MEASUREMENTS OF THE LONGITUDAL POLARIZATION OF ELECTRONS EMITTED IN THE BETA DECAY OF Au^{198}

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The dependence of polarization on β-electron energy is investigated for Au^{198}. Polarization measurement results are presented (in units of v/c) for Au^{198} β electrons relative to Sm^{153}. For Au^{198} the polarization differs significantly from unity at β-electron energies of 60, 90, and 120 kev. A spherical capacitor was used to change longitudinal into transverse polarization. The polarization was calculated from the asymmetry of β-electron scattering on a heavy element.

NUMEROUS papers devoted to the experimental investigation of longitudinal electron polarization in β decay have shown that the polarization is either equal to or negligibly different from v/c* for a large number of elements. However there exist cases of first-forbidden β-decay transitions in which the electron polarization differs appreciably from unity. Apparently this deviation is strongly correlated with the deviation of the β spectrum from the Fermi shape.[1] The classic example of this type is the β decay of RaE, whose electron polarization is considerably different from unity[2] and whose β-spectrum shape differs from the Fermi shape. Both of these anomalies are explained by the particular structure of this nucleus.

Another example is Au^{198} (the $2^+ \rightarrow 2^-$ transition), whose electron polarization equals unity at energies greater than 200 kev but deviates from unity at low energies (100 — 150 kev).[3-6]

We measured the longitudinal polarization of Au^{198} β electrons in the 60 — 120-kev energy range using the method of Mott scattering. The longitudinal polarization was converted into transverse polarization by deflecting the electrons in the electric field of a spherical capacitor.

DESCRIPTION OF THE EXPERIMENTAL ARRANGEMENT

A schematic diagram of the apparatus is presented in Fig. 1. Electrons from the β-active source are collimated and enter the electrostatic spectrometer (a spherical capacitor which deflects the electrons by 108° and has an energy resolution of $\Delta E/E = \pm 0.07$).

*The polarization is measured everywhere below in units of v/c.

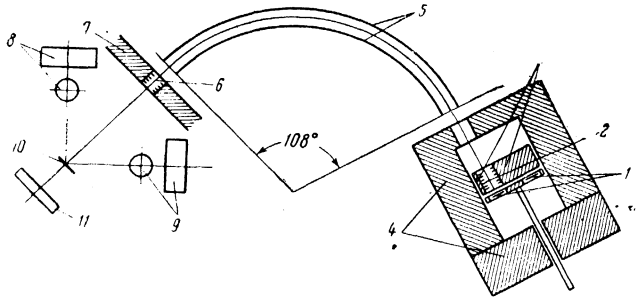

FIG. 1. Schematic diagram of the apparatus: 1 — β sources; 2, 6 — collimators; 3, 4, 7 — lead shielding; 5 — spectrometer; 8, 9 — Geiger counter telescopes; 10 — scatterer; 11 — scintillation counter.

The electron beam from the spectrometer strikes the scatterer. Electrons scattered through 112 — 141° are recorded by two counter telescopes, each consisting of two Geiger counters connected in coincidence.

In order to carry out relative measurements, two sources are inserted simultaneously into the apparatus. The construction of the device permits one to change scatterers and sources without breaking the vacuum and to apply high voltage to the source in order to vary the β-electron energy.

The sources were prepared in the following manner: a thin film of gold was sputtered onto an aluminum foil in vacuum; the samarium was deposited on an aluminum foil by the precipitation method. A silicon organic resin was used as a binding agent. The sources thus prepared were activated in a reactor.

MEASUREMENTS

The longitudinal polarization of β electrons was measured for Au^{198} at 60, 90, and 120 kev, and for Sm^{153} at 120 kev.

T, kev	Element	Δ	P_{rel}	P_{abs}
60	Au^{198}	0.134±0.016	0.60±0.07	0.56±0.06
90	Au^{198}	0.181±0.018	0.73±0.08	0.68±0.08
120	Au^{198}	0.226±0.017*	0.80±0.07	0.74±0.07
120	Sm^{153}	0.257±0.016	1	0.93±0.06

*The value presented is corrected for the presence of conversion electrons.

During the work a constant voltage was applied to the spherical capacitor which separated out electrons of 90 ± 6 kev energy. Thus, in all the experiments electrons of the same energy struck the scatterer, and all corrections to azimuthal asymmetry in the scattering were the same irrespective of the β-spectrum region chosen. In order to measure the polarization of 60- or 120-kev β electrons, an accelerating or braking electric field of 30 kev was applied between source and condenser.

A cycle of measurements at one energy consisted of measuring the azimuthal asymmetry in β-electron scattering on gold and aluminum scatterers. In addition, the background in the experimental setup was measured with the scatterers removed. To eliminate instability over time, a short (15 min) cycle was chosen.

The measurement results are presented in the table, where the following symbols are used: T is the kinetic energy of the electrons, Δ is the azimuthal asymmetry in electron scattering from 0.13 mg/cm² of gold, and P is the longitudinal polarization of the electrons.

In calculating the β-electron polarization of Au^{198} relative to Sm^{153}, only the corrections for depolarization in the sources and for internal conversion electrons are important. All other corrections associated with the relative nature of the measurements are eliminated.

The absolute value of the polarization is $P = \Delta/S$, where Δ is the azimuthal asymmetry of the scattering, measured experimentally, and S is the scattering asymmetry of a completely polarized beam.

To determine S we made use of Sherman's results,[7] introducing corrections for the screening and Z of the nucleus as well as for multiple scattering in the scatterer.[8] Depolarization in the source varied between 1 and 10% in the various experiments. Apparatus asymmetry, eliminated by substituting an aluminum scatterer for the gold one, did not exceed 6%. A spectrum of the source $Au^{198} + Au^{199}$ in the 30 — 160-kev energy region was taken on our apparatus (Fig. 2) in order to investigate the presence of conversion electrons in the given energy intervals. Here the correction to the

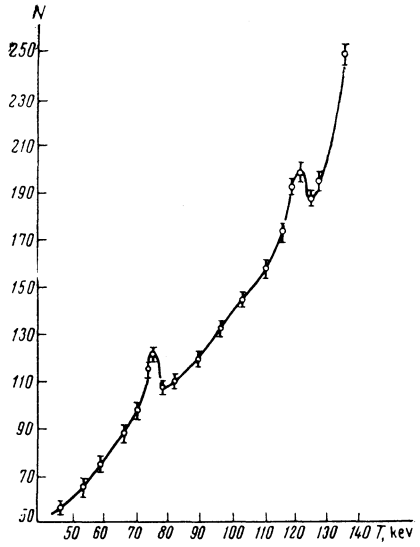

FIG. 2. Spectrum of conversion electrons and β electrons from $Au^{198} + Au^{199}$.

polarization was 0.05 for an average energy of 120 kev. At 60 and 90 kev no noticeable contribution from internal conversion electrons was observed. The measurements showed that the contribution from electrons multiply scattered on the condenser plates was (1 — 2)%, and that from electrons backscattered by the walls of the source chamber less than 1%.

The longitudinal polarization of Au^{198} β electrons in the 60 — 120-kev energy range as measured by us differs appreciably from unity. This difference increases with decrease in energy. The deviation obtained in the polarization value is not unexpected,[1] since the β spectrum of Au^{198} apparently does not have a Fermi shape at energies lower than 250 kev.[9]

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