Comments and Addenda

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Relative Transmission of Positive and Negative Electrons through Aluminum

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This paper comments on an earlier paper by Takhar and questions the validity of his conclusions.

IN an experimental comparison of the penetration of positively and negatively charged electrons through matter, Takhar[1] concludes that the mass absorption coefficient of various materials is lower for positrons than for negatrons. Specifically, for aluminum, the increase in positron transmission is reported as 12%. Further, Takhar concludes that his results do not agree with the measurements of Chang *et al.*,[2] but do agree with the measurements by Seliger.[3]

The primary purpose of this note is to point out that the experimental results found by Takhar and the specific techniques he used to obtain these results are such that comparisons with the results of either Chang *et al.*, or Seliger, are extremely difficult and perhaps impossible so, in my opinion, they invalidate his conclusions. Furthermore, the results of Chang *et al.*, who used only relatively thin foils of 7.3, 10.8, and 26.3 mg/cm^2, do not disagree with the results of Seliger, as implied in Takhar's paper. Neither Fig. 3 nor Fig. 8 of Seliger's paper show any observable difference between β^+ and β^- transmission through these small foil thicknesses for electrons with kinetic energies of 250, 336, and 960 keV. What difference in transmission that Seliger finds for 159 keV electrons could easily have been masked in the experiments of Chang *et al.*, by the large slope of their transmission curve at this energy.

Both earlier experiments[2,3] measured the transmission of monenergetic electrons through foils, whereas Takhar used two β-ray emitters without providing any method for selection of kinetic energies. The difficulty introduced by such use of radioactive sources is that the β spectra of ^{68}Ga and ^{86}Rb are not sufficiently similar to allow direct comparison of the transmission through various foils of the positrons and negatrons emitted by these sources. Because of the Coulomb effect in β decay, a positron spectrum has a larger average energy than a negatron spectrum with the same endpoint energy. Furthermore, the β spectra of both ^{68}Ga and ^{86}Rb are complex. The energy spectra of the β particles emitted

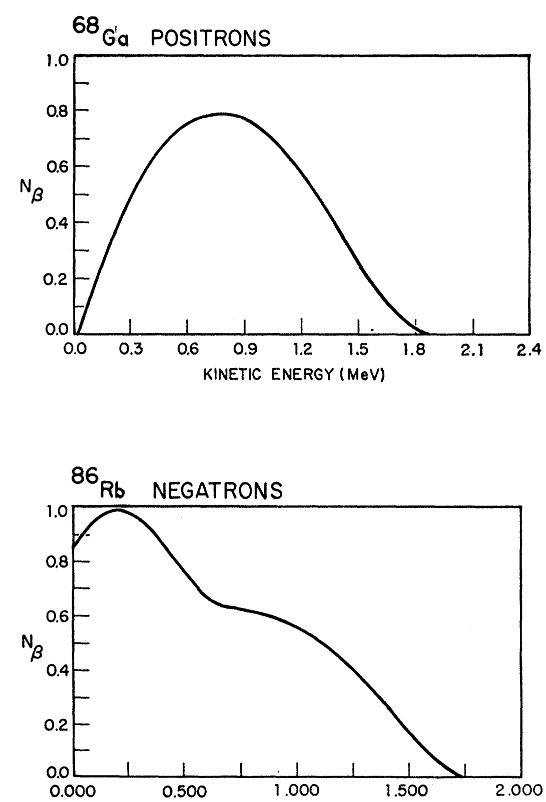

FIG. 1. The spectral distributions of ^{68}Ga and ^{86}Rb as a function of β-particle kinetic energy.

[1] P. S. Takhar, Phys. Rev. **157**, 257 (1967).
[2] C. H. Chang, C. S. Cook, and H. Primakoff, Phys. Rev. **90**, 544 (1953).
[3] H. H. Seliger, Phys. Rev. **100**, 1029 (1955).
[4] See, for example, J. M. Blatt and V. F. Weisskopf, *Theoretical Nuclear Physics* (J. Wiley & Sons, Inc., New York, 1952), pp. 673–684.

by these two nuclides are shown in Fig. 1, calculated[5,6] from experimentally observed end-point energies and assuming an allowed shape. Even a quick glance at this figure shows rather clearly the lower average energy of the β particles emitted by ^{86}Rb. The mean energy of the β particles emitted by ^{68}Ga is 0.826 MeV and by ^{86}Rb is 0.622 MeV. The median energy is 0.811 MeV for ^{68}Ga and 0.562 MeV for ^{86}Rb. The ratio of the mean energies is 1.328 and of the median energies 1.443. Both these ratios indicate that Takhar's sources emitted a much larger proportion of low-energy negatrons than positrons.

Gleason *et al.*[7] have observed that the mass absorption coefficients in aluminum of negative β particles emitted by a single transition source are energy-dependent in accordance with the formula $\mu/\rho = 17.0 W_0^{-1.43}$ cm^2/g, in which W_0 is the endpoint energy of the β spectrum. The ratio of the endpoint energies of the β spectra of the radionuclides used by Takhar in his experiment is $W_{Ga}/W_{Rb} = 1.88/1.77 = 1.062$. If this energy-dependent formula for μ/ρ can be applied to positive β particles as well as negative β particles and if the lower energy β groups are ignored, the ratio of the mass absorption coefficients is $(\mu/\rho)_{Rb}/(\mu/\rho)_{Ga} = (1.062)^{1.43} = 1.09$, and would account for at least 9% of the 12% difference observed by Takhar. The assumptions that have been made to be able to apply the formula of Gleason *et al.* to β^+ particles are probably not valid but have been introduced to indicate that several difficulties may arise when monoenergetic electrons are not used for transmission measurement experiments.

Although Takhar's results undoubtedly show the correct trends in the nature of β^+ and β^- transmission through various materials, the values given in Table IV of his paper should not be viewed as necessarily being quantitatively accurate.

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[5] O. Hogan, P. E. Zigman, and J. L. Mackin, United States Radiological Defense Laboratory Report No. USNRDL-TR-802, 1964 (unpublished).

[6] O. Hogan, United States Radiological Defense Laboratory Report No. USNRDL-TR-1101, 1966 (unpublished).

[7] G. I. Gleason, I. D. Taylor, and D. L. Tabern, Nucleonics 8, No. 5, 12 (1951). See, also, G. Knop and W. Paul, in *Alpha, Beta and Gamma Spectroscopy*, edited by K. Siegbahn (North-Holland Publishing Co., Amsterdam, 1965), p. 23.