Bev and π-mesons of 1.5 and 3 Bev, i.e., $\sim 10^{-3}$, and is not inconsistent with the value found for cosmic rays,[7] i.e., $2\text{–}3\times 10^{-4}$. This agreement lends support to our assumption of uniform distribution of the Λ^0's within the nucleus, connected with the evaporation model for the hyperfragments.

Rows 3 and 4 of Table I give the values of $(A-Z)\times n(Z)$,[8] normalized to 27, and the values of the frequencies of Λ^0 fragments in emulsion as observed by Fry[6] for 27 cases with $Z\geq 3$. Within the poor statistics, the two distributions are not in disagreement.

I am indebted to Professor G. Cocconi for helpful discussions.

Note added in proof.—A recent systematic study by Fry[9] of hyperfragment stars produced by cosmic rays, 6-Bev protons, and 3-Bev π^- mesons shows the same (or slightly smaller) production probabilities, and a similar Z spectrum.

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Inelastic Scattering of 42-Mev α's by Mg†

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Experimental work on the inelastic scattering of nucleons which leave the residual nucleus in an excited state[1] revealed a complexity in the angular distribution of the scattered particles which cannot be explained by the theory of the compound nucleus.[2] These results show, in general, angular distributions which are peaked in the forward direction. McManus and Sharp[3] and Austern, Butler, and McManus[4] proposed a direct interaction theory which describes the scattering by an interaction between an incident neutron and a nuclear proton taking place at the nuclear surface. The predicted distributions are a sum of different spherical Bessel functions according to the spin change between initial and final state.

Most experimental results are given for the excitation of the first excited state of even-even nuclei where the single-particle excitation is not likely to hold. More recently, Hayakawa and Yoshida[5] described the scattering process for even-even nuclei by the excitation of Bohr-Mottelson surface vibrations. A simple Born approximation calculation using this model shows that the angular distribution of scattered nucleons should be proportional to $j_2{}^2(QR)$ for a 0 to 2^+ transition, where j_2 is the spherical Bessel function of order 2, $Q=|k_{\text{in}}-k_{\text{out}}|$ is the momentum change of the scattered particle, and R is the nuclear radius. The same angular distribution would be expected from the work of Austern, Butler, and McManus. The main difference between the two treatments should be in the prediction of the value for the cross section if the excited state is formed by the scattering of α particles instead of nucleons. The large momentum transfer required to scatter an α by an angle of twenty or thirty degrees would eject the recoiling nucleon in the single-particle description from the nucleus. Consequently the cross section for the excitation of a low-lying state may be very small. In a collective description, the α interacts with the surface and there is a large probability that it will excite surface vibrations.

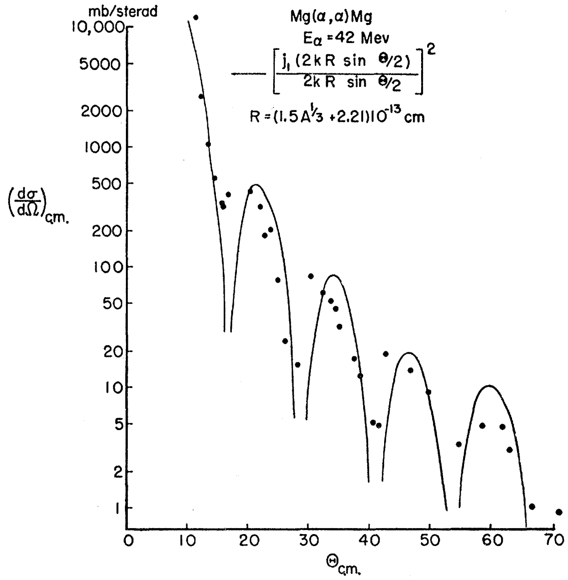

FIG. 1. Differential cross section for the elastic scattering of 42-Mev α particles by Mg.

The Born approximation calculation gives the differential cross section for the 0 to 2^+ transition:

$$\frac{d\sigma}{d\Omega}=\frac{5R^6V^2m_\alpha{}^2}{\hbar^4}\frac{k_{\text{out}}}{k_{\text{in}}}\left(\frac{Q_0}{3ZR^2}\right)^2[j_2(QR)]^2,$$

where Q_0 is the intrinsic quadrupole moment, R is the nuclear radius, and V is the interaction potential of the α with the surface.

In this experiment 42-Mev α particles were scattered by Mg^{24}, exciting the 2^+ level at 1.37 Mev. Mg^{24} seems to have collective properties even though it is a light nucleus.[6]

Figure 1 shows the observed angular distribution of

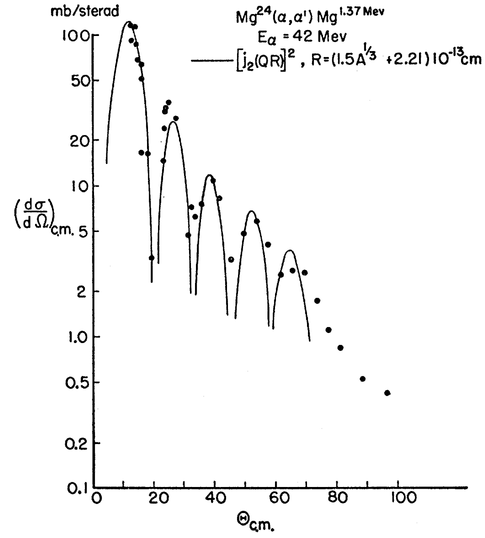

FIG. 2. Differential cross section for the inelastic scattering of 42-Mev α particles to the 1.37-Mev level in Mg^{24}.

the elastically scattered α particles in the center-of-mass system. Figure 2 presents the angular distribution of the α's which excite the 1.37-Mev state in Mg^{24}. The uncertainty in the cross section is about 20% at the small angles and about 10% at the larger angles.

The elastic scattering curve fits $[j_1(2kR\sin\frac{1}{2}\Theta)/2kR\sin\frac{1}{2}\Theta]^2$, the angular distribution one obtains from a simple diffraction picture for a square well. The depth of this potential obtained from the absolute value of the cross section is only 5.6 Mev. The radius is assumed to be $R=(1.5A^{\frac{1}{3}}+2.21)\times 10^{-13}$ cm).[7] Only little meaning can be attributed to the value of this depth, except that it is small as compared to the 45-Mev nucleon nucleus potential.[8] This may be the reason that the Born approximation result gives a reasonable account of the differential elastic cross section.

The angular distribution of the inelastically scattered α's fits $[j_2(QR)]^2$ remarkably well. The nuclear radius is the same as for the elastic scattering. From the absolute cross section, one can estimate the product of the intrinsic quadrupole moment and the interaction potential: $Q_0V=2.6\times 10^{-24}$ Mev cm^2. For a potential depth of 5.6 Mev the calculated value for Q_0 is 0.46×10^{-24} cm^2. The quadrupole moment of Al^{27} is measured to be 0.156×10^{-24} cm^2.[9] The intrinsic quadrupole moment in the strong-coupling approximation[10] is then 0.45×10^{-24} cm^2. The γ-transition probability of the 1.37-Mev state gives another estimate for Q_0. Coleman[11] measured this lifetime to be $(3\pm 2)\times 10^{-11}$ sec, which yields $Q_0=(0.14_{-0.03}^{+0.1})\times 10^{-24}$ cm^2. The surface interaction energy of α particle and nucleus may then be between 5 and 20 Mev.

These results show that a direct interaction picture represents at least the angular distribution data. This may be due to a relatively weak interaction between the α particle and the nuclear core, as is indicated by the elastic scattering cross section. If a collective model can be used to interpret the data more quantatively, one will be able to obtain information either on the surface interaction energy or on the intrinsic quadrupole moment of the investigated nucleus.

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Inelastic Scattering of 18-Mev Protons by Mg^{24}†

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THE partial success with the interpretation of the inelastic scattering of α particles by Mg in the preceding letter[1] prompted the study of the excitation of the same 1.37-Mev state in Mg^{24} by 18-Mev protons. The experimental arrangement to measure the angular distribution of the protons was similar to the arrangement in the α-particle experiment. The counts due to elastic scattering spilling over into the inelastic channels were subtracted as before with the help of a master curve for the elastic scattering peak obtained at very small angles to the incident beam. The subtraction procedure is responsible for most of the uncertainty in the experimental points. The scattering of protons from hydrogen and oxygen contamination in the foils produced some additional uncertainty around 17 degrees and around 110 degrees respectively. The inelastic scattering from Mg^{25} (levels at 0.98 Mev and 1.61 Mev) and from Mg^{26} (level at 1.83 Mev) was occasionally observed by a small irregularity in the pulse height spectrum. Their effect on the cross section measurement is negligible.

Figure 1 presents in the center-of-mass system the observed differential cross section of the scattered protons which leave Mg^{24} in the 1.37-Mev state. A pronounced forward distribution is observed in addi-