PARTICLE PHYSICS

(ABRIDGED)

HADRONS

Composite subatomic particles made of quarks that partake in the strong interaction (as well as the weak interaction). All baryons decay into protons, while mesons do not.

BARYONS

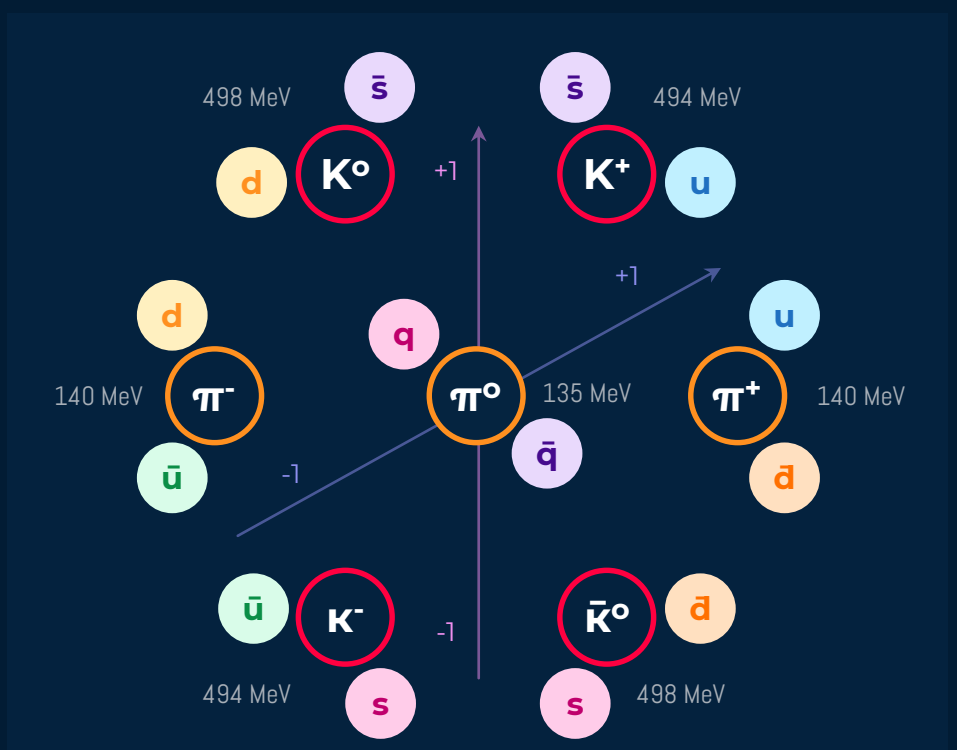
Baryons are composed of 3 quarks, and have the greatest mass of any subatomic particle. Together with electrons (a lepton), they form the nuclei of atoms, making up most of the mass of all the visible matter in our universe.

PROTON	NEUTRON	ANTIPROTON	ANTINEUTRON
+1 +1 938 MeV	0 +1 939 MeV	-1 -1	0 -1

Protons and antiprotons are charged, while neutrons are neutral. During particle interactions, the baryon number should remain constant. Protons and neutrons increase it, and their antiparticles decrease it.

MESONS

Mesons consist of an equal number of quarks and antiquarks, usually one of each. They are, however, very unstable, quickly decaying into lighter particles within fractions of a nanosecond. They appear as products of high-energy collisions between particles composed of quarks, such as in particle accelerators.



LEPTONS

Elementary subatomic particles that partake in the weak interaction (but not the strong interaction). There are 3 branches – electron, muon, tau – each with their own quantum number that must be preserved in interactions.

ELECTRON BRANCH

The eponymous electron and its antiparticle, more commonly known as the positron, are charged, while the massless neutrinos are not. The electron and electron neutrino increase the electron lepton number, and their antiparticles decrease it.

ELECTRON	POSITRON	ELECTRON NEUTRINOS	
-1 +1 0.511 MeV	+1 -1	0 +1 0 MeV	0 -1

MUON BRANCH

Muons are very similar to electrons, but with much greater mass. Like mesons, they are unstable, decaying within microseconds. The regular muon almost always decays into an electron or positron with the same charge, and 2 neutrinos.

MUON	ANTIMUON	MUON NEUTRINOS	
-1 +1 106 MeV	+1 -1	0 +1	0 -1

TAU BRANCH

Tau particles can be thought of as really heavy electrons.

TAU	ANTITAU	TAU NEUTRINOS	
-1 +1 1777 MeV	+1 -1	0 +1	0 -1

QUARKS

Elementary particles that combine to form hadrons. They come in 6 varieties – up, down, strange, charm, top, bottom – as well as the antiparticles of each. Due to colour confinement, quarks are never found in isolation, which makes them quite illusive to study.

	u	d	s	ū	d̄	s̄
Q	+⅔	-⅓	-⅓	-⅔	+⅓	+⅓
S	0	0	-1	0	0	+1
B	+⅓	+⅓	+⅓	-⅓	-⅓	-⅓

Strange particles contain strange quarks, and are created in pairs by the strong interaction, conserving strangeness. In weak interactions, strangeness can change by +1 or −1. During β^- decay, a down quark changes into an up quark, and vice versa in β^+ decay.

FUNDAMENTALS

For each kind of particle, there is a corresponding antiparticle. When a particle and its antiparticle collide, they annihilate each other, forming 2 photons. Particles interact with each other via the 4 fundamental interactions – the strong interaction, the weak interaction, electromagnetism, and gravity.

STRONG AND WEAK

The strong interaction binds quarks into hadrons, and keeps nucleons together in the nuclei of atoms. Only hadrons partake in the strong interaction, but the weak interaction, which is significantly weaker, affects both hadrons and leptons, and causes beta decay in radioactive nuclei. The exchange particles of the weak interaction are the W^+ and W^- bosons.

ELECTROMAGNETISM AND GRAVITY

Electromagnetism occurs between electrically charged particles, and is the root of most interactions between atoms and molecules. The exchange particle for electromagnetism is the virtual photon. Gravity, despite being the weakest fundamental interaction, becomes dominant at the macroscopic scale, forming planets and stars, and governing the movements of orbiting celestial bodies and entire galaxies.

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