Quantum electrodynamics

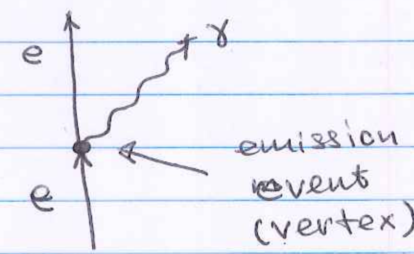
Interactions of charged particles + quantized e-m field

Electrons interact via exchange of virtual photons

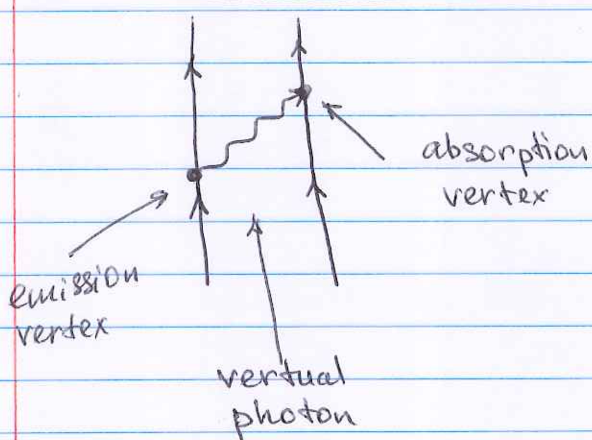
Fenman diagrams : visualization of e-m interactions

word line of a stationary electron

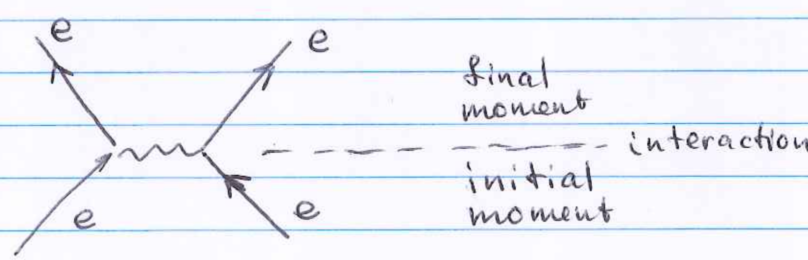
electron emitting a photon



(impossible process by itself)



Two electrons became aware of each other (interacted) via the exchange of a (virtual) photon



Charged particles — solid line with arrows

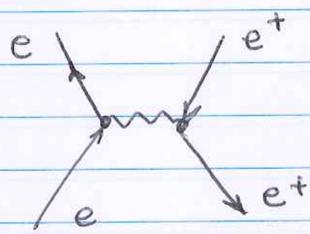
Photons — wavy lines. When attached to a vertex they designate absorption or emission

Region below the vertex — initial state
" above " — final state

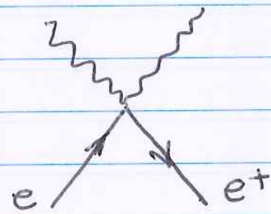
Any line b/w two vertexes represent a virtual particle

Any process that follow these rules, and whose final state and initial state obey conservation laws is a possible physical process!

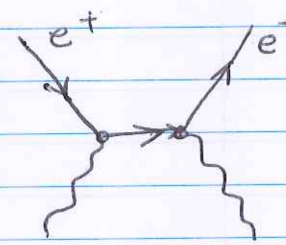
Possible electron-positron interaction



Coulumb interaction



electron-positron annihilation



electron-positron pair production

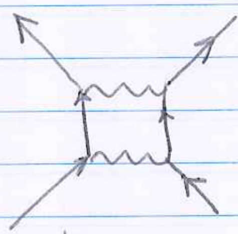
Feynman diagrams are more than funny pictures, they are prescriptions for very precise calculations.

For example – e–e scattering

First-order effect (involves 1 photon)

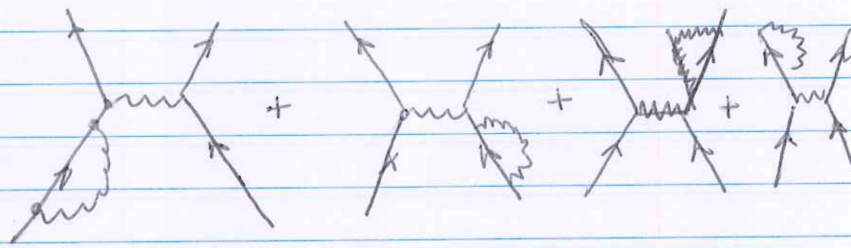
one possible contribution

Second-order effect (involves 2 photons)



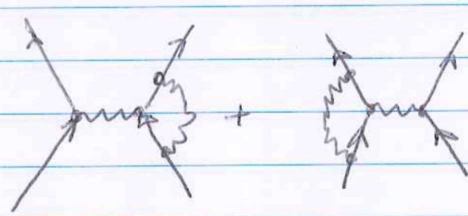
two-photon exchange

and



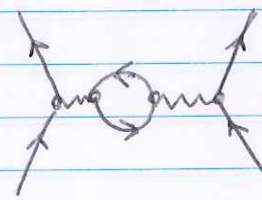
electron self-interaction

and



vertex correction

and



vacuum polarization

~~It is necessary to~~ Each pair of verteces in calculations introduces a factor of $\alpha = 1/137$ (fine structure constant)

Thus, higher order processes give weaker contributions compare to the first order effects. Still, they are necessary to conduct <u>precise</u> measurements

For example: electron magnetic moment

$\vec{\mu} = \frac{q}{2m} \vec{S}\vec{B}$ – classical (incorrect) assumption

$\vec{\mu} = g \frac{q}{2m} \vec{S}\vec{B}$ $g = 2$ from Dirac equatio

experiment $g = 2.0023193048 \pm 4 \cdot 10^{-10}$

theory $g = 2.0023193048 \pm 8 \cdot 10^{-10}$