the (γf) process. The minimum observed fission widths in a large sequence are expected to correspond to the value of $\Gamma_{(\gamma f)}$ of the 4^- level of the compound nucleus ^{234}U. The minimum observed values from the cross section of ^{235}U up to 35 eV are about 2 to 3 MeV, in reasonable agreement with the estimates made above. Similar arguments may be made for the 1^+ states in the compound nucleus ^{240}Pu; the minimum observed values are about 4 MeV [22, 23]. The mean fission widths of all the compound nucleus states of ^{234}U and ^{242}Pu are expected to be so large that the (γf) process has no appreciable effect on the fission width statistics and we can derive no evidence for the reaction from the resonance studies of these nuclei.

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ALPHA-GAMMA CORRELATION STUDY OF THE ^{56}Fe(α, $\alpha'\gamma_{0.84}$)^{56}Fe REACTION *

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Received 6 July 1965

When alpha particles are inelastically scattered from an even-even nucleus to excite a $J^{\pi} = 2^+$ state, all particles in the reaction except the final nucleus are spinless. When the excited state, which has been polarized by the reaction, gamma-decays back to the ground state, the angular correlation function of the reaction plane gamma-rays has a particularly simple and transparent form [1]. Therefore, it is possible through measurement of angular correlations to obtain information on the way in which the excited nucleus was polarized by the nuclear reaction, and thus on the relative phases and amplitudes of the scattering amplitudes of the reaction process. Such information cannot be obtained from differential cross section measurements, since the latter are determined only by the over-all magnitude of the scattering amplitudes.

Although complete information can be obtained on the relative phases and magnitudes of these

* Supported by the National Science Foundation.

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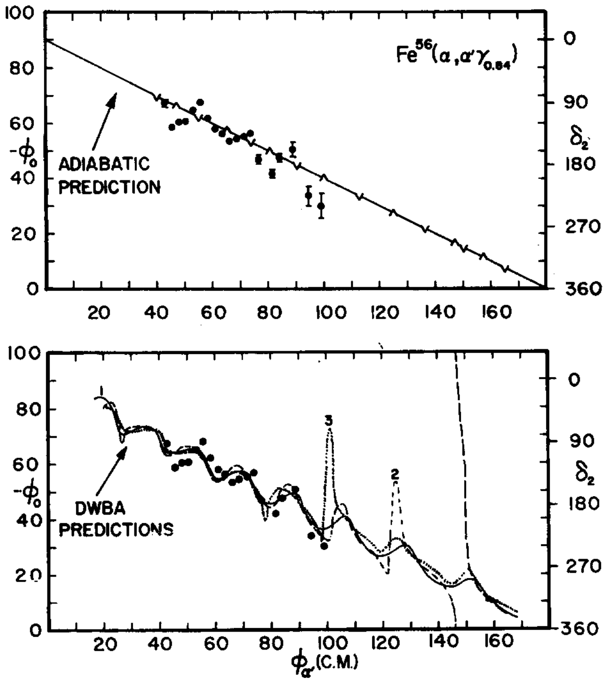

Fig. 1. Plot of the correlation symmetry axis φ_0 as a function of centre of mass scattering angle of the inelastically scattered alpha particles for the reaction $^{56}Fe(\alpha,\alpha'\gamma_{0.84})^{56}Fe$. Notation used is the same as in ref. 1. In the upper half of the figure, the data are compared to the adiabatic prediction of ref. 7; in the lower half of the figure, the data are compared with three DWBA predictions using the parameters of ref. 10: Curve 1: V = -20 MeV, W = -8 MeV; Curve 2: V = -40 MeV, W= -9 MeV; Curve 3: V = -70 MeV, W = -12 MeV.

scattering amplitudes [1] by measuring correlation functions both in and out of the reaction plane, this discussion concerns the behavior of φ_0, the symmetry angle of the reaction-plane correlation function

$$W(\tfrac{1}{2}\pi,\varphi) = A + B \sin^2 2(\varphi - \varphi_0).$$

Here φ is the angle of gamma emission and A, B and φ_0 are empirical parameters; all are functions of the alpha-particle scattering angle, φ_α. Note that the form of the correlation function is independent of reaction mechanism and arises purely from correlation theory [1].

Previous alpha-gamma angular correlations have been measured at many scattering angles for the reactions $^{12}C(\alpha,\alpha'\gamma_{4.43})$ [2,3], $^{16}O(\alpha,\alpha'\gamma_{6.13})$ [5], $^{24}Mg(\alpha,\alpha'\gamma_{1.37})$ [3,4], and $^{28}Si(\alpha,\alpha'\gamma_{1.77})$ [5]. These earlier measurements on light nuclei have provided considerable information: (1) Plane-wave [6] and adiabatic [7] theories are not capable [2-4] of describing the behavior of the correlation symmetry axis: i.e. for all nuclei for which detailed correlation measurements have been made, a rapidly varying dependence on scattering angle is found, rather than the smooth dependence predicted by the adiabatic [7] and plane-wave [6] theories. (2) Rapid shifting of the correlation symmetry angle with scattering angle should be expected on the basis of a simple surface interaction mechanism [8,9] in which the S-matrix peaks at the nuclear surface, and the term with $l \approx kR$ is the dominant amplitude. (3) Ambiguities in the optical potentials used in conjunction with DWBA and Coupled-Channel fits to the elastic and inelastic angular distribution data can be resolved by simultaneously fitting angular distribution and angular correlation data [2-4]. Experience with 22 MeV alpha-particle data has indicated that such a procedure selects a low value of the real part of the optical potential - generally about -20 MeV [3,5].

To extend the previous work to heavier nuclei, we made $(\alpha,\alpha'\gamma)$ angular correlation studies of the reaction $^{56}Fe(\alpha,\alpha'\gamma_{0.84})^{56}Fe$ at 30 scattering angles from 30° to 110° at a beam energy of 22.2 MeV. A natural iron target was used; ambiguities due to the presence of other isotopes were removed by the gamma-ray coincidence. Apparatus and procedures were the same as described elsewhere [3]. Complementary angular distribution measurements were made at this laboratory with the same iron target by Wilson and Sampson [10].

The behavior of the reaction-plane symmetry axis as a function of scattering angle is shown in fig. 1. The final results are somewhat different from the earlier preliminary results [11], and quite unlike the results from light nuclei. Instead of shifting rapidly with scattering angle, φ_0 is observed to vary smoothly around the line predicted [7] by adiabatic theory. Also shown on the figure are three DWBA predictions for the symmetry axis behavior; the parameters used were those which provided the best fits to the data of Wilson and Sampson [10]. Unfortunately, the sharp parameter selection found for the light nuclei is not observed here, and the cross section became too small to extend the data to larger angles.

A simple, physical explanation of this behavior, is that the larger Coulomb field of this higher-Z nucleus prevents the relatively low-energy alpha particles from reaching the nuclear surface. Diffraction scattering, which apparently selects a single l-value in the reactions involving light nuclei, is washed out here by the strong

Coulomb potential, and several l-values are probably contributing to the cross section. This effect can be seen theoretically in a DWBA calculation by holding fixed the optical parameters for a light nucleus and either increasing Z or the number of partial waves: the symmetry angle shifts more slowly, in a manner similar to the adiabatic prediction, as Z or the number of partial waves is artificially increased.

However, the angular distribution [10] exhibits a sharp diffraction pattern throughout the entire angular range. Furthermore, recent correlation work [12] on ^{26}Mg yielded very similar results to those reported here for ^{56}Fe. This is surprising, since the ^{26}Mg results differed considerably from those of ^{24}Mg and ^{28}Si - and all measurements were made with 22 MeV alpha-particles. Both ^{56}Fe and ^{26}Mg are thought to be only slightly deformed ($\beta \approx 0.2$), whereas the other light nuclei studied are thought to be considerably more deformed. An alternative explanation then might be that the observed behavior of the correlation symmetry axis is due to nuclear structure effects.

To test this hypothesis, we are attempting to include more realistic nuclear wave functions in the reaction calculations, and to study more nuclei in this region. Measurements need to be made over a broad range of energies to investigate the utility of this type of measurement in providing nuclear structure information.

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PRECISION MEASUREMENTS OF SOME GAMMA-TRANSITION ENERGIES IN THE 800 keV REGION USING A Ge(Li) DETECTOR *

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Received 5 July 1965

The high resolution of lithium-drifted germanium detectors makes it possible to investigate complicated γ-spectra, and to measure with high accuracy the energies and intensities of γ-transitions.

In order to measure γ-ray energies, one needs reference lines with accurately known energies. These reference lines should come from radioelements whose half-lives are relatively long, and whose decay schemes are simple. There exist many calibration lines in the energy region from 60 keV to 660 keV whose energies have been determined with the curved crystal technique to high accuracy. There are also some well known lines from 1064 keV to 1368 keV whose energies are known within a few tenths to a few hundredths of a keV. Between 661 keV and 1064 keV, there exists no such standard which is known to better than 1.1 keV. Therefore, if one measures energies over this region with a Ge(Li) detector, one must interpolate over a wide range of energy, thus reducing considerably the precision of the measurement.

* This work was performed under the auspices of the U.S.Atomic Energy Commission. Prepared under Contract AT(04-3)-63 for the San Francisco Operations Office, U.S.Atomic Energy Commission.