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Equivalent photons approximation: survival factor

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In a large fraction of collisions at the Large Hadron Collider (LHC), the colliding particles miss each other and collide with their electromagnetic fields. If the particles remain intact after such collision, the collision is called ultraperipheral (UPC). In the equivalent photons approximation, the electromagnetic field of an ultrarelativistic particle can be represented as a bunch of real photons distributed according to a known spectrum $n(\omega)$. This allows treatment of UPCs as photon-photon collisions, and the Large Hadron Collider as a photon-photon collider. The photon-photon luminosity can be calculated as

$\frac{\mathrm{d}L_0}{\mathrm{d}s} = \int\limits_0^\infty \frac{\mathrm{d}x}{8x} n\left(\sqrt{\frac{sx}{4}}\right) n\left(\sqrt{\frac{s}{4x}}\right)$

(assuming that the colliding particles are identical), where $s = 4\omega_1\omega_2$ ($\sqrt{s}$ is the invariant mass of the photons), $x = \omega_1/\omega_2$ (x is related to the pseudorapidity of the system produced), ω_1 and ω_2 are the photons energies.

To take into account finite sizes of the colliding particles, the dependence on the transverse distance to the particle b has to be introduced into the spectrum:

$n(\omega) = \int \mathrm{d}^2 b\, n(b, \omega)$.

The photon-photon luminosity is then

$\frac{\mathrm{d}L}{\mathrm{d}s} = \int\limits_0^\infty \frac{\mathrm{d}x}{8x} \int \mathrm{d}^2 b_1 \int \mathrm{d}^2 b_2\, n\left(b_1, \sqrt{\frac{sx}{4}}\right) n\left(b_2, \sqrt{\frac{s}{4x}}\right) P(|\vec{b}_2 - \vec{b}_1|)$

where $P(b)$ is the probability for the particles to survive after the collision with the impact parameter b. The ratio of the luminosities,

$S = \frac{\mathrm{d}L/\mathrm{d}s}{\mathrm{d}L_0/\mathrm{d}s}$,

is called the survival factor, and it describes the diminishing of the cross section of the ultraperipheral collision due to the disintegration of the colliding particles.

In the talk, survival factors for the proton-proton and lead-lead collisions at the LHC are presented in a wide range of s. Calculations with and without the survival factor taken into account are compared to the measurements of the cross section for muon pair production in UPCs (low s). Effects of the survival factor on the production of heavy charged particles are discussed. In the case of lead ions, significant disagreement between the two currently available sources of data on ^{208}Pb electromagnetic form factors is revealed.

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