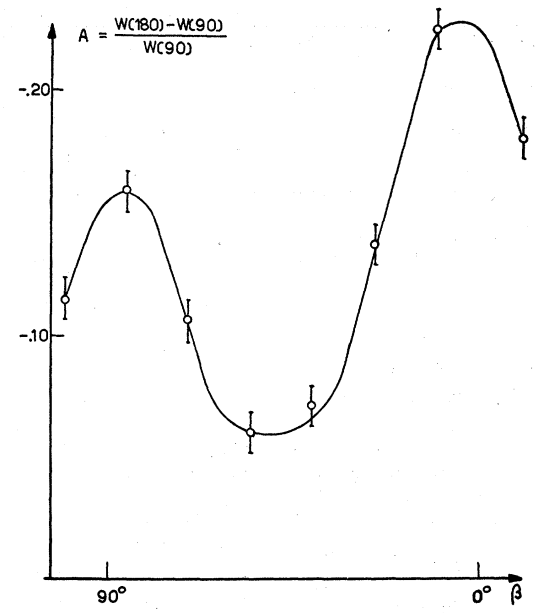

FIG. 3. Anisotropy *vs* angle β of the c axis with respect to the direction of the fixed detector (experiment 2).

We conclude from these experiments that the attenuation in this type of source is due to quadrupole interaction, with very little doubt. Further experiments are in progress, and it will be possible to obtain the quadrupole moment of the first excited state of Cd^{111} by comparing the experimental result with formulas derived by Alder,[8] if one makes reasonable assumptions for the value of grad$E$ in the crystal. In addition, we intend to make more detailed investigations of observed attenuations from the new viewpoint of the quadrupole interaction.

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Angular Distribution of Deuterons from $Be^9(p,d)Be^8$

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THE angular distribution of deuterons from the reaction $Be^9(p,d)Be^8$ (ground state) was measured using the internal, circulating 22-Mev proton beam of the Oak Ridge National Laboratory 86-inch cyclotron. The target assembly, which is described in detail elsewhere,[1] consists essentially of a thin beryllium target at the center of a $3\frac{1}{2}$-in. radius semicircular detector holder. The deuterons are detected both by the 3.3-hour activity they induce in lead by the reaction $Pb^{208}(d,p)Pb^{209}$ and by the 15-hour activity they induce in sodium by the reaction $Na^{23}(d,p)Na^{24}$. Both of these activities can also result from (n,γ) reactions, so that it is necessary to correct for the neutron activity by bombarding additional detectors under a thick absorber. The lead foils are processed chemically after bombardment to remove the proton-induced activities, and counted under end-window Geiger counters. The sodium detectors are made from sodium fluoride with a small amount of sodium silicate as a binder. About 36 hours after the bombardment they are counted with a scintillation spectrometer set on the 2.76-Mev photoelectric peak. Chemical checks have confirmed that the activity is due to sodium, but routine chemical processing was proved unnecessary.

All parts of the target assembly which are exposed to the cyclotron beam are covered with carbon since the (p,d) reaction in C^{12} has a very high threshold. Deuteron background, as determined by running with the beryllium target removed from the target assembly, was undetectable. The beam is stopped several inches past the target by a large slab made of carbon to minimize neutron background [the (p,n) threshold is very high for C^{12}].

In order to obtain energy discrimination and to correct for the variation of energy with angle due to center-of-mass motion, the detectors are covered by a stepped absorber which is adjusted to equalize the energy of the longest range group to below the detection threshold. The excitation function for the $Na^{23}(d,p)$

reaction is available from the literature;[2] for lead, the bismuth excitation function[3] was used since it has been confirmed that the proton yield as a function of deuteron bombarding energy is very similar for lead and bismuth.[4] The methods of determining the energy and energy distribution of the proton beam, its angle of incidence on the target, and various other experimental details are described in reference 1.

The measured angular distributions are shown in Fig. 1. The closed points were obtained with lead detection, while the open

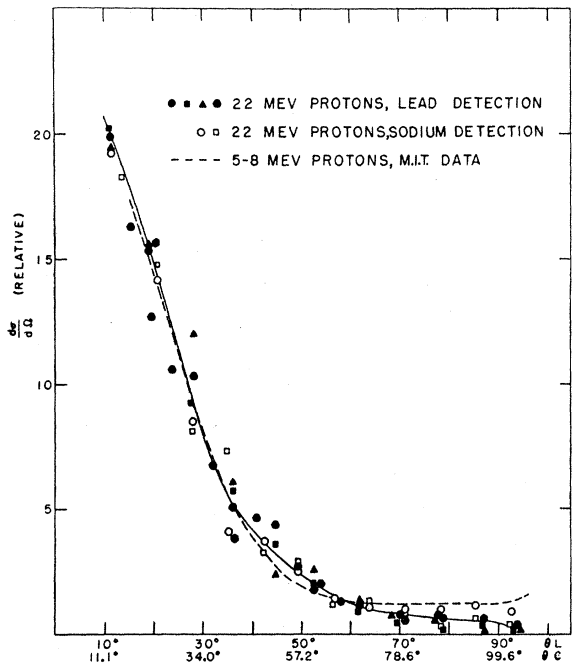

FIG. 1. Angular distribution of deuterons from $Be^9(p,d)Be^8$ (ground state).

ones are the sodium measurements. The dashed line shows the angular distribution for the same reaction obtained in the MIT cyclotron with deuterons of 5, 6, 7, and 8 Mev.[5]

The pronounced forward peak is good evidence that the reaction proceeds almost entirely by neutron pick-up. While no calculations have been made on the basis of the Butler theory,[6] it seems very strange that a calculation characterized by rapidly varying interfering terms—except for the case $l_n=0$—should give such similar results for proton energies of 5, 8, and 22 Mev. The case $l_n=0$ would seem to be excluded because of the relatively gentle rise in the forward direction and also because it would demand $I=\frac{1}{2}$ and even parity for the Be^9 nucleus, in contradiction to the prediction of both the alpha-particle and shell models. In any case, since the parity and spin of Be^8 are known, a theoretical analysis of this angular distribution should determine the parity and spin of Be^9 and thereby, from the published angular distributions[7] for $Be^9(d,p)Be^{10}$ and $Be^9(d,n)B^{10}$ and the known spin of the ground state of B^{10}, the parities and spins of Be^{10} and B^{10}.

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Mass Synchrometer Doublet Measurements at Masses 28 and 30*

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ORIGINALLY designed as a time-of-flight device,[1] the "mass synchrometer" has been converted to an rf mass spectrometer with which masses of ions are measured in terms of high harmonics of their cyclotron frequencies. Its present form is a modification of those previously described.[2] Because intensities are now enormously greater than obtained with a pulsing technique, the magnetic multiplier has been replaced by a Faraday collector connected through a dc feedback preamplifier to the dc input of a Dumont 304A oscilloscope. Band width is such that a single peak may be displayed without distortion 30 times/sec by applying a sawtooth sweep to the frequency (f) of the short rf field wherein the velocity of the (continuous) ion beam is modulated 180° from the source.

To measure the relative mass difference ($\Delta M/M$) between two components of a doublet, f is displaced on alternate sweeps by an amount Δf so adjusted (along with amplifier gain, dc level, and a small fractional increment $\Delta M/M$ in accelerating voltage) that the two peaks appear entirely coincident. A 12-kc square wave applied to the second Y input of the oscilloscope on alternate sweeps considerably augments matching precision by making one peak appear as two parallel traces between which the other is centered. With optimum adjustment $\Delta M/\bar{M}$ is taken as $\Delta f/\bar{f}$ ($\bar{f}$ being the mean frequency for the two peaks). At present this is measured by applying to f the square wave modulation (Δf) alone at about one cycle/sec. A frequency meter is then adjusted to $\bar{f}$ so that the beat between it and f is very nearly constant. The average beat ($=\Delta f/2$) is then measured with scalers over an interval determined by a precision tuning fork. Calibration of the tuning fork and frequency meter are checked with WWV.

Values of ΔM thus obtained for three doublets at mass 28 and one at mass 30 appear in Table I. Each value is the mean of from

TABLE I. Values of ΔM(amu) $\times 10^4$.

	Mass synchrometer	Disintegration energies[a]	Other mass spectrometers
$(N^{14})_2-C^{12}O^{16}$	112.372 ±0.021	112.27 ±0.11	112.54 ±0.09[b] 112.80 ±0.13[c]
$(C^{12})_2(H^1)_4-(N^{14})_2$	251.493 ±0.041		251.61 ±0.11[b] 251.70 ±0.25[c]
$2[C^{12}(H^1)_2-N^{14}]$		251.46 ±0.24	251.68 ±0.10[b] 251.72 ±0.26[c] 251.28 ±0.20[d]
$(C^{12})_2(H^1)_4-C^{12}O^{16}$	363.877 ±0.041		364.23 ±0.08[b] 364.43 ±0.22[c]
$[(C^{12})_2(H^1)_4-(N^{14})_2]$ $+[(N^{14})_2-C^{12}O^{16}]$	363.865 ±0.046		364.15 ±0.14[b] 364.50 ±0.28[c]
$C^{12}(H^1)_4-O^{16}$		363.72 ±0.19	364.15 ±0.08[b] 364.78 ±0.22[c] 363.71 ±0.12[d]
$\frac{1}{2}[(C^{12})_3(H^1)_8-C^{12}(O^{16})_2]$			364.84 ±0.20[c]
$(C^{12})_2(H^1)_6-N^{14}O^{16}$	489.623 ±0.055		
$[(C^{12})_2(H^1)_4-C^{12}O^{16}]$ $+\frac{1}{2}[(C^{12})_2(H^1)_4-(N^{14})_2]$	489.624 ±0.046		

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10 to 21 readings obtained with ion energies of about 1000 volts at various harmonics of the cyclotron frequency between the 140th and 160th (frequencies between 13 and 16 Mc/sec) under