ON A POSSIBLE DETERMINATION OF THE SIGN OF MUON POLARIZATION

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A determination of the polarization sign of μ mesons produced in the π-μ decay would decide the validity of the conservation law of leptons. In this connection it seems to us that the following possibility for the experimental determination of the polarization sign is of interest.

Longitudinally polarized μ mesons from the decay process are sent into a transverse magnetic field. The anomalous magnetic moment of the meson will cause its spin to rotate somewhat faster than its momentum. After a certain number of revolutions the meson will be transversely polarized. The necessary number of revolutions for the spin to turn away from the momentum by $\pi/2$ may be estimated as follows. The angle of "deviation" of the spin from the momentum is $\psi' = 2\pi n(\epsilon/m)\Delta\mu/\mu$, where $\Delta\mu/\mu$ is the relative anomalous moment of the μ meson and ϵ is its energy. To lowest order $\Delta\mu/\mu = \alpha/2\pi = 1.15 \times 10^{-3}$.[1] Hence for mesons with energy $\epsilon/m = 1.7$ the value of $n_{\pi/2} \approx 125$ is obtained.

The sign of the transverse polarization may be determined, for example, by measuring the asymmetry in Coulomb scattering of the meson.[2] The asymmetry in the scattering of polarized particles has a rather sharp maximum for velocities of the order of $\beta^2 \approx 2/3$ (for scattering through an angle $\pi/2$).[1] Consequently mesons of appropriate energy should be selected for the experiment. Since at such high energies the scattering cross section becomes very small for large angles one should use a scatterer with high Z and of substantial thickness (although not so thick as to stop the mesons altogether).

Let us estimate the intensity of the scattered mesons and the degree of asymmetry in the scattering. Assuming scattering into a solid angle ~ 1 we find (for $Z = 80$ and for a kinetic energy of the meson of 80 Mev) for the number of scatterings through $\pi/2$ per g/cm^2 of the substance: $\nu \approx 1.5 \times 10^{-5}$. Further, in a field $H \approx 10 \times 10^3$ oe the time spent by the mesons in the system will be $\approx 1.5 \times 10^{-6}$ sec. At $\epsilon/m \approx 1.7$ approximately half of the mesons that entered the system will traverse it (assuming no losses in the system). Assuming $\sim 10^4$ mesons incident on the system per sec and using 15 g/cm^2 for the thickness of the scatterer we obtain for the meson intensity $I \sim 1$ sec^{-1}.

The degree of asymmetry $a(\theta)$ is determined by the expression

$$I(\theta)/I(-\theta) = (1 + Pa)/(1 - Pa),$$

where P is the degree of polarization of the initial meson beam. For $\theta = \pi/2$, a_{max} has a value of $\approx \frac{1}{4}$. Apparently it is not difficult to obtain $P > 0.5$, so that the ratio of intensities is $\gtrsim 1.3$.

The proposed experiment may easily be combined with an experiment designed to measure the size of the anomalous magnetic moment μ.

I am deeply grateful to Yu. F. Orlov for a discussion of this problem which was very valuable to me.

[1] A. I. Akhiezer and V. B. Berestetskiĭ, Квантовая электродинамика (Quantum Electrodynamics) Teortekhizdat, 1953 (Trans. by U.S. Dept. Comm.).

[2] H. A. Tolhoek, Usp. Fiz. Nauk **63**, 4 (1957).

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QUADRUPOLE MOMENT OF Er^{168}

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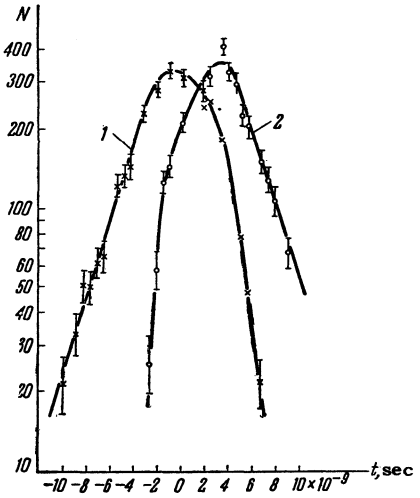
GROMOV et al.[1] and Jacob et al.[2] identified the 80-kev level of Er^{198}, produced by K capture in Tu^{168}, as the first level of the rotational band. A measurement of the lifetime of this level permits determination of the quadrupole moment and the deformation parameter of Er^{168}, using the equations of the generalized model of the nucleus.[3]

We used a weak source of Tu^{168} (T = 85 days), obtained in a deep splitting reaction by prolonged exposure of tantalum to 660-Mev protons in the synchrocyclotron of the Joint Institute for Nuclear Research.



The coincidence curves obtained in the setup described by one of the authors[4] are shown in the figure. The abscissas represent the delay time, and the ordinate the number of coincidences in logarithmic scale. Curves 1 and 2 correspond to coincidences between the x-rays that accompany the K captures and the conversion electrons produced in transitions from the 80-kev level. Curve 1 is for measurements in which the electron-absorbing filter is to the right of the source (eX coincidences), while curve 2 pertains to an absorber to the left of the source (Xe coincidences).

The errors introduced in the principal curves by x-γ, γ-x, and γ-γ coincidences, and also by multiple scattering of gamma rays in both crystals, were accounted for by measuring separately the number of coincidences as a function of the delay time, using electron absorbers placed on both sides of the source. In plotting the eX and Xe coincidences, the channel analyzers separated those parts of the spectra, corresponding to the photopeak for x-rays and to the L + M + N conversion peaks for electrons. A certain difference in shape and width of curves 1 and 2 is probably due to the different energy resolution of the two stilbene crystals. The same value of half-life is obtained from the slopes of the left and right branches of curves 1 and 2, $(1.8 \pm 0.3) \times 10^{-9}$ sec. The error given here exceeds the statistical error and takes into account possible methodical effects.

Taking into account conversion on all shells (the values of the coefficients of conversion are taken from the tables of Sliv and Band[5] for the K and L shells and from the paper of Listengarten[6] for the M + N shell) we obtain for the radiative half life

$$T_{\gamma} = (1+\alpha)\, T_{\mathrm{exp}} = (15 \pm 2.5)\cdot 10^{-19} \text{ sec},$$

where α is the total conversion coefficient.

The Weisskopf formula for a type E2 single-particle transition with energy 80 kev yields a half life of 3.10×10^{-6} sec, leading to an acceleration factor F = 200 (F is the ratio of the half-life obtained from the Weisskopf formula to the experimental radiative half-life).

The internal quadrupole moment and the deformation parameter, calculated from the Bohr formulas,[3] are equal to $(7.6 \pm 0.6) \times 10^{-24}$ and 0.32 ± 0.03, respectively. The quadrupole moment we obtained from the measurement of the half life is in good agreement with the value 7.8×10^{-24} obtained from experiments on Coulomb excitation of Er^{168} (reference 7).

[1] Gromov, Dzhelepov, and Preobrazenskiĭ, Izv. Akad. Nauk SSSR, Ser. Fiz. **21**, 918 (1957), Columbia Tech. Transl. p. 920.

[2] Jacob, Mihelic, and Harmatz, Phys. Rev. **106**, 1232 (1957); Bull. Am. Phys. Soc. **2**, 260 (1957).

[3] A. Bohr, Rotational States of Atomic Nuclei, Copenhagen, 1954; transl. in Пробл. совр. физ. (Probl. of Mod. Phys.) **1**, 5 (1956).

[4] É. E. Berlovich, Izv. Akad. Nauk SSSR, Ser. Fiz. **20**, 1438 (1956), Columbia Tech. Transl. p. 1315.

[5] L. A. Sliv and I. M. Band, Таблицы коэф. Внутр. конверсии гамма излучения, (Tables of Coefficients of Internal Conversion of Gamma Radiation) part 1, 1956; part 2, 1958.

[6] M. A. Listergarten, Izv. Akad. Nauk SSSR, Ser. Fiz. **22**, 759 (1958), Columbia Tech. Transl. p. 755.

[7] Alder, Bohr, Huus, Mottelson, and Winther, Revs. Modern Phys. **28**, 432 (1956).

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