Charge asymmetry of elastic $e^{\pm}p$-scattering due to radiation

A. Afanasev
GWU, Washington, DC 20052 USA
A. Ilyichev
INP BSU, Minsk, 220088 Belarus

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Radiative Corrections to the exclusive process

$$A_1(p_1) + A_2(p_2) \to \sum_{i=1}^{n} B_i(p_i')$$

Contribution of additional virtual particles calculated exactly or in ultrarelativistic approximation

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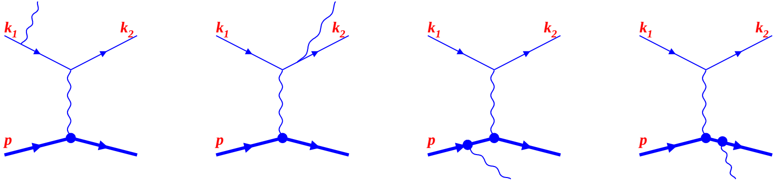
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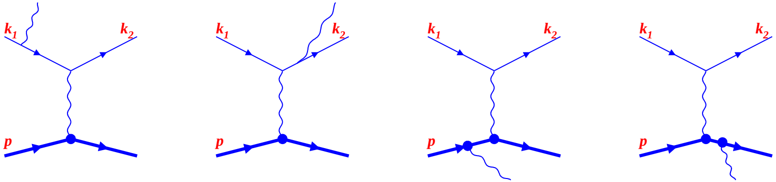
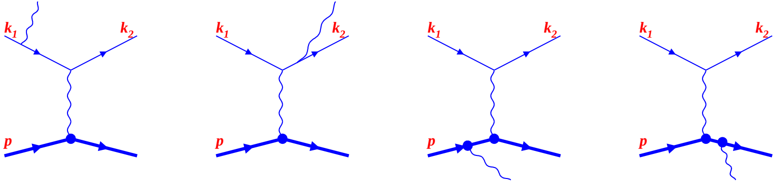


$ie\gamma_\mu$ – electron-photon vertex



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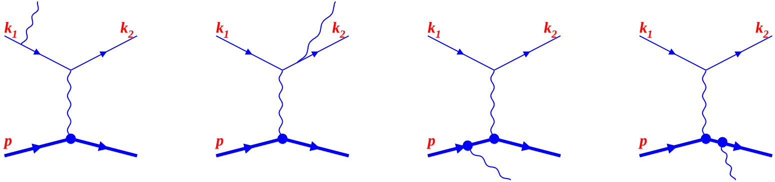
$-ie\left[\gamma_\mu F_d(q^2) + \frac{i\sigma_{\alpha\mu}q^\mu}{2M}F_p(q^2)\right]$ – proton-photon vertex

$q = p' - p$, $p^2 = p'^2 = M$, $\tau = Q^2/4M^2$, $Q^2 = -q^2$

$$F_d(q^2) = \frac{G_E(q^2) + \tau G_M(q^2)}{1+\tau},\ F_p(q^2) = \frac{G_M(q^2) - G_E(q^2)}{1+\tau},$$



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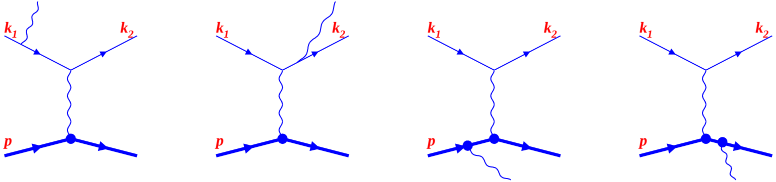

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$$d\sigma_i = \frac{1}{2S}\left(\mathcal{M}_{BH}\mathcal{M}_h^\dagger + \mathcal{M}_h\mathcal{M}_{BH}^\dagger\right) d\Gamma$$

$$d\Gamma = \frac{dQ^2 dv dt d\phi_k}{2^8\pi^4 S\sqrt{Q^2(Q^2+4M^2)}}$$

$S = 2k_1 k$, $Q^2 = -q^2 = -(k_1 - k_2)^2$, $t = -(q-k)^2 = -(p-p')^2$

$v = (p+q)^2 - M^2$ – inelasticity

ϕ_k angle between $(\vec{q}, \vec{k})$ and $(\vec{k_1}, \vec{k_2})$ for $p = (M, 0, 0, 0)$

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Infrared free part

$$d\sigma_i^F = d\sigma_i - d\sigma_i^{IR} = \int_0^{v_{cut}} dv \sum_{i,j,k=d,p} \theta_{ijk} F_i(Q^2) F_j(t) F_k(0)$$

$$0 < v_{cut} < v_{max} = S - Q^2 - \frac{M^2 Q^2}{S}$$

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$$F_{IR} = \int \frac{dtd\phi_k}{4}\left[\frac{S}{(k_2k)(p_2k)} + \frac{S}{(k_1k)(p_1k)} - \frac{S-Q^2}{(k_1k)(p_2k)} - \frac{S-Q^2}{(k_2k)(p_1k)}\right]$$

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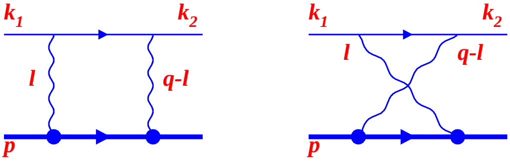
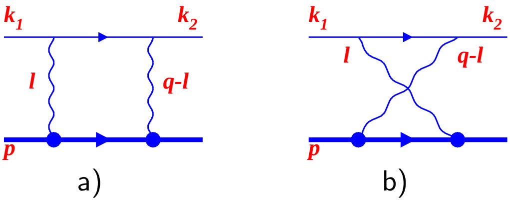


a) b)

$$\frac{d\sigma_{2\gamma}}{dQ^2} = \frac{1}{16\pi S}\int \frac{d^4 l}{(2\pi)^4}\left[\mathcal{M}_a\mathcal{M}_{el}^\dagger + \mathcal{M}_{el}\mathcal{M}_a^\dagger + \mathcal{M}_b\mathcal{M}_{el}^\dagger + \mathcal{M}_{el}\mathcal{M}_b^\dagger\right]$$



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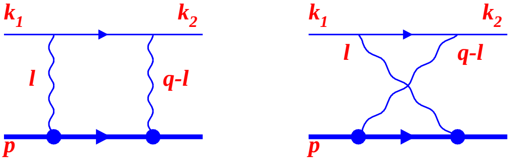
Take into account only infrared divergence part i.e. $l \to 0, q$



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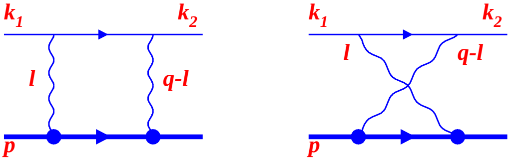

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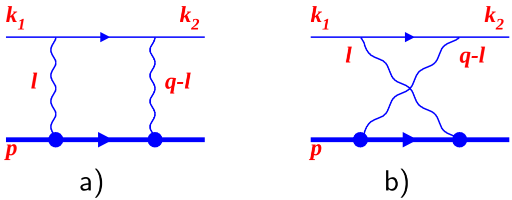
The sum $\frac{d\sigma_i^{IR}}{dQ^2} + \frac{d\sigma_{2\gamma}^{IR}}{dQ^2}$ are infrared free



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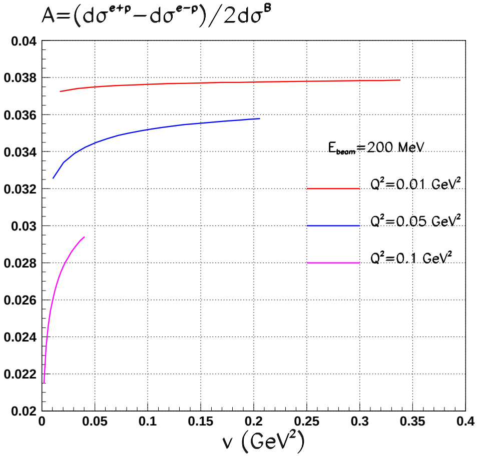
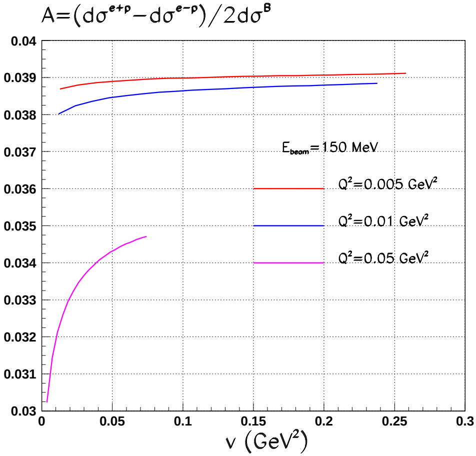
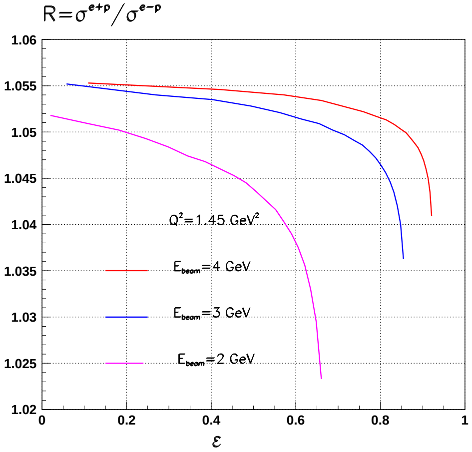

A=(dσ^e+p − dσ^e−p)/2dσ^B
E_beam=200 MeV
Q²=0.01 GeV²
Q²=0.05 GeV²
Q²=0.1 GeV²
v (GeV²)
0.04
0.038
0.036
0.034
0.032
0.03
0.028
0.026
0.024
0.022
0.02
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4


A=(dσ^e+p − dσ^e−p)/2dσ^B
E_beam=150 MeV
Q²=0.005 GeV²
Q²=0.01 GeV²
Q²=0.05 GeV²
v (GeV²)
0.04
0.039
0.038
0.037
0.036
0.035
0.034
0.033
0.032
0.031
0.03
0
0.05
0.1
0.15
0.2
0.25
0.3



$$\varepsilon^{-1} = 1 + 2(1+\tau)\tan^2\frac{\theta}{2}$$

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- Numerical result shown that at the fixed electron energy the dependence of charge asymmetry on hard photon emission more essential at high Q^2.

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