Contribution ID: **22** Type: **theoretical**

On the spin correlations of final leptons produced in the annihilation processes $e^+e^- \to \mu^+\mu^-, \tau^+\tau^-$ and in the high-energy two-photon processes $\gamma\gamma \to e^+e^-, \mu^+\mu^-, \tau^+\tau^-$

Tuesday, June 5, 2018 5:15 PM (15 minutes)

The electromagnetic processes of annihilation of (e^+e^-) pairs, generated in high-energy nucleus-nucleus and hadron-nucleus collisions, into heavy lepton pairs are theoretically studied in the one-photon approximation, using the technique of helicity amplitudes . For the process $e^+e^- \to \mu^+\mu^-$, it is shown that – in the case of the unpolarized electron and positron – the final muons are also unpolarized but their spins are strongly correlated. For the final $(\mu^+\mu^-)$ system, the structure of triplet states is analyzed and explicit expressions for the components of the spin density matrix and correlation tensor are derived.
It is demonstrated that here the spin correlations of muons have the purely quantum character, since one of the Bell-type incoherence inequalities for the correlation tensor components is always violated. In doing so, it is also established that, when involving the additional contribution of the weak interaction of lepton neutral currents through the virtual Z^0 boson, the qualitative character of the muon spin correlations does not change .

On the other hand, the theoretical investigation of spin structure for the processes of lepton pair production by pairs of photons (which, in particular, may be emitted in relativistic heavy-ion and hadron-nucleus collisions) is performed as well. For the two-photon process $\gamma\gamma \to e^+e^-$, it is found that – quite similarly to the process $e^+e^- \to \mu^+\mu^-$ – in the case of unpolarized photons the final electron and positron remain unpolarized, but their spins prove to be strongly correlated. Explicit expressions for the components of the correlation tensor and for the relative fractions of singlet and triplet states of the final (e^+e^-) system are derived. Again, here one of the Bell-type incoherence inequalities for the correlation tensor components is always violated and, thus, spin correlations of the electron and positron have the strongly pronounced quantum character.

Analogous considerations can be wholly applied as well, respectively, to the annihilation process $e^+e^- \to \tau^+\tau^-$ and to the two-photon processes $\gamma\gamma \to \mu^+\mu^-$, $\gamma\gamma \to \tau^+\tau^-$, which become possible at much higher energies.

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Session Classification: Posters session