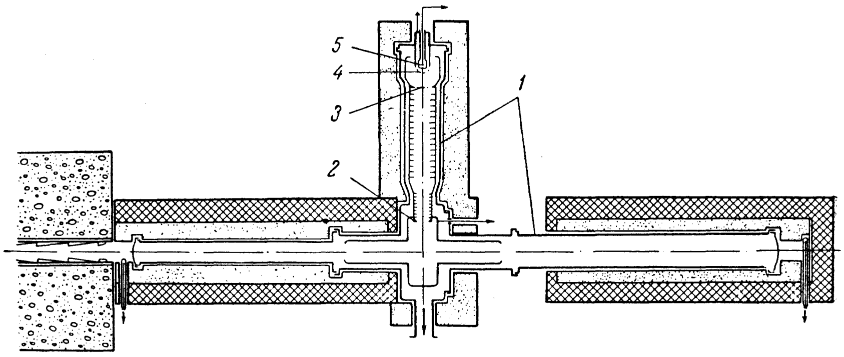

FIG. 1

taking account of the slight correction (~1 – 1.5%) due to its dependence on the angle of incidence of the protons, was 0.84 ± 0.5%. The coefficient k was determined on a computer† and was equal, to 7.87×10^{-3}. The uncertainty in this number was determined mainly by the lack of precision in fixing the geometry of the apparatus, and did not exceed a few tenths of a percent.

Inserting these values in the expression for T gives a value of T = (11.7 ± 0.3) min for the neutron half-life. This half-life leads to an ft value for the neutron of 1180 ± 35. If we make use of the relation between the ft value and the ratio of the coupling constants g_{GT} and g_F, we find from a comparison of the neutron ft value and that of O^{14} (ft = 3100[4]) the value $|g_{GT}/g_F|^2 = 1.42 \pm 0.08$ for this ratio.

*Deceased.

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[1] Snell, Pleasonton, and McCord, Phys. Rev. **78**, 310 (1950).

[2] J. M. Robson, Phys. Rev. **83**, 349 (1951).

[3] A. N. Sosnovskii and P. E. Spivak. Report at the International Conference, Geneva, 1955; vol. II, p. 38.

[4] J. B. Gerhart, Phys. Rev. **109**, 897 (1958).

Translated by M. Hamermesh
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POLARIZATION OF RaE *ELECTRONS AND TIME REVERSAL INVARIANCE*

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In a previous paper by the authors[1] it was shown that for β decays in heavy nuclei corresponding to first forbidden transitions (so-called Coulomb transitions, $\Delta J \neq 2$, as well as unique transitions $\Delta J = 2$, yes) the longitudinal polarization of the electrons should equal $-v/c$ accurate to 5%, and should be energy independent. However there exists a Coulomb transition, namely RaE ($1^- \rightarrow 0^+$), for which the shape of the β-spectrum is anomalous.

To explain this anomaly, Yamada[2] postulated an accidental cancellation of matrix elements such that the large energy independent terms determining the β spectrum are reduced by destructive interference down to 1% of their value; thus the small energy dependent terms become important and are responsible for the anomaly in the β-spectrum shape. Two parameters, x and y, are introduced, representing the ratios of two matrix elements to a third one and by an appropriate choice of these parameters the normal β-spectrum shape is changed to fit the experimental shape for RaE.

The fit is obtained by the introduction of a correction factor $C(R_0, \epsilon, x, y)$[3-6] where R_0 is the nuclear radius and ϵ the total energy. It is to be expected that if the accidental-cancellation hypothesis is valid the magnitude of longitudinal polarization ($-\langle\sigma\rangle c/v$) of electrons will also exhibit an anomaly in the exceptional case of RaE.

This case is of particular interest since, as was noted by Lewis[6] and Fujita et al,[7] the Yamada hypothesis permits limits to be set on the violation of time-reversal invariance.

The additional term arising from the assumption that the β decay coupling constants are complex affects the correction factor and narrows down the range of possible fits to the experimental spectrum shape.

We have measured the longitudinal polarization of electrons of average energy $\overline{E} = 125$ and 350 kev using the apparatus and technique previously described.[1]

The source of Ra(D + E) of 5 millicurie intensity was approximately 0.8 mg/cm^2 thick. We obtained $-\langle\sigma\rangle\, c/v = 0.733 \pm 0.06$ and 0.725 ± 0.06 (average: 0.73 ± 0.04) for $\overline{E} = 125$ and 390 kev respectively.

Geshkenbein, Nemirovskaia, and Rudik,[8] drawing on the above mentioned papers, calculated the longitudinal polarization for RaE electrons for the VA and ST covariants allowing for parity nonconservation, and assuming time reversal invariance either to be valid or to be violated.

In the case of the VA covariants, the two parameters entering into the correction factor are

$$x = (iC_V/C_A)\int \mathbf{r} \Big/ \int [\sigma\times\mathbf{r}], \qquad y = (C_V/C_A)\int \alpha \Big/ \int [\sigma\times\mathbf{r}].$$

Under the assumption of time reversal invariance ($F^2 = 0$) the parameter x is limited by the spectrum shape to lie in the range $2 > x > 0.2$, and the theoretically-possible values for $-\langle\sigma\rangle\, c/v$ at $E = 250$ kev lie between 0.67 and 0.835. The experimental value 0.73 ± 0.04 lies within these narrow limits which serves as confirmation of Yamada's hypothesis and limits x to the range $2 > x > 1$, i.e., reduces the uncertainty in x by a factor of 5. The magnitude of the polarization is very sensitive to time reversal invariance violation. Taking the same range of values $2 > x > 1$ and $F^2 = 6 \times 10^{-3}$, $F < 0$ (where F is the imaginary part of C_A) we have: $0.63 > -\langle\sigma\rangle\, c/v > 0.57$ and for $F > 0$: $0.85 > -\langle\sigma\rangle\, c/v > 0.79$. Both cases are in disagreement with experiment.

However, it is possible to fit the experiment with $F^2 = 6 \times 10^{-3}$, $F < 0$ provided $0.2 < x < 0.5$; the polarization then lies in the range $0.71 > -\langle\sigma\rangle\, c/v > 0.67$ and $x = 0.2$ is the minimum value of the parameter x that will yield a fit for the spectrum. From this the maximum possible value of F and, consequently, of time reversal invariance violation turns out to be less than 7.5% which coresponds to an angle $\Delta\theta$ between A and V of $\sim 4.5°$. At this time this appears to be the most precise determination of time reversal invariance.

A greater precision would be possible if an independent determination (e.g., by use of shell model calculations) were made of at least the order of magnitude of the parameter x or if the energy dependence in the range from 100 to 700 kev of the longitudinal polarization of RaE electrons were measured.

[1] Alikhanov, Eliseev, and Liubimov, J. Exptl. Theoret. Phys. (U.S.S.R.) **34**, 1045 (1958), Soviet Phys. JETP **7**, 723 (1958).

[2] M. Yamada, Progr. Theoret. Phys. Japan **10**, 252 (1953).

[3] G. E. Lee-Whiting, Phys. Rev. **97**, 463 (1955).

[4] E. A. Plassman and L. M. Langer, Phys. Rev. **96**, 1593 (1954).

[5] Takebe, Nakamura, and Taketani, Progr. Theoret. Phys. (Japan) **14**, 317 (1955).

[6] R. R. Lewis, Phys. Rev. **108**, 904 (1957).

[7] Fujita, Yamada, Matumoto, and Nakamura, Phys. Rev. **108**, 1104 (1957).

[8] Geshkenbein, Nemirovskaia, and Rudik, J. Exptl. Theoret. Phys. (U.S.S.R.) (in press).

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A NOTE ON d-d REACTIONS

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RECENTLY D. I. Blokhintsev[1] made the suggestion that the formation of "sub-barrier" fragments in the disintegration of nuclei by high energy nucleons can be explained by assuming that during the motion of the nucleons in the nucleus a close agglomeration of nucleons can result from fluctuations. As a result of a direct collision of the incident particle with such a cluster, "sub-barrier" fragments are produced. The results were compared with experiments on the scattering of 675-Mev protons by light nuclei.

A test of these ideas can be made with a variety of nuclear reactions, including the d + d reactions at these same energies. These reactions can proceed via the following channels: