Lepton pairs and vector mesons production in ultraperipheral nuclear collisions. Challenge for SPD.

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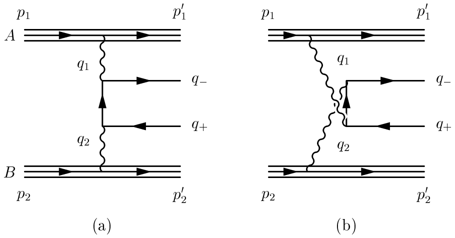
The interest in the process of lepton pair $e^+e^-, \mu^+\mu^-$ production off the Coulomb fields of two highly relativistic ions with charge numbers Z_1 and Z_2

$$Z_1 + Z_2 \to l^+l^- + Z_1 + Z_2$$

is provided by operation of heavy ion colliders as RHIC & LHC. Ultraperipheral nuclear collisions $b \gg R_1 + R_2 = 14fm$ for Pb-Pb.



Born approximation

At relativistic energies the yield of pairs is huge.
L.Landau and E.Lifshitz,1934; G.Racah,1937

$$\sigma_B = \frac{28}{27}\frac{\alpha^4(Z_1Z_2)^2}{\pi m^2}[L^3 - 2.2L^2 + 3.84L - 1.636]$$

$$L = \ln(\gamma_1\gamma_2), \gamma_i = \frac{E_i}{m_i}, \alpha = \frac{e^2}{4\pi} = \frac{1}{137}$$

$$Au - Au; Z = 79$$

$RHIC$	$\gamma = \frac{E}{M} = 100; \sigma = 36 kbarn$
LHC	$\gamma = 3000; \sigma = 227 kbarn$
$NICA$	$\gamma = 5; \sigma = 1.8 kbarn$

Equivalent photons approximation or Weizsäcker-Williams method.

E.Fermi,1924;E.Williams,1933;C.Weizsäcker,1934

QED

$$\sigma(Z_1 Z_2 \to Z_1 Z_2 e^- e^+) = \int d\omega_1 d\omega_2 n_1(\omega_1) n_2(\omega_2) \sigma_{\gamma\gamma \to e^+ e^-}(\omega_1, \omega_2)$$

$$n(\omega) \sim \frac{\alpha Z^2}{\omega}; \sigma_{\gamma\gamma \to e^+ e^-}(\omega_1, \omega_2) \sim \frac{\alpha^2 \log(\frac{\sqrt{s}}{2m})}{s}$$

$$\sigma(Z_1 Z_2 \to Z_1 Z_2 e^- e^+) = \int d\omega n(\omega) \sigma_{\gamma Z_2 \to e^+ e^-}(\omega)$$

QCD

$$\sigma(pp \to e^+ e^- X) = \int dx_1 dx_2 \sum_{q,g} f_1(x_1) \bar{f}_2(x_2) \sigma(x_1, x_2)$$

Coulomb corrections

The parameter $Z\alpha$ is not small. For instance,for lead $Z\alpha \sim 0.6$ and Coulomb corrections can be essential.
S. Gevorkyan ,A. Tarasov, Particle and Nuclei Letters 10, 105, 2013

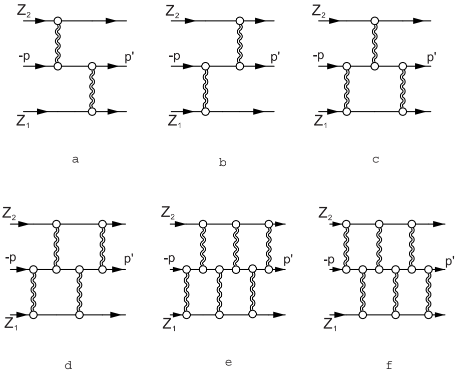


Figure: The Coulomb corrections

Publications:

1. S.Gevorkyan ,A. Tarasov,
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   J.Exp.Theor.Phys.,100,645, 2005
3. E.Bartosh,S.Gevorkyan, E. Kuraev,
   Physics of Atomic Nuclei,67,1923, 2004
4. S. Gevorkyan, E.Kuraev, J. Phys. G.29, 1, 2003
5. E. Bartos, S. R. Gevorkyan, E. A. Kuraev, N.Nikolaev,
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7. E.Bartosh,S. Gevorkyan,E. Kuraev,
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   vol.111, 253, 2003

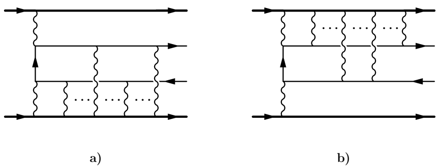


Figure: The Coulomb corrections

S. Gevorkyan, E.Kuraev, Jour. Phys. G.29, 1, 2003

$$\sigma_C = \frac{28\nu_1^2\nu_2^2}{9\pi m^2}(f(\nu_1)+f(\nu_2))[\ln^2(\gamma_1\gamma_2)+\frac{20}{21}\ln(\gamma_1\gamma_2)+O(const)].$$

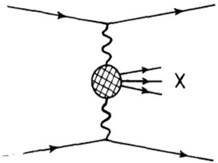
$$f(x) = x^2\sum_{n=1}^{\infty}\frac{1}{n(n^2+x^2)};\nu_i = Z_i\alpha.$$

$$R = \frac{\sigma_C}{\sigma_B}; Au-Au$$

$$R = 0.1 \quad (LHC); 0.16 \quad (RHIC); 0.47 \quad (NICA)$$

Vector mesons production

Two photons can produce hadronic state X with charge parity C=+1 for instance pseudoscalar mesons $\pi^0, \eta, \eta\prime$ etc. The vector meson with C=-1 for instance ρ can be produced in semi ultraperipheral nucleus collision, when the photon from one nucleus splits to the quark-antiquark pair, which than interacts with another nuclei through pomeron (or reggeon) exchange.
From the other hand it is possible to produce vector meson in ultraperipheral collision of relativistic ions as a result of three photons exchange. The investigation of contribution of this two approaches can be a good challenge for SPD as the relative contribution of three photons production is large and can be comparable with photoproduction in the strong field of nucleus.



Spin density matrix element (ρ_{00}) measurements