

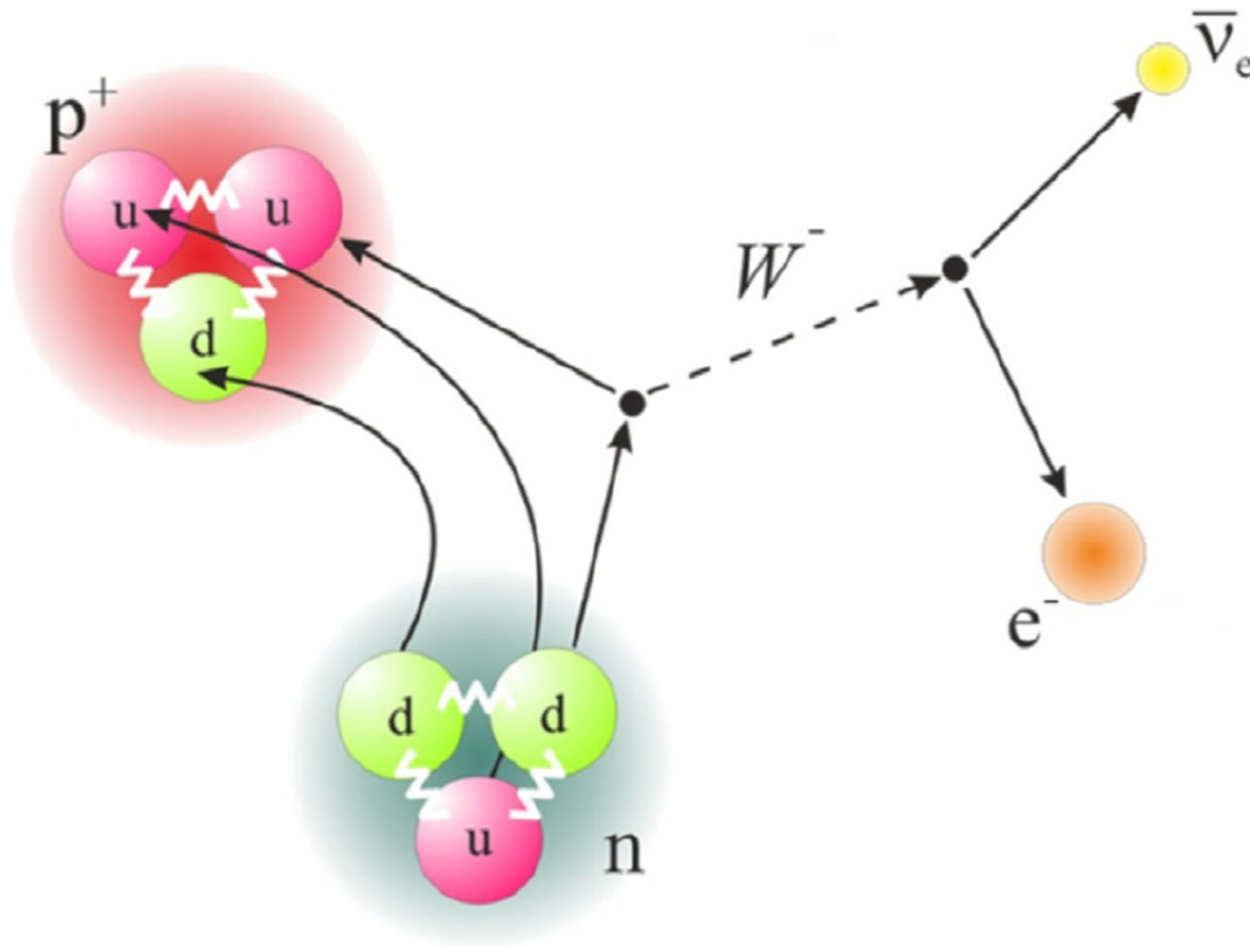
Force carriers

Interaction	Force carrier	Mass (GeV/c ²)	Spin (\hbar)	Source	Particles carrying charge	Range (m)	Interaction time (s)	Coupling constant
Strong	gluon	0	1	color charge	q, g	10^{-15}	10^{-23}	$\alpha_s \approx 1$
Electromagnetic	photon	0	1	electric charge	q, e, μ, τ, W^\pm	∞	10^{-18}	$\alpha = 1/137$
Weak	W^\pm, Z^0	80, 91	1, 1	weak charge	$q, e, \mu, \tau, W^\pm, Z^0$	10^{-18}	10^{-16} to 10^{-10}	$\alpha_w \approx 10^{-5}$
Gravity	graviton	0	2	mass	$q, e, \mu, \tau, \nu, W^\pm, Z^0$	∞	?	$\alpha_g \approx 10^{-38}$



Neutron decay

$$udd \rightarrow uud + W^- \rightarrow uud + e^- + \bar{\nu}_e.$$



Standard model

		three generations of matter (fermions)			interactions / force carriers (bosons)	
		I	II	III		
QUARKS	mass	$\approx 2.2 \text{ MeV}/c^2$	$\approx 1.28 \text{ GeV}/c^2$	$\approx 173.1 \text{ GeV}/c^2$	0	$\approx 124.97 \text{ GeV}/c^2$
	charge	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0	0
	spin	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	0
		u up	c charm	t top	g gluon	H higgs
		$\approx 4.7 \text{ MeV}/c^2$	$\approx 96 \text{ MeV}/c^2$	$\approx 4.18 \text{ GeV}/c^2$	0	
		$-\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	0	
		$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
		d down	s strange	b bottom	γ photon	
LEPTONS		$\approx 0.511 \text{ MeV}/c^2$	$\approx 105.66 \text{ MeV}/c^2$	$\approx 1.7768 \text{ GeV}/c^2$	$\approx 91.19 \text{ GeV}/c^2$	
		-1	-1	-1	0	
		$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
		e electron	μ muon	τ tau	Z Z boson	
		$< 1.0 \text{ eV}/c^2$	$< 0.17 \text{ MeV}/c^2$	$< 18.2 \text{ MeV}/c^2$	$\approx 80.39 \text{ GeV}/c^2$	
		0	0	0	± 1	
		$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
		ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson	

SCALAR BOSONS

GAUGE BOSONS
VECTOR BOSONS

