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WEAK NEUTRAL CURRENTS OF NEW QUARKS IN e^+e^- ANNIHILATION

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abstract

P-odd dependence on the longitudinal polarization of colliding particles of the total cross-section of hadron production in e^+e^- collisions near ψ- and Υ-peaks is calculated. At Υ-peak the expected relative magnitude of the effect constitutes 1.6%.

Obtaining of longitudinal polarization of electrons and positrons in storage rings/1-3/ would open great prospects for the study of the weak neutral currents structure in e^+e^- collisions. Experiments on the search for weak interactions effects in colliding electron-positron beams were often discussed previously/4-20/. Here we wish to call attention to the importance of study of P - odd dependence of the total cross-section of hadron production near ψ- and Υ-peaks on longitudinal polarization of electrons and positrons. This experiment would give valuable information on weak interaction of new quarks and electrons due to neutral currents. For u- and d-quarks the information on such an interaction is obtained already in the atomic experiments/21/ and in deep inelastic electron scattering/22/, as to c- and b-quarks the colliding beams experiments would be of unique interest indeed.

Write down the Lagrangian for the interaction of electrons and quarks with photon and neutral vector boson as

$$\mathcal{L} = e A_\mu [\bar{u}_e \gamma_\mu u_e - Q \bar{u}_q \gamma_\mu u_q] + Z_\mu [\bar{u}_e \gamma_\mu (g_V + g_A \gamma_5) u_e + \bar{u}_q \gamma_\mu (h_V + h_A \gamma_5) u_q] \quad (1)$$

Standard calculations lead to the following dependence of the total cross-section of hadron production near a peak corresponding to $q\bar{q}$ bound state on the degree of longitudinal polarization of electron ξ_- and positron ξ_+:

$$\sigma = \sigma_0 \left[1 - \xi_- \xi_+ - \frac{2 h_V g_A m^2}{4\pi\alpha M^2} (\xi_- - \xi_+)\right] \quad (2)$$

where σ_0 is the resonance cross-section for unpolarized beam. We assume here that the resonance mass m is much smaller than that of Z-boson M. Parity violation is characterized by the quantity

$$\eta(\xi_-,\xi_+) = \frac{\sigma(\xi_-,\xi_+)-\sigma(-\xi_-,-\xi_+)}{\sigma(\xi_-,\xi_+)+\sigma(-\xi_-,-\xi_+)} \quad (3)$$

In our case

$$\eta(\xi_-,\xi_+) = -\frac{2h_V g_A m^2}{4\pi\alpha M^2 Q}\,\frac{\xi_- - \xi_+}{1-\xi_-\xi_+} \quad (4)$$

In the Weinberg-Salam model

$$g_A = -\frac{e}{2\sin 2\theta}, \quad h_V = \frac{e}{2\sin 2\theta}\left[\frac{Q}{|Q|} - 4Q\sin^2\theta\right] \quad (5)$$

and for the total longitudinal polarization of both or only one of the initial particles we find for $q\bar{q}$ resonance

$$\eta \equiv \eta(1,-1) = \eta(1,0) = \eta(0,-1) = \frac{\sqrt{2}Gm^2}{8\pi\alpha|Q|}\left(1-4|Q|\sin^2\theta\right) \quad (6)$$

At $\sin^2\theta = \frac{1}{4}$ [1] this quantity constitutes for ψ- and Υ-peaks correspondingly

$$\eta_\psi = \frac{\sqrt{2}Gm^2}{16\pi\alpha} = 4\cdot 10^{-4}, \quad \eta_\Upsilon = \frac{\sqrt{2}Gm^2}{4\pi\alpha} = 1.6\cdot 10^{-2} \quad (7)$$

Note that for Υ-meson the effect is not much smaller than in ψ-peak:

$$\eta_\psi = \frac{\sqrt{2}Gm^2}{4\pi\alpha} = 1.8\cdot 10^{-4} \quad (8)$$

We have assumed here that in a peak non-resonant contribution to the hadron production cross-section can be neglected.

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[1] It is curious that at such mixing angle the product of weak and electric charges is the same for all quarks: $-eQh_V = -\frac{2\sqrt{3}}{27}e^2$. On the other hand, at $\sin^2 = \frac{3}{8}$ (this value of the mixing parameter is predicted by the unified model of strong, electromagnetic and weak interactions based on SU(5) symmetry /23/) weak charge of the quarks with Q = 2/3 turns to zero, and the discussed effect in ψ-peak vanishes as well.

Near ψ-peak the non-resonant effect due to the contribution of u-, d- and s-quarks to the cross-section constitutes

$$\eta = \frac{\sqrt{2}Gs}{4\pi\alpha}\left(1-2\sin^2\theta\right) = 8\cdot 10^{-4} \quad (9)$$

and near Υ-peak where one should take into account c-quark as well, it is equal to

$$\eta = \frac{\sqrt{2}Gs}{4\pi\alpha}\,\frac{9-20\sin^2\theta}{10} = 0.6\cdot 10^{-2} \quad (10)$$

Relatively large expected value of the effect discused in Υ-resonance and possibility to get large statistics in ψ-peak make the corresponding experiments sufficiently realistic, of course, if the longitudinal polarization will be obtained in colliding beams.

Note in conclusion that near narrow resonance of the ψ-peak type charge asymmetry of muons in the reaction $e^+e^-\to\mu^+\mu^-$ due to the interference of electromagnetic and weak amplitudes turns to be very small[2]. As it was noted by A.P.Onuchin, this circumstance can be used effectively for control experiments at the search for the charge asymmetry outside of peaks.

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[2] For the charge asymmetry caused by radiative corrections this fact was pointed out previously in the references /24,25/.

References

1. Ya.S.Derbenev, A.M.Kondratenko, A.N.Skrinsky. Dokl. Akad. Nauk SSSR 192,1255,1970 (Sov.Phys.Dokl. 15,583,1970).
2. Ya.S.Derbenev, A.M.Kondratenko, A.N.Skrinsky. Zh.Eksp.Teor. Phys. 60,1216,1971 (Sov.Phys.JETP 33,658,1971).
3. Ya.S.Derbenev, A.M.Kondratenko, S.I.Serednyakov, A.N.Skrinsky, G.M.Tumaikin, Yu.M.Shatunov. Particle Accelerators 8,115,1978.
4. V.K.Cung, A.K.Mann, E.A.Paschos. Phys.Lett.41B,355,1972.
5. A.Love. Nuovo Cim.Lett. 5,113,1972.
6. I.B.Khriplovich. Yad.Fiz. 17,576,1973 (Sov.J.Nucl.Phys. 17, 298,1973).
7. F.A.Berends, K.J.F.Gaemers, R.Gastmans. Nucl.Phys.B63,381, 1973.
8. O.P.Sushkov, V.V.Flambaum, I.B.Khriplovich. Yad.Fiz. 20, 1016,1974 (Sov.J.Nucl.Phys. 20,537,1975).
9. A.McDonald. Nucl.Phys. B75,343,1974.
10. K.O.Mikaelian. Phys.Lett. 55B,219,1975.
11. E.Lendvai, G.Pocsik. Phys.Lett. 56B,462,1975.
12. R.Budny. Phys.Lett. 58B,338,1975.
13. E.Lendvai, K.Nagy, G.Pocsik. Phys.Lett. 62B,426,1976.
14. E.Lendvai, L.Palla, G.Pocsik. Nuovo Cim. 36A,367,1976.
15. R.Simard, M.Suzuki. Phys.Lett. 63B,304,1976.
16. G.V.Dass, G.G.Ross. Nucl.Phys. B118,284,1977.
17. E.Kh.Khristova. Yad.Fiz. 25,154,1977.
18. A.V.Smilga. Yad.Fiz. 25,461,1977.
19. S.G.Grigoryan, S.V.Yesaibegyan. Yad.Fiz. 26,840,1977.
20. M.Greco, G.Pancheri-Srivastava, Y.Srivastava. Phys.Lett. 80B,390,1979.
21. L.M.Barkov, M.S.Zolotoryov. Pis'ma v ZhETF 26,379,1978; 27,544,1978.
22. C.Y.Prescott et al. Phys.Lett. 77B,347,1978.
23. H.Georgi, Sh.Glashow. Phys.Rev.Lett.32,438,1974.
24. O.P.Sushkov. Yad.Fiz. 22,868,1975.
25. A.B.Kraemmer, B.Lautrup. Nucl.Phys. B95,380,1975.

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