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On the coherent inelastic binary and multiparticle processes in ultra relativistic hadron-nucleus, photon-nucleus and nucleus-nucleus collisions

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The coherent inelastic processes of the type $a \to b$, which may take place in the interaction of hadrons and γ quanta with nuclei at very high energies (the nucleus remains the same, and its quantum state does not change), and - in particular - may lead to the production of strange and heavy-flavor mesons and baryons, are theoretically investigated. For taking into account the influence of matter inside the nucleus, the optical model based on the concept of refraction index is applied.
Analytical formulas for the effective cross section $\sigma_{\rm coh}(a \to b)$ are obtained, taking into account that at ultrarelativistic energies the main contribution into $\sigma_{\rm coh}(a \to b)$ is provided by very small transferred momenta in the vicinity of the minimum longitudinal momentum transferred to the nucleus. It is shown that the cross section $\sigma_{\rm coh}(a \to b)$ may be expressed through the "forward" amplitudes of inelastic scattering $f_{a+N\to b+N}(0)$ and elastic scattering $f_{a+N\to a+N}(0)$, $f_{b+N\to b+N}(0)$ on a separate nucleon, and it depends on the ratios L_a/R and L_b/R, where L_a, L_b are the respective mean free paths in the nucleus matter for the particles a, b and R is the nuclear radius.

In doing so, several characteristic cases with different relations of the magnitudes L_a, L_b, R are considered in detail. When
$L_a/R \gg 1$, but $L_b/R \ll 1$ (or, on the contrary, $L_a/R \ll 1$ but $L_b/R \gg 1$), then the cross section $\sigma_{\rm coh}(a \to b)$ is equal to the ratio of the "forward" cross sections of inelastic scattering $a + N \to b + N$ and elastic scattering of the particle b (or, respectively, a) on a nucleon, multiplied by the cross section of scattering on the "black" nucleus πR^2. The cases $L_a/R \gg 1$, $L_b/R \leq 1$ and $L_a/R \gg 1$, $L_b/R \ll 1$ (for heavy nuclei) correspond, in particular, to the coherent production of vector mesons ρ^0, ω, ϕ at the interaction of very high-energy photons with nuclei .

Meantime, when both the conditions $L_a/R \gg 1$ and $L_b/R \gg 1$ are satisfied, then the cross section $\sigma_{\rm coh}(a \to b)$ is proportional to the factor R^4/k^2, where k is the initial energy of the particle a in the laboratory frame.

The formalism described above is generalized also for the case of coherent inelastic multiparticle processes on a nucleus of the type $a \to \{b_1, b_2, b_3 ....b_i\}$ and for the case of coherent processes in collisions of two ultrarelativistic nuclei.

Collaboration name

Track

Others

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