Structure of QCD string near the Casimir surface

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Purpose and Outline

Purpose:

To study the behavior of chromoelectro-magnetic fields between quarks in a quark-antiquark pair near the Casimir plane.

Outline:

1) Introduction

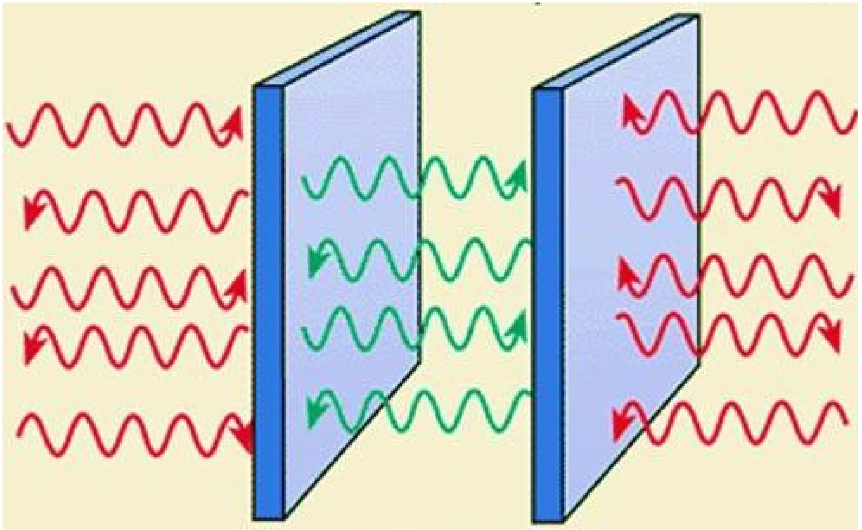
2) Distribution of fields between quarks in the absence of a Casimir plate.

3) Behavior of string at different values of distance between plane and quarks

4) Behavior of string at different values of coupling constant **β.**

5) Direction of chromoelectric fields between quarks

Introduction

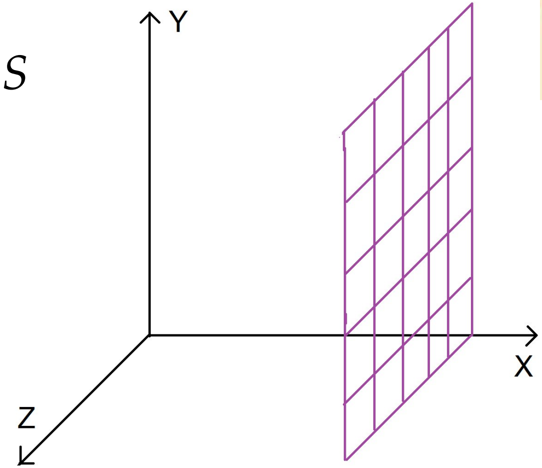


Casimir surface S impose additional boundary conditions on the electromagnetic field Aμ.

$$E_{\parallel}(r) = 0;\ B_{\perp}(r) = 0;\ r \in S$$

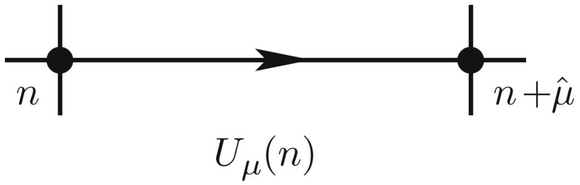
If we locate Casimir plate perpendicular to X axis:

$$E_y(r) = E_z(r) = B_x(r) = 0;\ r \in S$$



Introduction

$$U_\mu(r) = exp(iaA_\mu(r))$$



$$S_G[\overline{\psi},\psi,U] = \frac{\beta}{3}\sum_{n\in\lambda}\sum_{\mu<\nu} Re\, Tr(I - U_{\mu\nu}(n))$$

Parameters of lattice:
1) Nt - time size of lattice
2) Ni - size of lattice in i direction
3) a - lattice spacing

Needed observables:

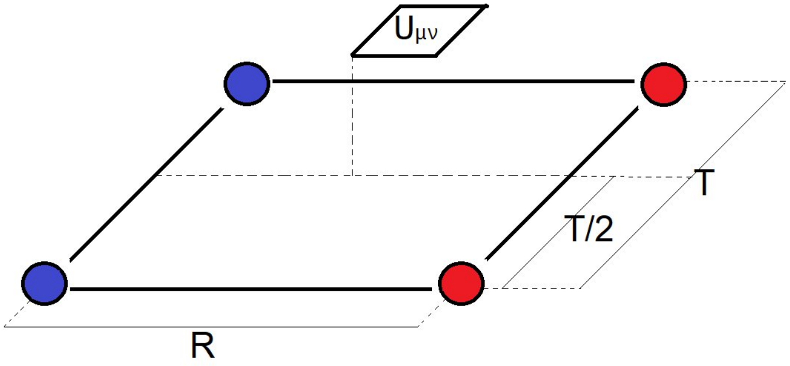
1) Plaquete $$U_{\mu\nu} = U_\mu(r)U_\nu(r+\mu)U_\mu^+(r+\nu)U_\nu^+(r)$$

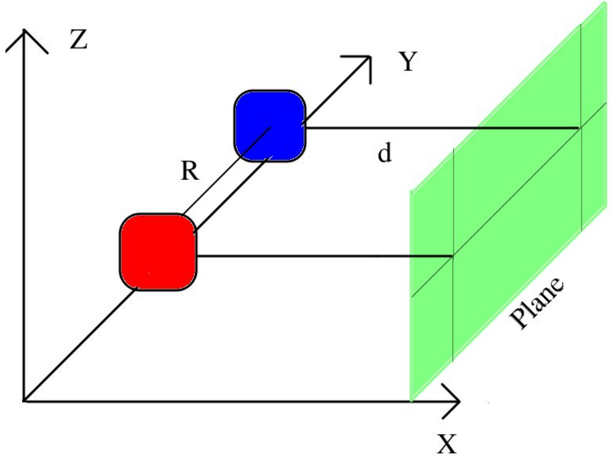
2) Wilson's Loop $$W_L[U] = \prod_{(k,\mu)\in L} U_\mu(k)$$

Calculation of $<F_{\mu\nu}^2>$

$$\langle E_i^2 \rangle = \langle tr(U_{0i}(r)) \rangle - \frac{\langle tr(W(r_1, r_2, T) U_{0i}(r)) \rangle}{\langle tr(W(r_1, r_2, T)) \rangle}$$

$$\langle B_i^2 \rangle = \frac{\langle tr(W(r_1, r_2, T) U_{jk}(r)) \rangle}{\langle tr(W(r_1, r_2, T)) \rangle} - \langle tr(U_{jk}(r)) \rangle$$

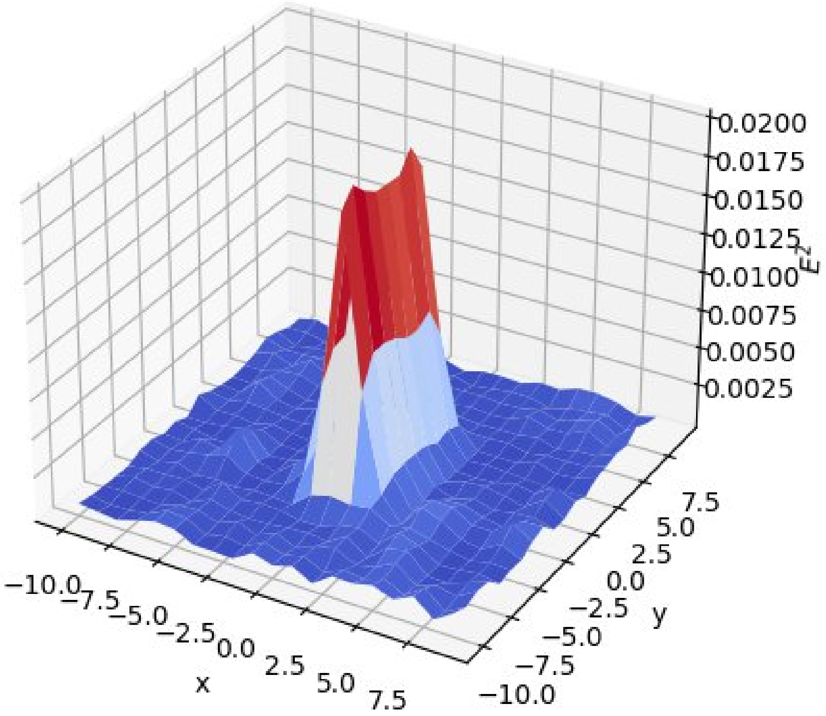




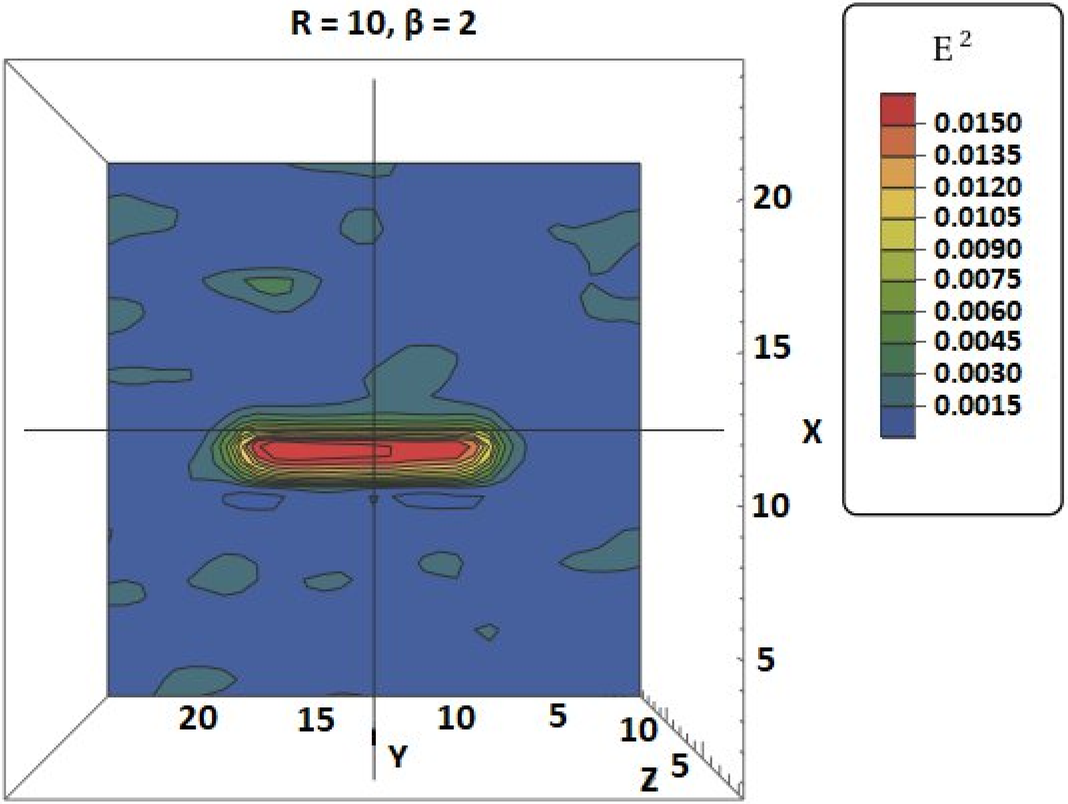
R — spatial distance between quarks
d – distance between a pair of quarks and a plate

Cardoso N., Cardoso M., Bicudo P. Colour field flux tubes and Casimir scaling for various SU(3) representations // Physics Letters B. - 2011. - №710

Field distribution in the absence of a plate

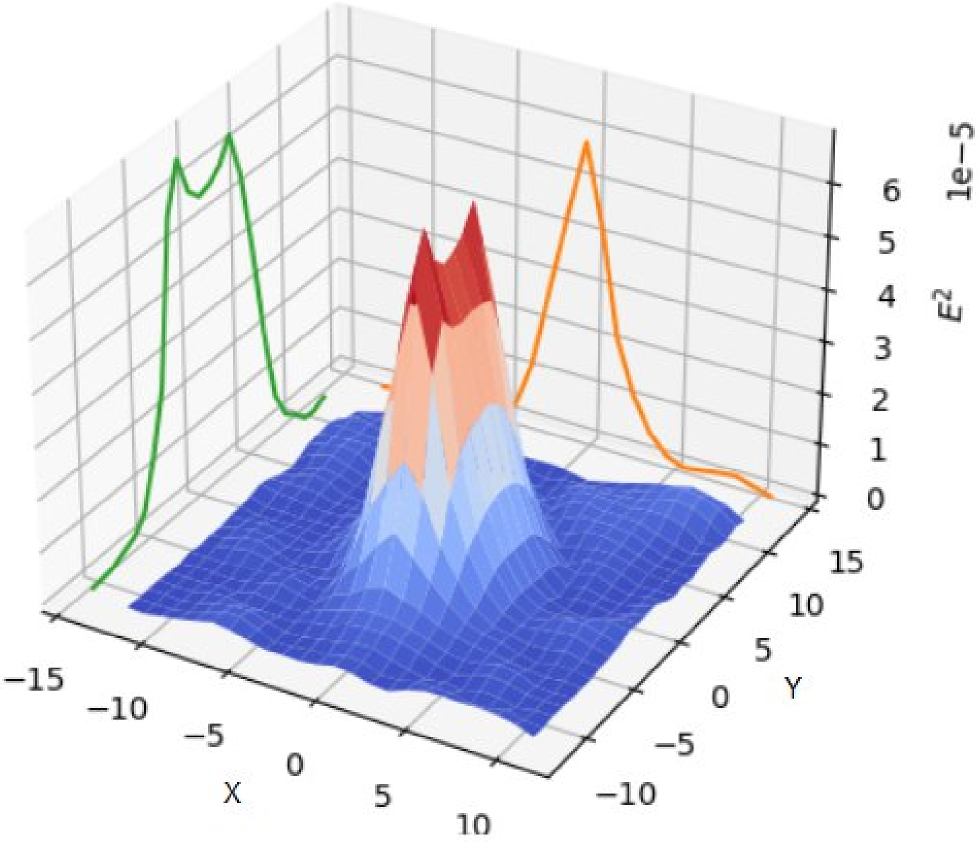


Dependencies E^2 on values x, y

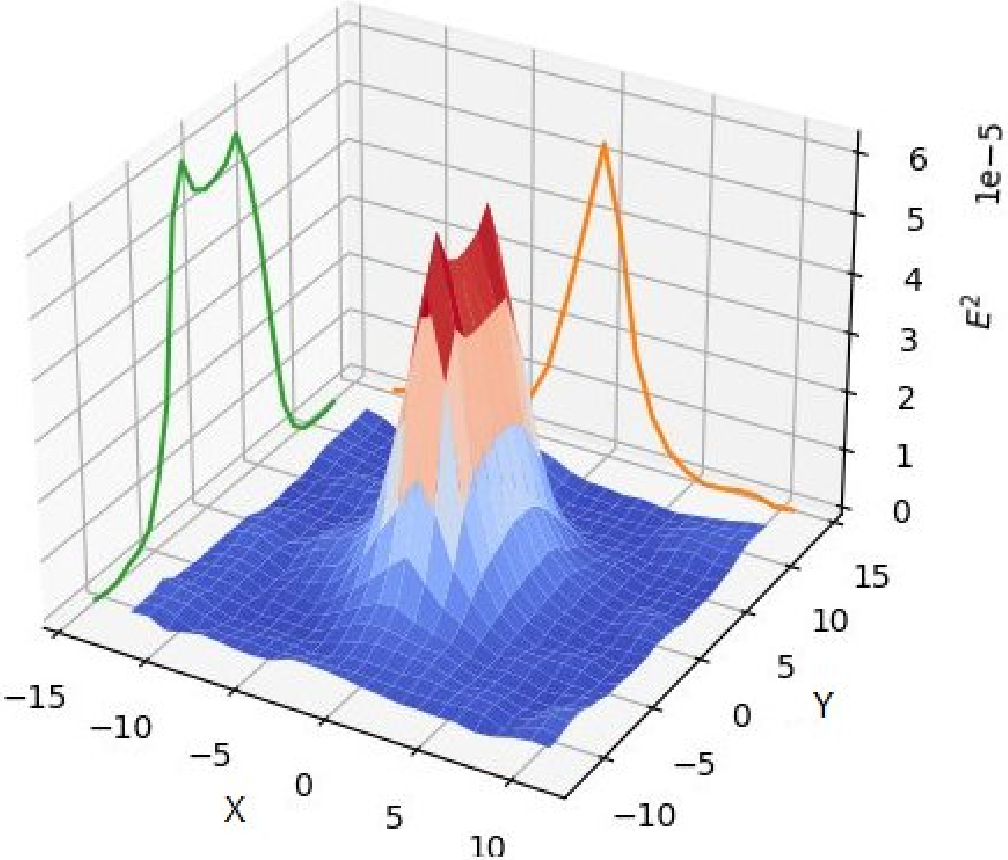


Slice of the equipotential surface of the chromoelectric field

Dependence on distance between plane and quarks

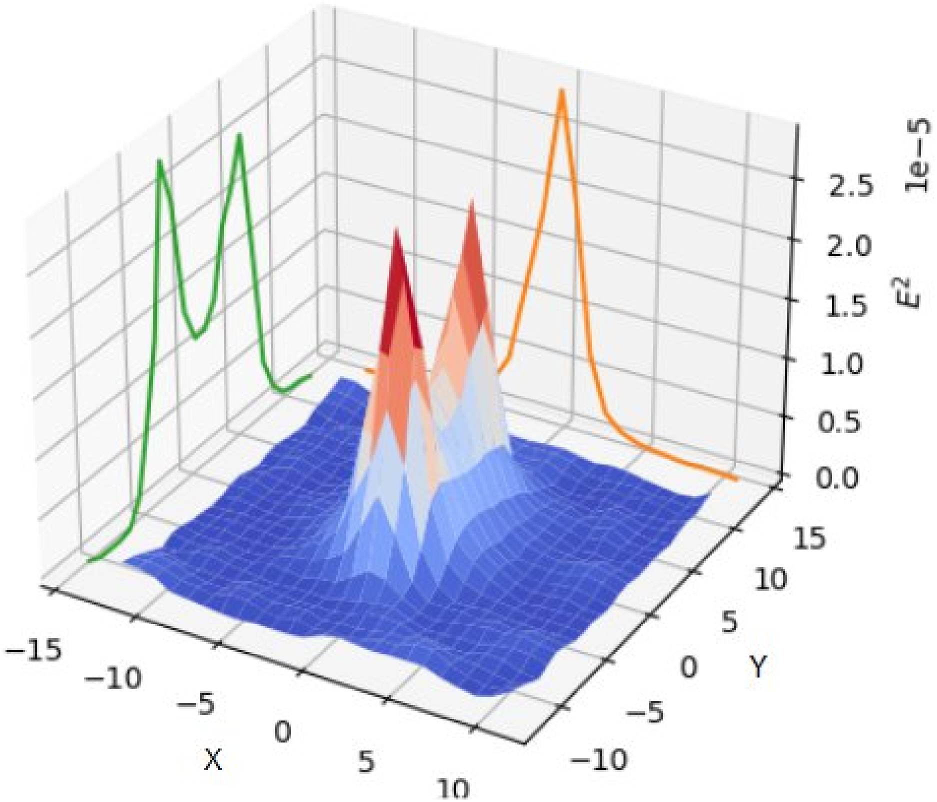


R = 8, d = 5, **β = 2**

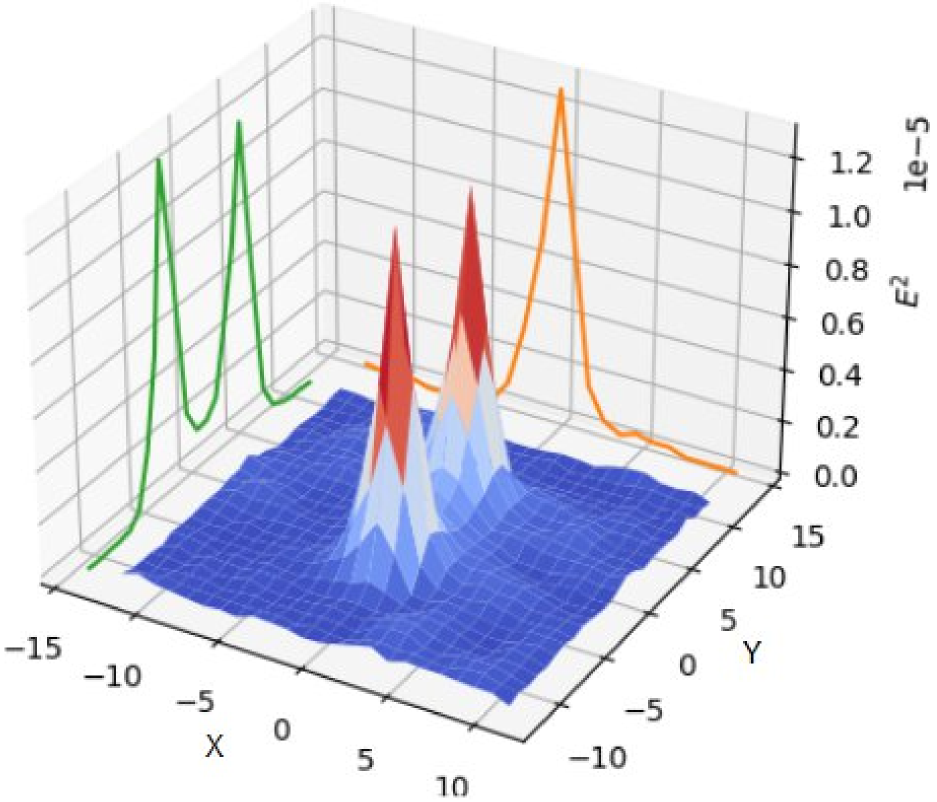


R = 8, d = 4, **β = 2**

Dependence on distance between plane and quarks

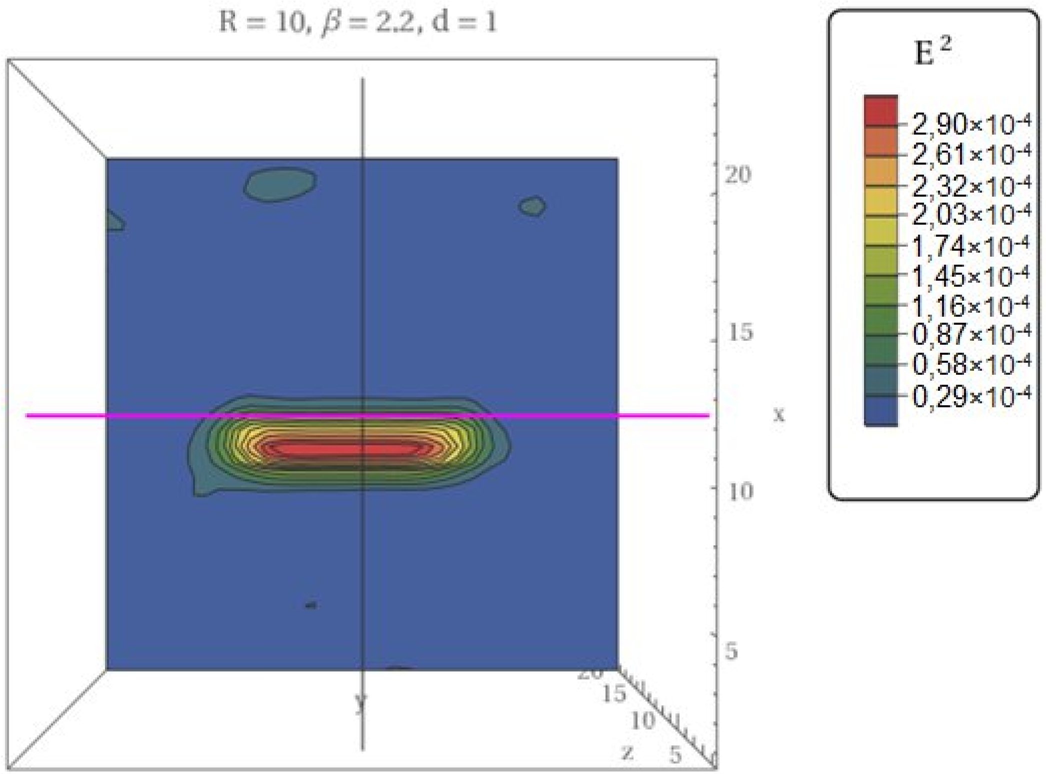


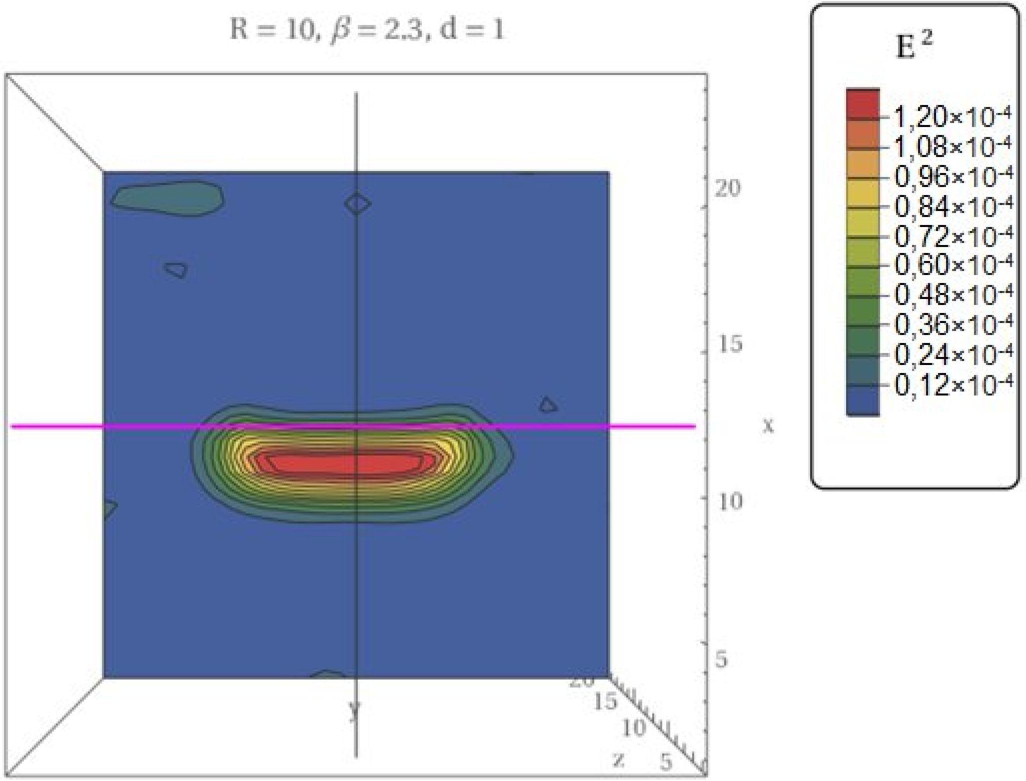
R = 8, d = 2, **β = 2**



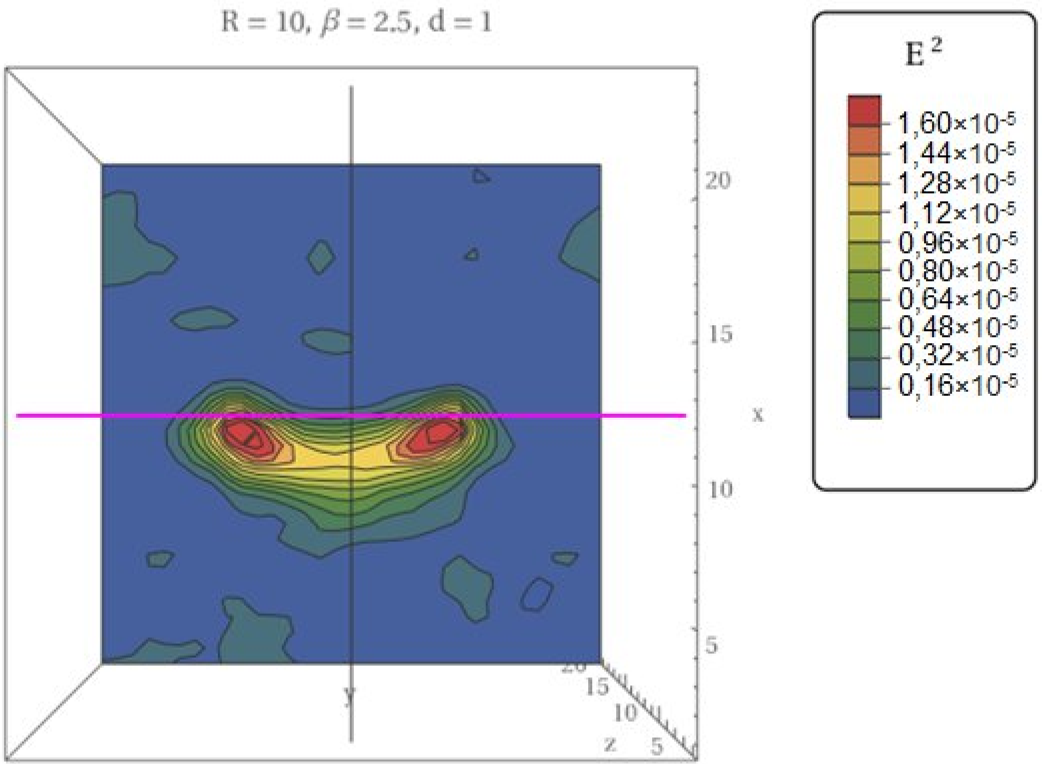
R = 8, d = 1, **β = 2**

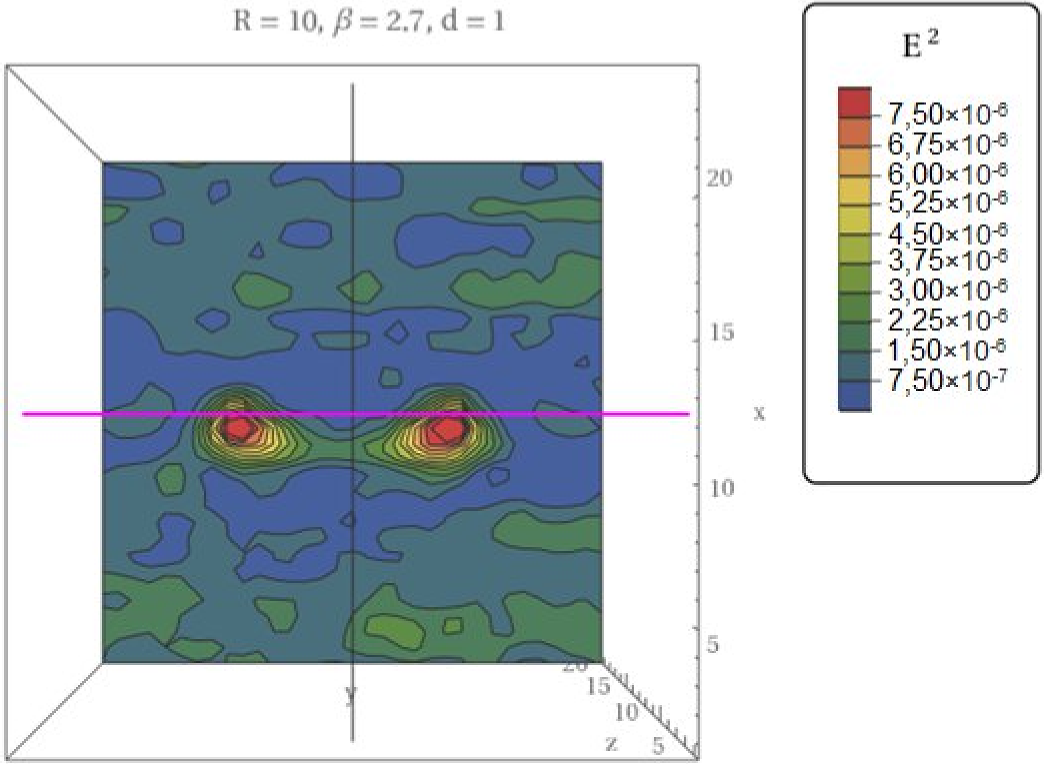
Distribution of fields with different values of β



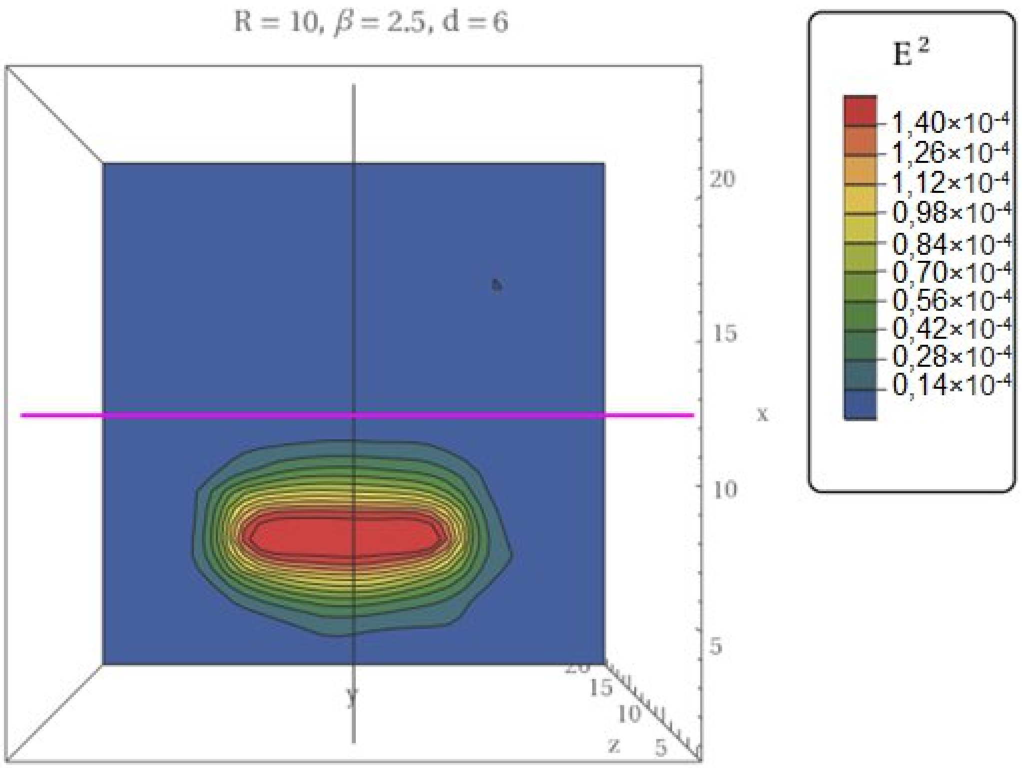


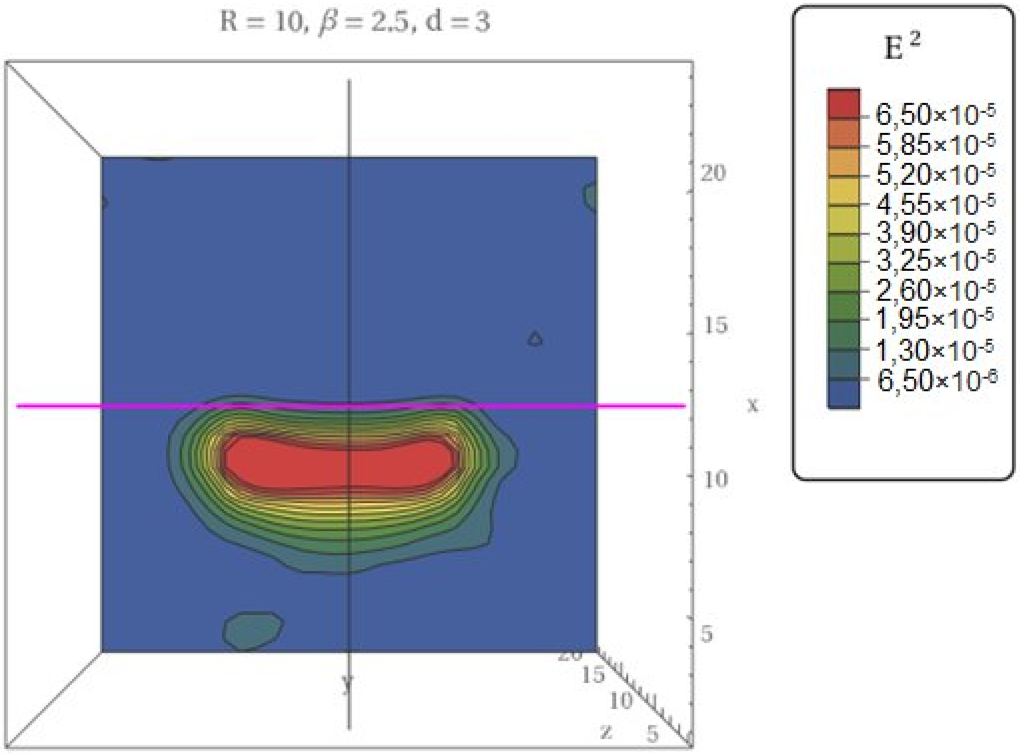
Distribution of fields with different values of β





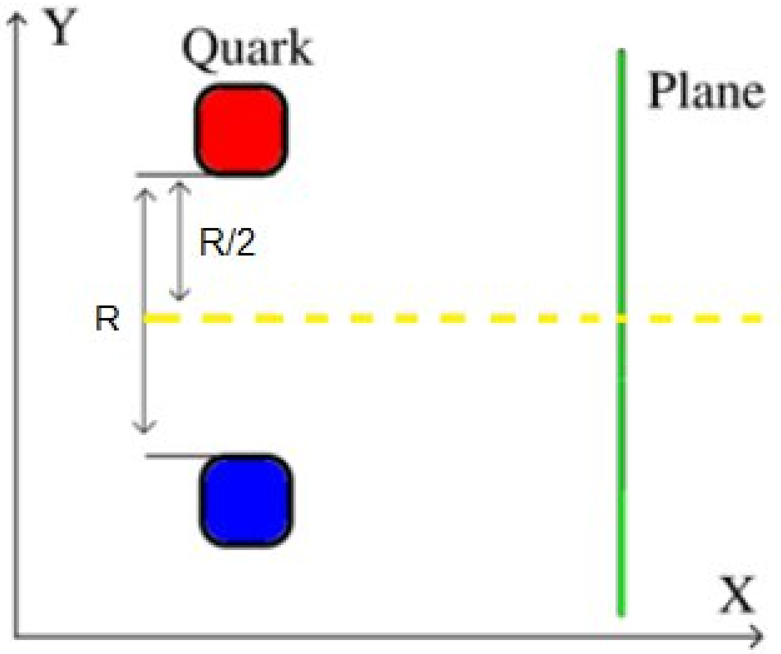
Determining the range of the plate's impact

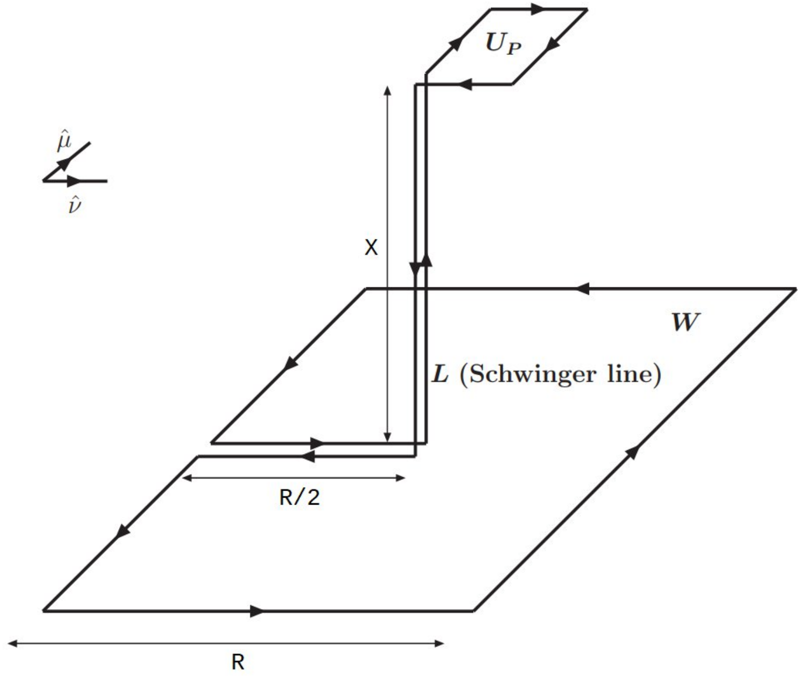




Calculation of <$F_{\mu\nu}$>

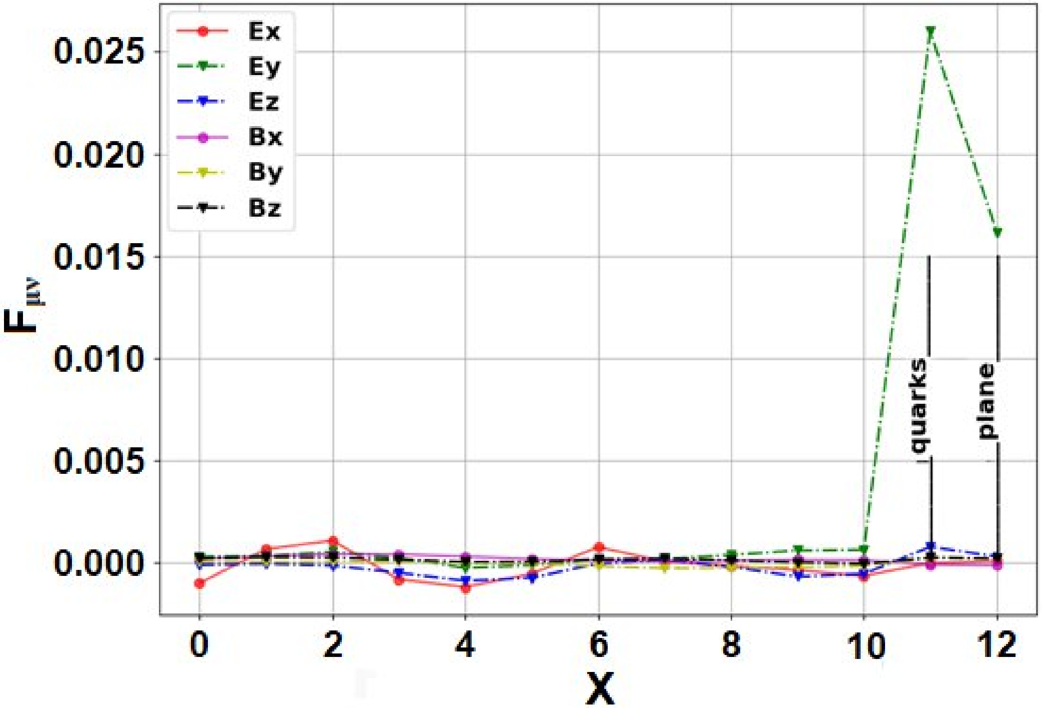
$$F_{\mu\nu}(r) = \frac{\left\langle \mathrm{tr}\left(W L U_P L^{\dagger}\right)\right\rangle}{\langle \mathrm{tr}(W)\rangle} - \frac{1}{2}\frac{\langle \mathrm{tr}(U_P)\mathrm{tr}(W)\rangle}{\langle \mathrm{tr}(W)\rangle}$$



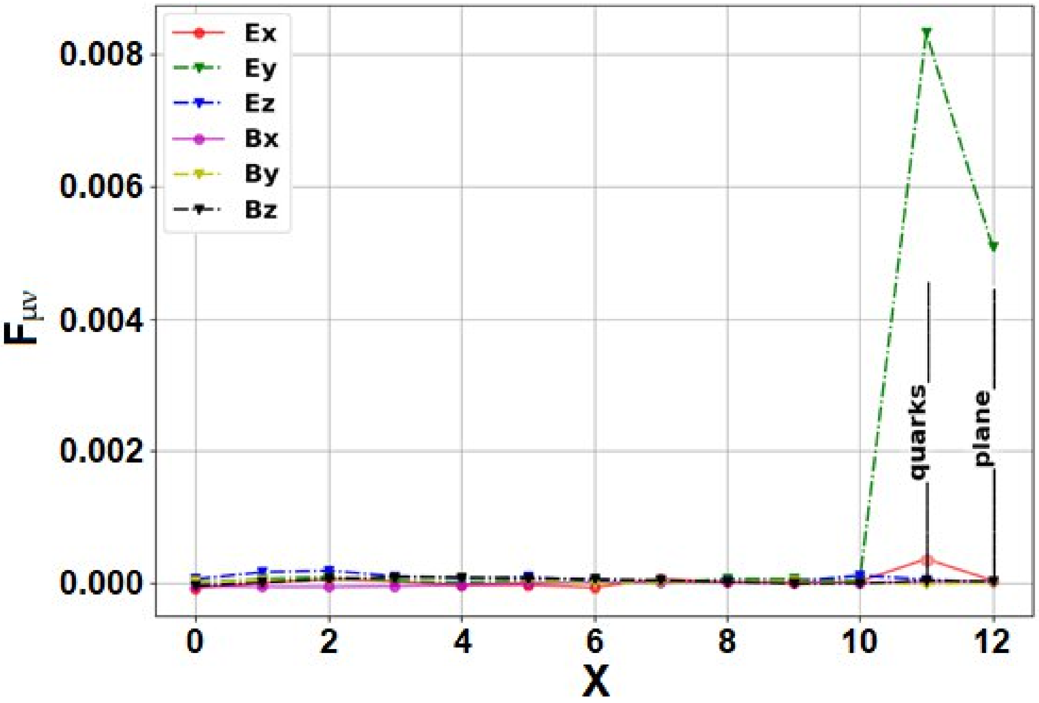


Cea P., Cosmai L., Cuteri F., Papa A QCD flux tubes across the deconfinement phase transition // preprint[arXiv.1710.01963]. - 2017

Field tensor components with different values of β

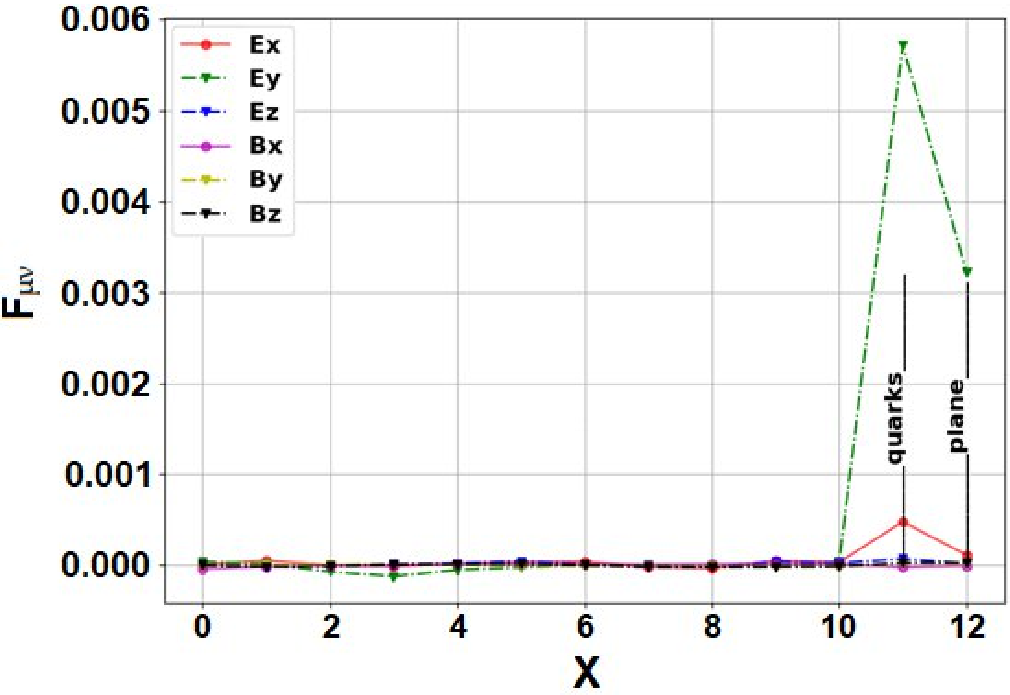


R = 10, d = 1, β = 2.2

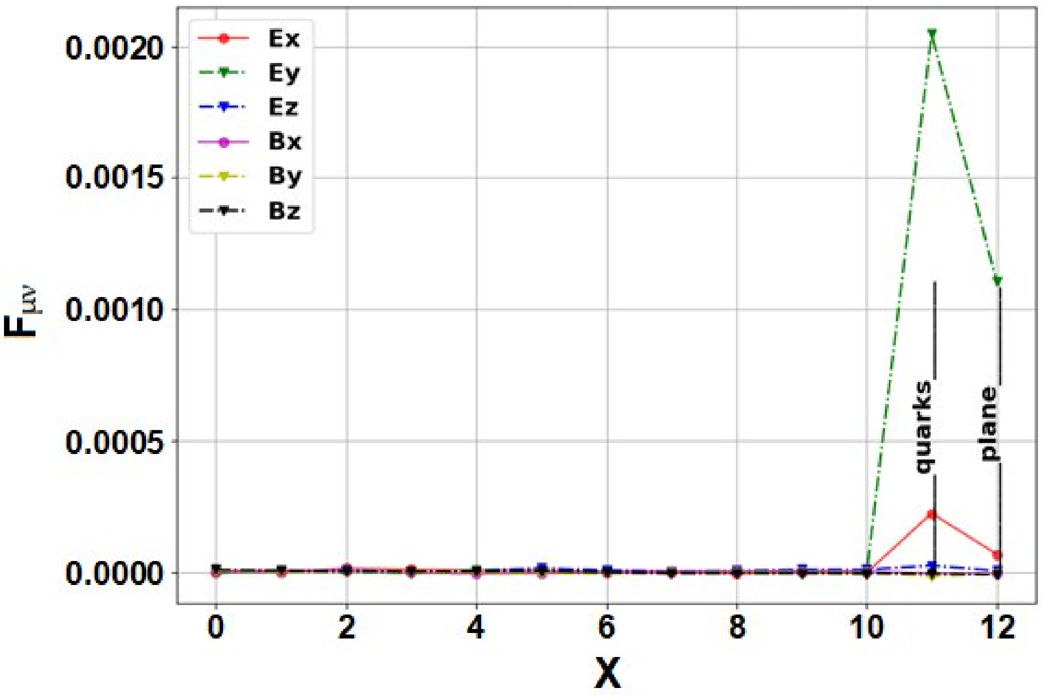


R = 10, d = 1, β = 2.3

Field tensor components with different values of β



R = 10, d = 1, β = 2.5



R = 10, d = 1, β = 2.7

Conclusion

The Casimir plate affects on the distribution and intensity of chromoelectric fields between a quark-antiquark pair.

Several interesting regularities are observed:

1) The values of the components of the force tensor of the field decrease when a pair of quarks come closer to the plate, which indicates a weakening of the interaction between quarks.

2) Plate changing phase structure of the system. Temperature near Casimir plate increases.

3) The plate begins to affect the fields between quarks only at close enough distances. At a large distance from the plate, the behavior of the fields differs little from systems without a Casimir plate.