

Feynman Diagrams

also known as boson

Force	Exchange Particle	Range	Relative Strength	Acts on
Strong	Gluon (pions)	10^{-15} m	1	Quarks
Electromagnetic	Virtual photon (λ)	∞	10^{-2}	Charged particles
Weak	Z^0, W^+, W^- bosons	10^{-17} m	10^{-5}	Quarks and leptons
Gravity	Graviton	∞	10^{-40}	All matter with mass

Electromagnetic force: (boson: virtual photon)

proton-proton



electron-electron

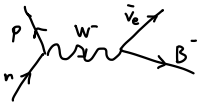


electron-proton

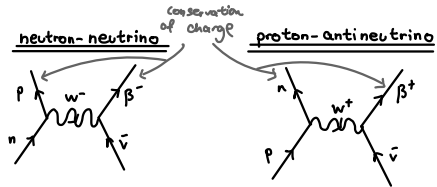
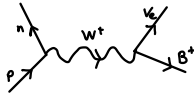


Weak Force: (boson: W^+, W^-)

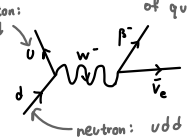
β^- decay (in terms of nucleons)



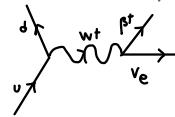
β^+ decay (in terms of nucleons)



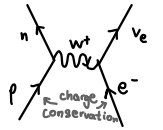
β^- decay (in terms of quarks)



β^+ decay (in terms of quarks)



Electron capture electron-proton collision

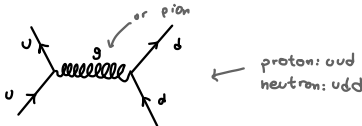


"proton rich" nucleus turns into a neutron as a result of interacting with an inner shell electron

electron requires very high kinetic energy to collide with proton

Strong nuclear force: (boson: gluon)

up quark-down quark attraction



W-bosons VS photons

Unlike photons, W-bosons:

- have a non-zero rest mass
- have a even shorter range than strong force distance
- are positively charged or negatively charged (W^+ / W^-)