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The hypothesis of electromagnetic CP-violation, first proposed by S.Barshay /1/ and by I.Bernstein et al./2/ was then widely discussed (see /3/). From the existing experimental information (see e.g. /4/) one may infer that this CP-violating interaction if it exists must conserve P, CPT , isotopic spin I and, probably, unitary spin F /5/. The new upper limit for the neutron electric dipole moment (e.d.m.) /6/ $d_n \lesssim 2.10^{-22}$ e.cm seems to impose severe restrictions on the magnitude of such an interaction. At first sight d_n must be of the order λGem , where e is the electron charge, G is the Fermi constant of weak interaction, m -nucleon mass, λ some dimensionless constant which characterizes the strength of CP-violating interaction (λ is obviously model depending). Using the upper limit for d_n we may infer that $\lambda \lesssim 10^{-8}$. If we believe in the universal weak interaction we should somehow explain the smallness of d_n . This problem will be considered here in more details.

The alternative explanation was discussed by T.D.Lee /5/ who pointed out that CP and strangeness (S)-conserving , P -violating nonleptonic weak interaction may be suppressed in comparison with non-leptonic S – violating interaction (and so the weak interaction supposed to be nonuniversal). The present experimental evidence does not absolutely exclude this alternative due to some uncertainty in nuclear matrix elements *). If this suppression is connected with the octet spurion model of weak interaction /8/, as was discussed by T.D.Lee /5/ then it must be not less then the suppression of the non-octet terms relative to octet terms (i.e. ≈ 10%).

We consider here the simplest estimations of e.d.m. of spinor particles (especially of d_n) assuming that electromagnetic CP violation is due to the off-mass-shell corrections to electromagnetic vertex of the particles.

The special models of such a kind were introduced in /9/ and a general phenomenological model of this sort was considered then in /10/. The general C-odd and T-odd but CPT-conserving spinor vertex is /10/

$$\begin{aligned}\Gamma_\mu (p', p) = \\ & i F_1 \gamma_\mu + F_2 \sigma_{\mu\nu} q^\nu + i F_3 q_\mu + \\ & + i F_4 (\hat{p}' \gamma_\mu - \gamma_\mu \hat{p}) + F_5 (\hat{p}' \sigma_{\mu\nu} - \sigma_{\mu\nu} \hat{p}) q^\nu + i F_6 \hat{q} q_\mu + \\ & + i F_7 (\hat{p}' \gamma_\mu + \gamma_\mu \hat{p}) + F_8 (\hat{p}' \sigma_{\mu\nu} + \sigma_{\mu\nu} \hat{p}) q^\nu + i F_9 (\hat{p}' + \hat{p}) q_\mu + \\ & + i F_{10} \hat{p}' \gamma_\mu \hat{p} + F_{11} \hat{p}' \sigma_{\mu\nu} q^\nu \hat{p} + i F_{12} \hat{p}' \hat{p} q_\mu ,\end{aligned} \tag{1}$$

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*) *Strictly speaking the results of V.M.Lobashov et al.* /7/ *demonstrated the existence of the interaction discussed above but it is a more difficult task to extract from them the exact magnitude of the corresponding coupling constants.*

where $F_i \equiv F_i(p'^2, p^2, q^2)$; $q = p - p'$, p and p' being the four-momenta of incoming and outgoing particles respectively, $\hat{p} = \gamma^\mu p_\mu$. All formfactors F_i are real and satisfy the following conditions

$$F(p'^2, p^2, q^2) = \begin{cases} + F_i(p^2, p'^2, q^2) & \text{for } i = 3,4,5,9,12 \\ - F_i(p^2, p'^2, q^2) & \text{for } i = 1,2,6,7,8,10,11 . \end{cases} \quad (2)$$

The general form of P-odd vector vertex on the mass-shell is

$$G^A_\alpha = [A(q^2)\gamma_\alpha + B(q^2)\sigma_{\alpha\beta} q^\beta + C(q^2) q_\alpha] i\gamma_5 . \quad (3)$$

where A, B, C are the formfactors and $B(0)$ is e.d.m. of the partcile.

Consider now the simplest diagrams /11/(Fig. 1a), where the photon vertex corresponds to (1) and the weak vertex (W) corresponds to $S = 0$, $CP = +1$, $P = -1$ spurion described by the factor $if\hat{k}\gamma_5$. Here f is some dimensionless constant, k is four momentum of the particle. The resulting e.d.m. is $d_n = \frac{e}{m} f F_5$ and we see that only F_5 contributes. For the estimation of the order of magnitude d_n we need to know the constant f. In the universal theory we may estimate it by considering s-wave in $\Lambda \to n\pi_0$ decay in the model Fig. (2). Using for strong $\Lambda\Sigma\pi$ and $NN\pi$ vertex $SU(3)$-symmetry relations we find $f = 3.10^{-7}$. Assuming the nonuniversal interaction with octet dominance we would find $f \approx 3.10^{-8}$. Comparing then the expression for d_n with experimental upper limit we get $F_5 \lessapprox 0.03$ and $F_5 \lessapprox 0.3$ for universal and nonuniversal interaction, respectively. These numbers are too small.

It is interesting to note that F_5 corresponds to the interaction Lagrangian density

$$\mathfrak{L} = i \frac{\lambda}{m^2} \left(\overline{\phi_1(x)} \gamma_\mu \partial_\nu \phi_2(x) - \overline{\partial_\nu \phi_1(x)} \gamma_\mu \phi_2(x) \right) F^{\mu\nu}(x), \quad (4)$$

where $F^{\mu\nu}$ is the electromagnetic field tensor and λ coupling constant which was introduced earlier in geometric model of the electromagnetic field and CP-violation /9/. For the coupling constant λ in (4) we now get the restriction $\lambda \lesssim 0.3$ or $\lambda \lesssim 0.03$, respectively.

Consider the contribution to d_n of the diagram Fig.1b, where in the bubble is inserted the general current-current T- conserving weak vertex in V-A theory (with all off-mass-shell terms). The simple calculations show that only F_i $(i = 1, 4, 5, 7, 10)$ contribute to e.d.m.

Now we put the question : why the other F_i do not contribute to e.d.m. The terms which correspond to $i = 3, 6, 9, 12$ can be omitted because they are proportional to q_μ (see (1)). In gauge invariant theories they also do not contribute in other processes and they will not be considered. The terms corresponding to F_2, F_8, F_{11} vanish in the limit $q_\mu \to 0$ as $q_\mu q(p' + p)$ because $F_i \sim p^2 - p'^2$ for $i = 1, 2, 6, 7, 8, 10, 11$ [x)]. So we can conclude that the general diagram Fig. 1b does not contribute to e.d.m. if we assume that electromagnetic vertex is constructed only of the terms corresponding to F_2, F_8, F_{11}.

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x) *Of course we assume the analyticity of* F_i *i.e.*

$$F_i \big|_{q^2 \to 0} = F_i^{(1)}(p'^2, p^2) + q^2 F_i^{(2)}(p'^2, p^2) + \dots$$

On the basis of this observation we propose now the new model of the electromagnetic CP-violation. Suppose first that every particle is composed of some fundamental spinor particles or fields (quarks, baryons etc). Suppose secondly that the CP-violating electromagnetic interaction is due only to the primary off-mass-shell CP--violating interaction with these fundamental particles with the following vertex

$$\Gamma^{\mu}(p', p) = [F_2 \sigma^{\mu\nu} + F_8 (\hat{p}' \sigma^{\mu\nu} + \sigma^{\mu\nu} \hat{p}) + F_{11} \hat{p}' \sigma^{\mu\nu} \hat{p}] q_{\nu} . \quad (5)$$

It is equivalent to the assumption that CP-noninvariant terms appear only in formfactors which give us the neutron magnetic moment. Then by the arguments developed above we get that in the first order in e the e.d.m. vanishes. Of course it is allowed in the third order in e . Roughly speaking we may say that they give $d_n \approx \frac{\alpha}{\pi} \frac{e}{m} f \approx 10^{-28}$.

We have demonstrated that the electromagnetic CP-violation may exist which does not contradict to present experimental evidence on e.d.m. quite independently of special assumptions on the $S = 0$, $P = -1$, $CP = +1$ nonleptonic weak interaction and which may cause rather large effects in electromagnetic processes where the off-mass--shell effects are essential. These effects were widely discussed in current literature (see e.g. (4)).

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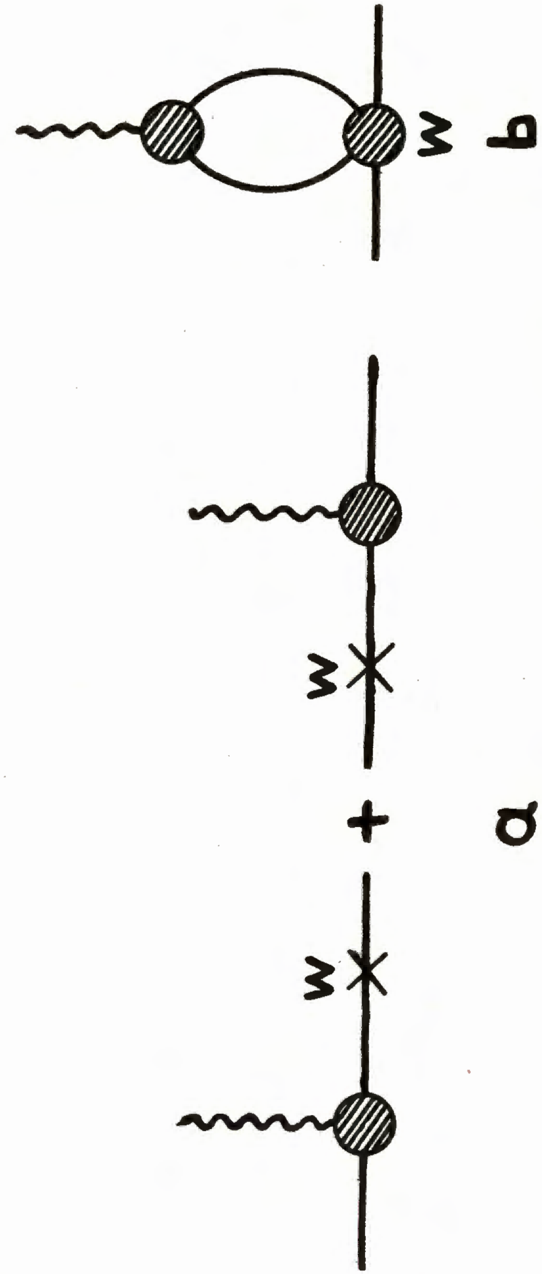

Fig. 1. Diagrams contributing to electric dipole moment in first order.

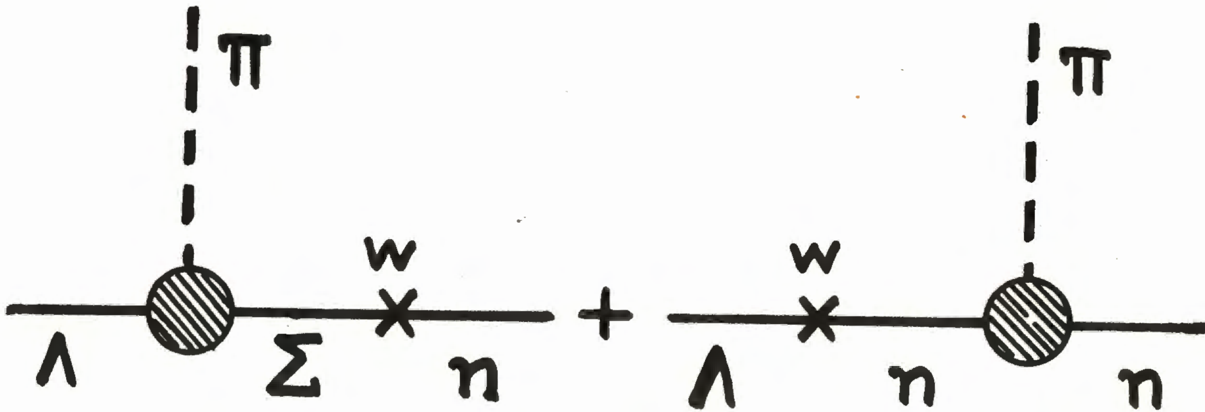

Fig.2. Pole diagrams for Λ decay.