

BASIC INTERACTIONS

Name	First Observation	Relative Coupling Strength	Range	Theories				
Strong	Nuclear forces	1	$\sim 10^{-15}$ m	QCD†	} Electroweak }	} S t a n d a r d M o d e l }	} *Grand Unified Theories }	} Super- gravity Theories }
Electromagnetic	Chemical and electrical forces	10^{-2}	$\text{long} \left(\frac{1}{r^2} \right)$	QED††				
Weak	Radioactivity, β -decays	10^{-5}	$\sim 10^{-18}$ m					
Gravitational	Weight and solar system	10^{-39}	$\text{long} \left(\frac{1}{r^2} \right)$					

†QCD = Quantum chromodynamics
 ††QED = Quantum electrodynamics
 *Theories beyond the standard model are conjectural, as indicated by the use of the plural (theories).

PARTICLE GLOSSARY

(All *charged* particles have electromagnetic interactions as well as the interactions indicated.)

HADRONS

Strongly Interacting (also have weak interactions)

- Baryons** (spin = 1/2, 3/2, . . .) Fermions (obey Pauli exclusion principle) – **bound state of three quarks**
 Examples:
 nucleon (proton, neutron); hyperons (usually Greek letter names)
- Mesons** (spin = 0, 1, . . .) Bosons – **bound state of quark-antiquark**
 Examples:
 pions; heavier mesons named with letters
- Quarks** (spin = 1/2) Fundamental fermions whose bound states form all the baryons and mesons

LEPTONS

Weakly Interacting (but no strong interaction)

- (Spin = 1/2) Fermions (obey Pauli exclusion principle)
 Only 6 are known to exist:
 e (electron), ν_e (electron neutrino); μ (muon), ν_μ (muon neutrino); τ (tau), ν_τ (tau neutrino)

GAUGE BOSONS† (quanta of the force field, which “transmit” the force)

Force	Quantum of the Force Field	Mass	Spin
Strong	gluon	0	1
Electromagnetic	photon	0	1
Weak	W^\pm, Z^0	$\sim 80, 91$ GeV	1
Gravitational	graviton††	0	2

†The spin 1 gauge bosons are also referred to as *intermediate vector bosons*.
 ††No experiments have yet detected gravitational waves, let alone their quanta.