Pillars of Electrostatics

1. Inverse square law: Force $\propto 1/r^2$

2. Superposition principle

Inverse Square Law

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- Williams, Faller, and Hill (1971): $\varepsilon = (2.7 \pm 3.1) \times 10^{-16}$

Inverse Square Law
vs.
Quantum Electrodynamics

For r << $\lambda_{Compton}$ QED renormalizes the charge of the e^-

$$V(r) = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$\lambda_{Compton} = \frac{h}{mc}$$
$$= 2.4 \times 10^{-12} \text{ m for } e^-$$

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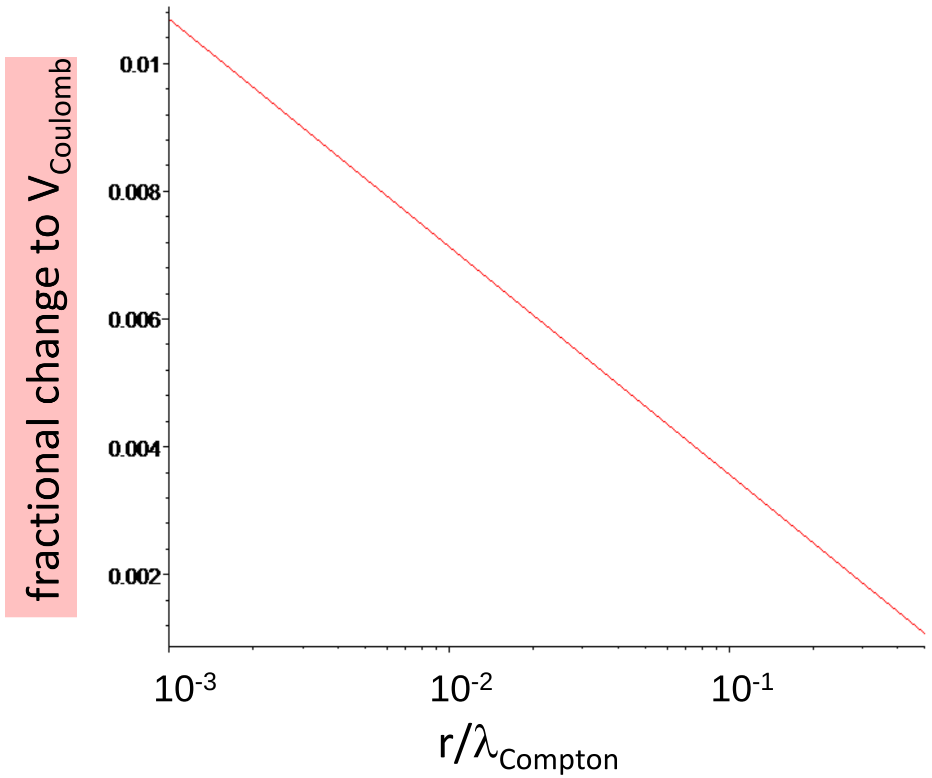

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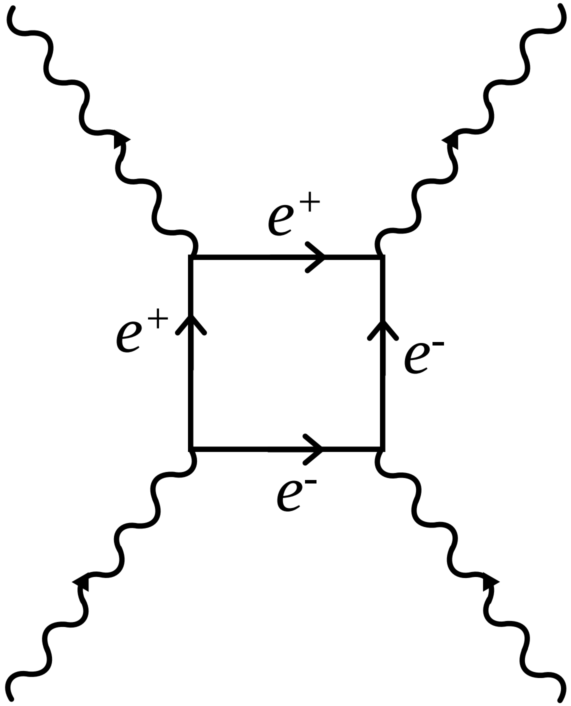
Superposition Principle

In vacuum, the superposition principle ($\vec{E}_{total} = \vec{E}_1 + \vec{E}_2$) is true.

How true?
QED predicts that photons begin to interact with each other (vacuum polarization effect) for

$$E - field \sim 10^{18}\, V/m$$
$$B - field \sim 10^{9}\, T$$



Photon-photon scattering in vacuum has NOT been detected yet.

In non-linear optical media, photon-photon scattering is a common effect.

Note : $E_{max,LAB} \sim 10^{14}\, V/m$ (ultrafast laser pulse)

Conclusion

1. Inverse square law: Force $\propto 1/r^2$

2. Superposition principle

Both of these statements are true over the range of experimental conditions where one would use classical electrodynamics/electrostatics.