This information was obtained from an experiment designed to measure the energy levels of O^{18} by observing alpha particle groups from the reaction $F^{19}(t,\alpha)O^{18}$. Narrow proton groups, presumably from the reaction $F^{19}(t,p)F^{21}$, were observed that did not correspond to any level possible from any of the common contaminants (O, C, N, etc.) or to any level observed in any background run. The groups were obtained by bombarding thin evaporated targets of CaF_2 or PbF_2 with a 1.82-Mev triton beam from one of our 2.5-Mev Van de Graaff accelerators and analyzing the reaction products at 90° with a Cal-Tech type 16-inch double-focusing magnetic spectrometer.

If one plots the masses and half-lives of nuclei differing from F^{21} by one or more alpha particles against the mass number as the abscissa, one gets rough curves with which one might empirically predict the characteristics of F^{21} and other such nuclei. It is of interest that the measured mass of F^{21} is consistent with this curve. The predicted value of the half-life of F^{21} from such considerations is 100 to 200 sec.

A detailed report of this work, verification, and more accurate values of the excited states, and information on O^{18} will be published in the future.

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

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Elastic Scattering of 48.2-Mev Alpha Particles*

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(Received May 9, 1955)

In view of the recent interest in the elastic scattering of alpha particles by heavy nuclei,[1–5] it seems desirable to report the results of investigations that have been under way here for some time.

The angular distributions of 48.2-Mev alpha particles (from the 60-inch cyclotron at Crocker Laboratory in Berkeley) elastically scattered by Au and Ag nuclei have been investigated in considerable detail for angles between 7° and 135° in the laboratory system (Figs. 1 and 2).

The 36-inch scattering chamber[6] was used, and the scattered particles detected by a proportional counter telescope. The long-time reproducibility of data was excellent, so there was no difficulty in normalizing from run to run. The angular resolution is estimated to be ±0.75 degree. No background difficulties were encountered below 90 degrees. At the wider angles the low yields made it difficult to accumulate statistics,

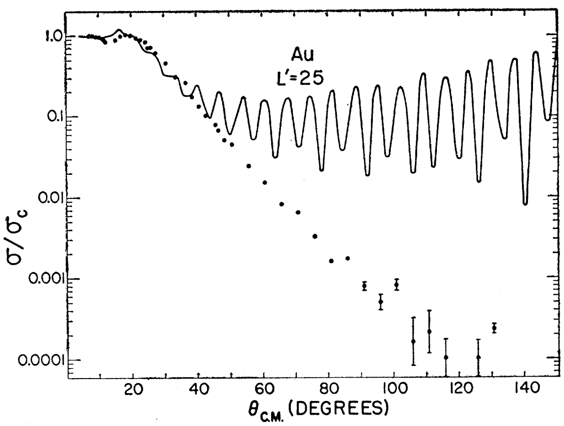

Fig. 1. Angular distribution (relative to Coulomb scattering) of elastically scattered alpha particles from Au. The curve represents the distribution predicted by Blair's sharp cut-off model.

but we feel sure that there is no appreciable rise in the cross sections.

The most striking features in these distributions are the departure from Coulomb scattering by factors of 10^3 to 10^4 at angles beyond 25°, and the structure exhibited in the silver curve between 20° and 60°. According to Blair's model[2] these may be attributed to the effect of collisions by the incident alpha particle with the nucleus. At these energies the incident particles interact strongly with the nucleus in spite of the Coulomb barrier, and it is reasonable to expect that a satisfactory theoretical explanation of these detailed distributions may shed light on the form of the interaction potential. As the figures show, the sharp cut-off model reproduces the general features for forward angles. Attempts are being made to find a satisfactory fit to the data by modifying Blair's theory to include a gradual cutoff of the interaction radius, following the suggestions of Wall *et al.*[4] In addition, an approach is being made using an optical model with a potential

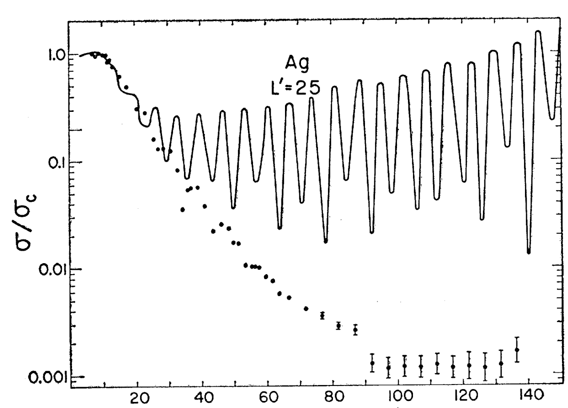

Fig. 2. Angular distribution of (relative to Coulomb scattering) elastically scattered alpha particles from Ag. The curve represents the distribution predicted by Blair's sharp cut-off model.

having real and imaginary parts. The complexity of the analysis has been mitigated by the cooperation of the electronic computing section at the University's Livermore laboratory.

Work is continuing in order to extend the distributions to wider angles, and other targets will be bombarded in order to determine the possible effects of shell structure on the interaction.

* This work was done under the auspices of the U. S. Atomic Energy Commission.

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Lifetime of the 279-kev Excited State of Tl^{203}

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(Received June 16, 1955)

A HALF-LIFE of $(1.2\pm0.3)\times10^{-10}$ sec was found for the 279-kev level of Tl^{203} from measurements of delayed coincidences between betas announcing this level and gammas de-exciting it.

For these measurements, an automatically recording "fast-slow" coincidence arrangement was used, in the fast section of which a unit with helical delay line of the type described by Bell *et al.*[1] had been incorporated. Samples of Hg^{203}, mounted on aluminum backings which absorb the electrons, were sandwiched between two stilbene crystals of equal thickness (0.5 cm) and area (1.5 cm^2), each attached to a 1P21 photomultiplier. The crystal at the absorber side detects the gammas in coincidence with betas accepted by the other crystal. Pulse-height selectors in both channels transmit pulses corresponding to electron energies roughly between 75 and 150 kev.

For such low energies, the accuracy of measurements of very short lifetimes is often seriously impaired by instrumental imperfections. In order to reduce the influence of such effects as much as possible, a "self-comparison-comparison" method was adopted in which the centroid shifts of self-comparison pairs of delayed coincidence plots obtained with samples of Hg^{203} were compared with those of a suitable reference source. The self-comparison pairs are obtained by recording first one run and then, after turning the source plus absorber assembly around, another run.

In the present case, thorium B is very suitable as a reference source because the energies of its strongest coincident radiations are not too much different from those of mercury (for Hg^{203}: $E_{\beta\,\max}=215$ kev, $E_\gamma=279$ kev; for ThB: $E_{\beta\,\max}=340$ kev, $E_\gamma=238$ kev) and because the lifetime of the 238-kev level excited in the decay of ThB is known to be very short: Graham and Bell[2] set an upper limit of 2×10^{-11} sec; Knowles[3] even gives the upper limit as 2×10^{-13} sec. This means that the centroid shift of self-comparison pairs obtained with this source is almost exclusively caused by instrumental effects. The experimental half-life of the 279-kev level of Tl^{203} is therefore given as 0.346 times the difference of the centroid shifts of self-comparison pairs obtained with samples of Hg and ThB.

In the experiments with mercury, unwanted prompt coincidences may occur between x-rays emitted by Tl^{203} nuclei after conversion processes and gammas or conversion electrons. They may also be caused by two successive Compton scatterings. Such coincidences would reduce the centroid shift to a value smaller than the lifetime of the investigated level. From measurements with suitable x-ray or electron absorbers at the appropriate side of the sample it was found, however, that the total contribution of prompt coincidences amounts to only about 8% of the total coincidence counting rate. To account for this effect the measured half-life was increased by 8%.

Combining the measured half-life with experimental conversion data, e.g., those found by Marty,[4] a lifetime $\tau_\gamma=(2.2\pm0.6)\times10^{-10}$ sec for decay by gamma-emission results. There is an appreciable difference between the present result for the lifetime and the value $\tau_\gamma=(5.5\pm1.8)\times10^{-10}$ sec obtained by Barloutaud *et al.*[5] from a measurement of the cross section for Coulomb excitation.

If we assume that the 279-kev transition is 30% magnetic dipole and 70% electric quadrupole, which is in agreement with most measurements,[4,6] partial lifetimes $\tau_\gamma(M1)=(7.2\pm1.3)\times10^{-10}$ sec and $\tau_\gamma(E2)=(3.1\pm0.6)\times10^{-10}$ sec result for these modes of decay. A comparison with Weisskopf's formula shows that the $M1$ transition is retarded by a factor $f=480$. This value of f is of the same magnitude as that found by Graham and Bell[2] and by de Waard and Gerholm[7,8] for a number of $M1$ transitions which according to the shell-model should be l-forbidden ($\Delta l=2$). In this way, the shell model assignments $d_{\frac{3}{2}}$ and $s_{\frac{1}{2}}$ for the 279-kev level and the ground state are confirmed. The $E2$ transition on the other hand is sped up by a factor $F=10$ compared with Weisskopf's estimate. This enhancement is a measure of the part played by collective phenomena. For a nucleus with only one hole in the

TABLE I. Comparative results of lifetime measurements by resonance fluorescence and delayed coincidence methods.

Nucleus	Level (kev)	Lifetime τ_γ in 10^{-10} sec units Res. fluor.	Del. coinc.
Pr^{141}	145	35 ± 10[a]	39 ± 4[b]
Hg^{198}	411	0.33 ± 0.03[c]	0.15 ± 0.25[d]
Tl^{203}	279	10 ± 4[c]	2.2 ± 0.6

[a] See reference 10.
[b] See reference 7.
[c] See reference 9.
[d] See reference 11.