

B. L. Ioffe

Submitted 7 July 1966

ZhETF Pis'ma 4, No. 9, 376-378, 1 November 1966

We have previously [1] considered the radiative corrections and corrections due to weak interactions for the ratio G_μ/G_β of the constants of β and μ decay in the theory with the intermediate boson. It was assumed there that at momentum transfers Λ of the order of μ/e ¹⁾ ($\mu = W$ -boson mass), when the electromagnetic interaction of the W bosons becomes effectively strong, the W bosons acquire a form factor that cuts off both the electromagnetic and the electric interactions. It was also assumed that the hadrons have a form factor that cuts off their interaction at momenta of the order of the nucleon mass. We calculated in [1] the radiative corrections to the ratio G_μ/G_β with allowance for terms of the order of $e^2 \ln(\Lambda^2/\mu^2) \sim e^2 \ln e^{-2}$, but neglecting terms of order e^2 . The radiative corrections of order $e^2 \ln(\Lambda^2/\mu^2)$

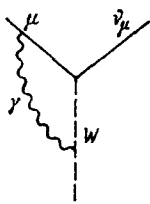


Fig. 1

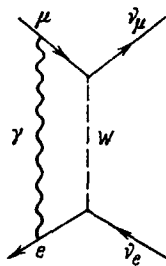


Fig. 2

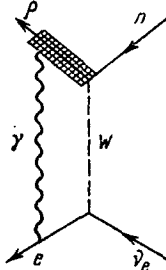


Fig. 3

were determined by the diagrams of Figs. 1 and 2 in the case of μ decay, whereas the similar diagrams introduced in the case of β decay a contribution on the order of e^2 , by virtue of the assumed form factors for the nucleons.

We shall use below the algebra of currents to show that the radiative corrections to the β -decay constants, described by the diagram of Fig. 3, actually contain no form factors due to the strong interactions; this

modifies the result of [1]. The hadron part of the diagram of Fig. 3 is proportional to the matrix element

$$\bar{u}(p)M_{\mu\nu}(p, k)u(p) = i \int d^4x \exp(-ikx) \langle p | T \{ j_\mu(0), j_\nu^+(x) \} | p \rangle, \quad (1)$$

where $j_\mu(x)$ is the electromagnetic current, $j_\nu^+(x)$ the weak current, $|p\rangle$ the single-nucleon state with momentum p , and k the W -boson momentum. From the current conservation law $\partial j_\nu^+(x)/\partial x_\nu = 0$ and from the equal-time commutation relations

$$[j_\mu(x), j_0^+(y)]_{x_0=y_0} = -j_\mu^+(x) \delta(\vec{x} - \vec{y}) \quad (2)$$

we get [2,3]

$$M_{\mu\nu}(p, k)k_\nu = \Gamma_\mu^+(p, p), \quad (3)$$

where $\Gamma_\mu^+(p_2, p_1)$ is the exact vertex part of the nucleon, $\Gamma_\mu^+(p, p) = \gamma_\mu \tau^+$. The logarithmically diverging terms in the diagram of Fig. 3 are obtained by taking the term $k_\nu k_\lambda / \mu^2$ in the W -boson propagator $G_{\nu\lambda}(k) = (\delta_{\nu\lambda} - k_\nu k_\lambda / \mu^2) / (k^2 - \mu^2)$. In this case, however, we obtain by

virtue of (3) the same expression as if the nucleon were not to participate in the strong interaction, i.e., a diagram similar to that of Fig. 2, and the terms proportional to $\ln(\Lambda^2/\mu^2)$ turn out to be the same in Figs. 3 and 2, and thus cancel out in the ratio G_μ/G_β .

As a result, we obtain (see [1]) for the ratio of the constants G_μ/G_β

$$\frac{G_\mu}{G_\beta} = \left[1 + \frac{3}{16} \frac{e^2}{\pi} \ln \frac{\Lambda^2}{\mu^2} - \frac{3e^2}{4\pi} \ln \frac{\Lambda_\beta}{2E} + \frac{3}{10} \frac{m^2}{\mu^2} \right] \frac{G_\mu^0}{G_\beta^0}, \quad (4)$$

where $\Lambda_\beta \sim M$ is the cutoff parameter due to the strong interaction, E the energy released in the β decay, G_μ^0 and G_β^0 the bare constants of the μ and β decay, connected in accord with the Cabibbo theory by the relation $G_\beta^0 = G_\mu^0 \cos\theta$. Substituting in (4) the values $\Lambda^2/\mu^2 \sim 10^3$, $\Lambda_\beta = M$, $E = 2.3$ MeV (the β -transition energy in O^{14}), $\mu \geq 3$ BeV, and $\sin\theta = 0.22$, we get $(G_\mu/G_\beta)_{\text{theor}} = 1.022$. This value should be compared with the experimental [4] $(G_\mu/G_\beta)_{\text{exp}} = 1.011 \pm 0.005$. It must be borne in mind in this comparison that terms of the order of e^2 , which do not contain the large logarithms $\ln(\Lambda^2/\mu^2)$ or $\ln(\Lambda_\beta/2E)$, have been neglected in [4]. In addition, as shown in [1], the corrections due to weak interactions lead to a decrease in the ratio G_μ/G_β and are of the order of $10^{-3} (\mu/M)^2$.

The presence of relation (3) leads to entirely different conclusions than in [1] with regard to the magnitude of the radiative corrections to the ratio G_μ/G_β , including the case when the W boson has a nonvanishing magnetic moment which is not small. Namely, the radiative corrections turn out in this case to be of the order of $e^2 \ln(\Lambda^2/\mu^2)$ and not $\sqrt{e^2}$ as found in [1].

- [1] B. L. Ioffe, JETP 47, 975 (1964), Soviet Phys. JETP 20, 654 (1965).
- [2] V. N. Gribov, B. L. Ioffe, and V. M. Shekhter, Phys. Lett. 21, 457 (1966).
- [3] J. D. Bjorken, Preprint SLAC-PUB-165, 1966
- [4] C. S. Wu, Rev. Mod. Phys. 36, 618 (1964).

1) We are considering a case when the W boson has no anomalous magnetic moment.

STRUCTURE OF ISOBARIC ANALOG STATES IN HEAVY NUCLEI

D. F. Zaretskii and M. G. Urin
 Moscow Engineering-physics Institute
 Submitted 15 July 1966
 ZhETF Pis'ma 4, No. 9, 379-381, 1 November 1966

Isobaric analog states have been recently observed systematically in various nuclear reactions for practically all nuclei with $N \neq Z$, thus pointing to a common microscopic nature of these states. Since analog states appear in particular as narrow resonances in the neutron spectrum in the direct (pn) reaction, it is natural to assume that these states constitute, with respect to the target nucleus, collective excitations of the proton-neutron hole type.