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COMPARATIVE MEASUREMENTS OF THE SHAPE OF Au^{198} *AND* Zn^{69} *BETA SPECTRA*

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The β spectra of Au^{198} and Zn^{69} were measured under identical conditions using an iron-free toroidal β spectrometer; the β spectrum of Zn^{69} is known to have a Fermi shape. A difference between the β spectra was observed at low energies (100—300 kev) which at 100 kev reached (6.5 ± 0.5)% on the Fermi plot, a lack of electrons being discovered in the Au^{198} spectrum in this region. It is interesting to note that some time ago a deviation from v/c in the longitudinal polarization of Au^{198} β electrons was observed at the same energies.

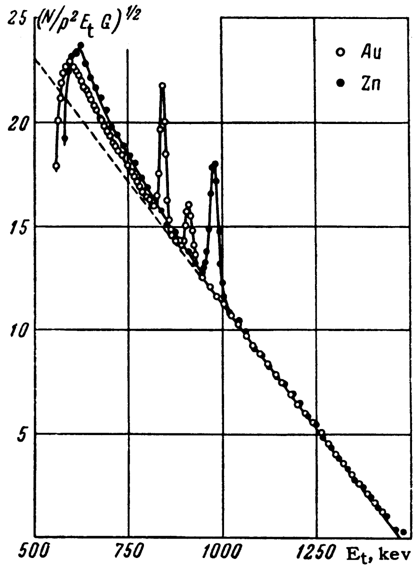
IT has been observed [1] when measuring the longitudinal polarization of Au^{198} β electrons that the magnitude of this polarization differs considerably from v/c at low energies. Geshkenbeĭn and Rudik have shown [2] that such a difference should be accompanied by a deviation of the β spectrum from the Fermi shape in this energy region. We performed an experiment aimed at detecting such deviations in the β spectrum of Au^{198}.

Distortions in the shape of the β spectrum may arise in measurements made with ordinary spectrometers, especially at low electron energies. The causes of this distortion may be divided into two groups. The first group has to do with the composition of the source. The scattering and slowing down of electrons in the source increase the number of low-energy electrons in the spectrum. Back scattering of electrons from the source backing can produce a similar effect.

The second group of causes is associated with the scattering of electrons inside the spectrometer and with the passage of electrons through the counter entrance window. If the measured β-spectrum shape is found to remain unchanged when thin sources of varying thickness (thinner than 100 $\mu g/cm^2$) are used, it may be supposed that the distortions in shape are due only to the second group of causes.

When comparative measurements are made of spectra with identical end-point energies, the difference observed in spectrum shape can be expected to reflect true differences in these spectra (in spite of the deviation of both spectra from the Fermi shape).

For this reason it was decided to compare under strictly identical conditions the β spectrum of Au^{198} with a spectrum of known Fermi shape. The β spectrum of Zn^{69} is especially suitable for such a comparison. When Zn^{68} is irradiated with neutrons, Zn^{69} is formed both in the ground state, from which β decay proceeds to the ground state of Zn^{69} (half-life 51 minutes), and in the isomer state, from which a γ transition to the ground state of Zn^{69} (half-life 14 hours) is followed by a 51-minute β decay. [3] The end-point energy of the Zn^{69} electrons is 914 kev, which is comparatively close to the maximum energy of the Au^{198} β spectrum (960 kev). A less essential but advantageous circumstance is the proximity of the energies of the γ rays emitted by both sources (411.8 kev for Au^{198} and 436 kev in the case of Zn^{69}). The β spectrum of Zn^{69} has



Fermi plot for Au^{198} and Zn^{69}. p and E_t are the momentum and total energy of the β electron, G is a modified Fermi function, and N is the number of counts per unit time.

log ft = 4.4,[3] indicating that this spectrum should have an allowed shape. This has been confirmed by earlier experiments, at least up to 200 kev.[4] Data on the longitudinal polarization of Zn^{69} β electrons are, unfortunately, lacking.

The measurements were made with a large iron-free β spectrometer.[5] The sources were prepared by evaporating one drop of the corresponding nitrate solution on a layer of insulin coating a 0.6-mg/cm^2 aluminum backing. This procedure is known to lead to considerable improvement in source homogeneity. The sources were 25 mm in diameter.

The β spectrum of the gold was measured using sources 25, 50, and 100 μg/cm^2 thick. Within an experimental error of ~ 1%, the spectra obtained from the various sources were identical in shape for electron energies greater than 80 kev. The zinc β-spectrum measurements were performed with 50- and 100-μg/cm^2 sources; with the same accuracy, no marked differences in β-spectrum shape were observed.

Sources from 50 to 60 μg/cm^2 thick were employed for the principal measurements. Ten series of such measurements were made with Au^{198} and Zn^{69}, fresh sources being prepared each time. The good reproducibility of the results thus attained is evidence of the absence of significant inhomogeneities in the sources. An end-window Geiger counter with a 1.6-mg/cm^2 mica window served as electron detector. The β spectra were compared by superposing the straight-line sections of the Fermi plots. The Zn^{69} and Au^{198} spectra superposed in this way are shown in the figure (the scales of the coordinate axes for the Zn^{69} spectrum are changed). The divergence between the plots in the low-energy region, which becomes as large as (6.5 ± 0.5)%, is distinctly visible; there is a lack of low-energy electrons in the Au^{198} spectrum. The Au^{199} β spectrum is estimated to contribute several hundredths of a percent. The deviation of the zinc Fermi plot from a straight line at low energies is due to the scattering of electrons inside the spectrometer, in particular on the current-conducting wires of the magnet coil. It was this circumstance which compelled us to employ a comparative method. Our result shows that the surplus of low-energy electrons discovered by Steffen[6] in the Au^{198} β spectrum is not connected with the increase in the β-spectrum shape factor in this region.

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231