The standard model

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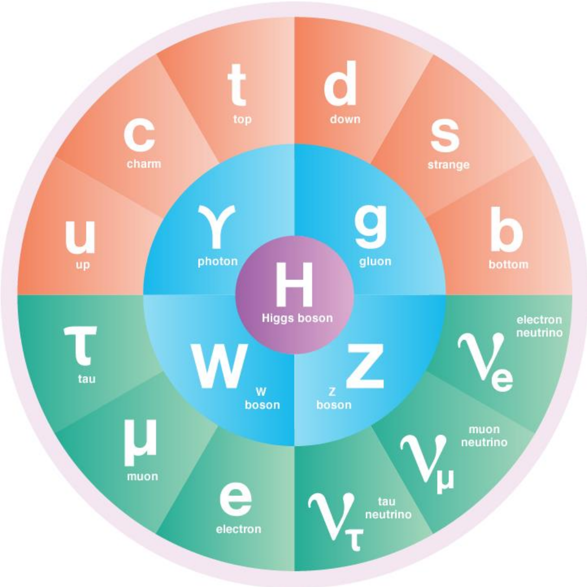
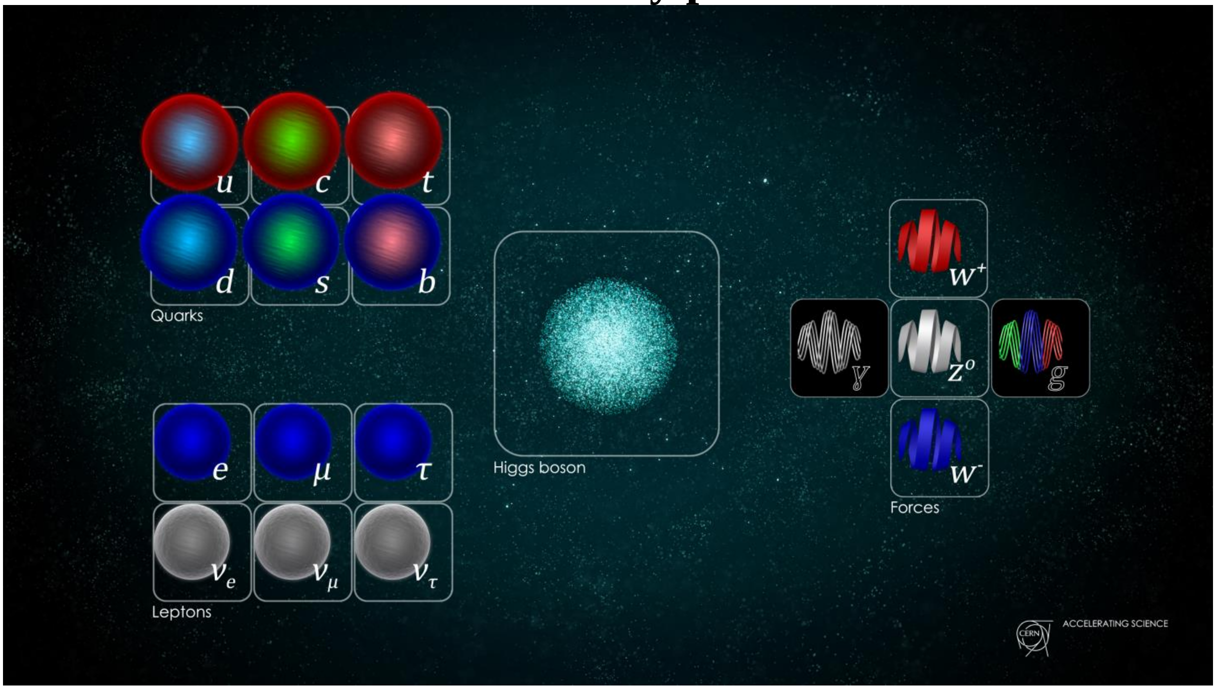
The Standard Model is the theory describing three of the four known fundamental forces (the electromagnetic, weak, strong interactions and the gravitational force) in the universe. It was developed in the 20th century, through the work of many scientists around the world. In the 1970s, it was proved by experimental confirmation that quarks exist. The formulation was then finally finalized. A quark is a type of elementary particle of matter. Experimental confirmation of other elementary particles, like the top quark, the tau neutrino , and the Higgs boson have added further belief to the Standard Model.



In addition, the Standard Model has predicted various properties of weak neutral currents. It is believed to be theoretically self-consistent and to predict a lot of experimentals. It still requires some things of being a complete theory. For example, it does not fully explain baryon asymmetry, incorporating the full theory of gravitation as described by general relativity (also known as the general theory of relativity: It is the geometric theory of gravitation published by Albert Einstein in 1915 and is the current description of gravitation in modern physics) or the expansion of the universe what possibly is caused by dark energy. Dark energy is an unknown form of energy that makes the universe expand. The model does not contain any viable dark matter particle that possesses all the required properties from observational cosmology. . Dark matter is a form of matter that appears in the universe. It is unsure what it exactly does, but they suspect it's something with gravitational effect that they can't explain. It is called dark because it is difficult to detect because it does not absorb, reflect or emit electromagnetic radiation. It also doesn't incorporate neutrino oscillations (a mechanical in which a neutrino (a fermion that interacts only via the weak subatomic force and gravity) is created and their non-zero masses. It is used as a basis for building more exotic models that incorporate hypothetical particles, extra dimensions, and elaborate symmetries (such as supersymmetry (a conjectured relationship between two basic classes of elementary particles: bosons, which have an integer-valued spin, and fermions, which have a half-integer spin)). They are also trying to prove the existence of dark matter and neutrino oscillations with this method.

The elementary particles



The Standard Model is the best theory to describe the most basic building blocks of the universe. It consists of 4 big groups: 6 flavors of quarks, 6 flavors of leptons, 1 higgs boson and 4 forces (bosons).

Quarks

There are two types of quarks that make up the protons and neutrons inside atomic nuclei. These are the up quark, which possesses two-thirds of a unit of electric charge, and the down quark, with an electric charge of −1/3. Up and down quarks can be either "left-handed" or "right-handed" depending on whether they are spinning clockwise or counterclockwise with respect to their direction of motion.

Quarks			
up-type	up	charm	top
down-type	down	strange	bottom

Leptons

a lepton is an elementary particle of half-integer spin (spin 1⁄2) that does not undergo strong interactions. Two main classes of leptons exist: charged leptons (also known as the electron-like leptons), and neutral leptons (better known as neutrinos). The best known of all leptons is the electron. There are six types of leptons, known as flavours, grouped in three generations. The first-generation leptons, also called electronic leptons, comprise the electron, the second are the muonic leptons, comprising the muon; and the third are the tauonic leptons, comprising the tau

Leptons			
charged	electron	muon	tau
neutral	electron neutrino	muon neutrino	tau neutrino

Higgs boson

The Higgs boson is an elementary particle in the Standard Model of particle physics produced by the quantum excitation of the Higgs field one of the fields in particle physics theory. It is named after physicist Peter Higgs who in 1964 along with other scientists proposed the Higgs mechanism to explain why some particles have mass. (Particles acquire mass in several ways, but a full explanation for all particles had been extremely difficult). This mechanism required that a spinless particle known as a boson should exist with properties as described by the Higgs Mechanism theory. This particle was called the Higgs boson.

(Gauche) Bosons or forces

In quantum mechanics, a boson is a particle which carries a force. Bosons make up one of two classes of elementary particles, the other being fermions.

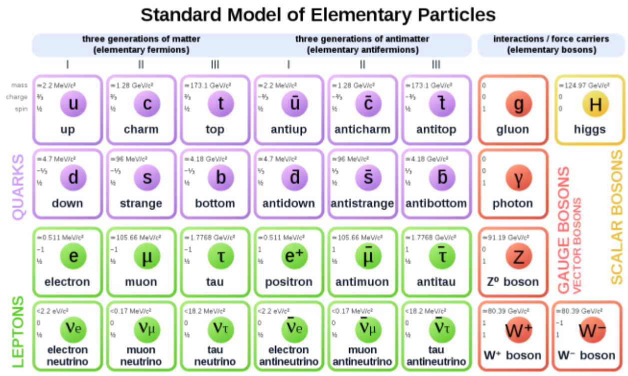
Examples of bosons are fundamental particles such as photons, gluons, and W and Z bosons (the four force-carrying gauge bosons of the Standard Model). there are 4 specific bosons in the standard model:

γ Photon

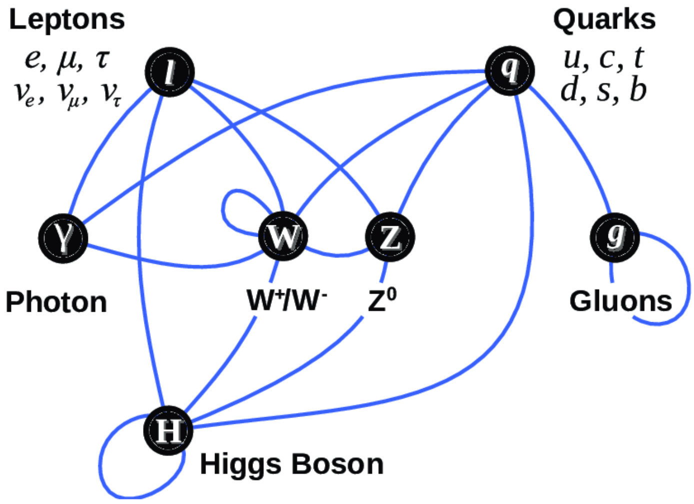
g Gluons (eight different types)

Z Neutral weak boson

W± Charged weak bosons (two types)



This figure also contains antimatter and antimatter is defined as matter that is composed of the antiparticles (or "partners") of the corresponding particles.



Particle interactions

Each force included in the Standard Model acts between particles because of some property of that particle: charge for electromagnetism, color for the strong force, and flavor for the weak force.

Starting with electromagnetism, Charge is the property of matter that gives rise to electric and magnetic phenomena. Charge is quantized, which means it can only exist in discrete amounts with restricted values (multiples and fractions of the elementary charge, which is $e = 1.6 \times 10^{-19}$ C). Particles that exist independently (the electron, muon, and tau) carry multiples of the elementary charge, while quarks carry fractions of the elementary charge. Quarks always bind together in groups whose total charge is an integral multiple of the elementary charge, which is why no one has ever directly measured a fractional charge. In addition, since opposite charges attract, electrons tend to bind to protons to form atoms that are neutral overall.

Concerning the strong force, quarks stick to other quarks because they possess a characteristic known as color (charge) and they come into - or +.

The colors of quarks in the Standard Model combine like the colors of light in human vision, indeed if we put together all the colors of the light, we obtain a "colorless" white light. A baryon is respectively a triplet of one red, one green, and one blue quark. By putting them together you get a color neutral particle. A meson is a doublet of one colored quark and one anti-colored antiquark, but they together make anyway a color neutral particle. Quarks can't stand being apart from one another, they have to join up and always do so in a way that hides their color from the outside world.

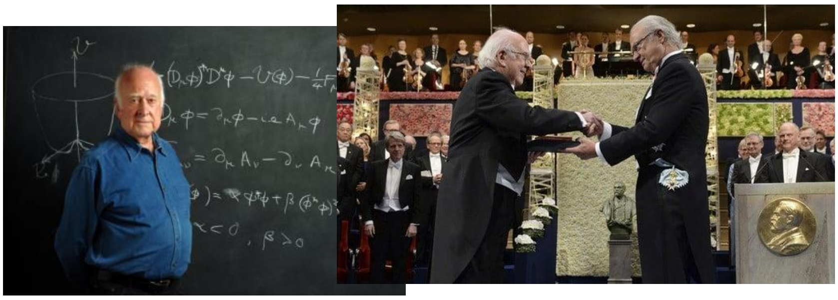
Colored particles are bound together by gluons. Six of the eight gluons have two colors, one of them has four, and the another gluon has six. Gluons glue quarks together, but they also stick to themselves. One consequence is that they can't reach out and do much beyond the nucleus. Without the strong force, every nucleus would break into a thousand pieces, as this force contributes to its cohesion.

Considering the weak force, it is mediated through the exchange of W o Z bosons, referring to the figure on the previous page.

Autobiography of Peter Ware Higgs

Peter Ware Higgs, born on May 29th 1929 has obtained a Nobel Prize for physics for proposing the existence of the Higgs boson. On 8 October 2013, the Nobel Prize in physics “for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles” was announced to Peter Higgs and François Englert. Higgs admits he had gone out to avoid the media attention, so he was informed by one of his former-neighbours that he had been awarded the prize.
Higgs turned down a knighthood in 1999, but in 2012 he accepted membership of The Order of the Companion of Honour. He later said that he only accepted the order because he was wrongly assured that the award was the gift of the Queen alone. He also expressed cynicism towards the honours system, and the way the system "is used for political purposes by the government in power". The order confers no title or precedence, but recipients of the order are entitled to use the post-nominal letters CH. In the same interview he also stated that when people ask what the CH after his name stands for, he replies "it means I'm an honorary Swiss. He received the order from the Queen at an investiture at Holyrood House on 1 July 2014.

Higgs has received a bachelor’s degree in the year 1950, a master’s degree in 1951 and a doctorate in physics from King’s College at the University of London in the year 1954. He was a research fellow at the University of Edinburgh from 1955 until 1956 and then became a research fellow, from 1956 until 1958, at the University of London. In these years he worked in quantum field theory. He also was a lecturer, from 1959 until 1960, at the University of London. He became a lecturer in mathematical physics at Edinburgh in 1960 and spent the remainder of his career here. Up to when he became a reader in mathematical physics from 1970 until 1980 and a professor of theoretical physics from 1980 until he retired in 1996. He wrote two papers in 1964 describing what later became known as the Higgs mechanism, in which a scalar field, a field present at all points in space, gives particles mass. To his surprise, the journal to which he submitted the second paper rejected it. The Higgs mechanism was independently discovered in 1964 by Robert Brout and François Englert. together with a group consisting of american physicists Gerald Guralnik, Carl Hagen and British physicist Tom Kibble. However, neither group mentioned the possibility of a massive boson.



Physics beyond the Standard Model

The Standard Model is not perfect. New discoveries and new data found have led to finding limits and problems of the standard model. Physics beyond the Standard Model consists of a series of theoretical developments that have been made to explain some shortcomings of the Standard Model. Among the imperfections we find some phenomena that cannot be explained by the Standard Model and also theoretical problems.

Phenomena

Dark Matter : Dark matter is part of the energy of the universe. It interacts little with the fields of the Standard Model. For this reason, the Standard Model does not support fundamental particles that may refer to Dark Matter.

Neutrino masses : By the theory of neutrino oscillations it has been discovered that they have mass. Consequently, they could be added to the Standard model, but this would present theoretical problems. In particular, since the masses are extremely small, it is not known if they behave in the same way as the masses of the particles of the standard model.

Gravity : Gravity is not explained in the Standard Model. The standard model cannot support the theory of gravity and the phenomenon cannot relate through experiment.

Matter-Antimatter Symmetry : The universe consists of matter and antimatter. Matter is more present in the universe. The Standard Model predicts that at the birth of the universe matter and antimatter should have been divided into equal parts. Considering this initial condition, the Standard Model does not explain this asymmetry between the proportion of matter and antimatter that is in the universe today.

Theoretical problems

The standard model has implemented features that present theoretical problems.

Number of parameters : The standard model depends on 19 numerical parameters. These values are obtained through experiments, but the origins are unknown. Some scholars have tried to find relationships between the various parameters.

Hierarchy problem : Particle masses are introduced by the Standard Model through spontaneous symmetry breaking caused by Higgs fields. The mass of the Higgs gets bigger and bigger because of the virtual particles. The mass of particles cannot be defined.

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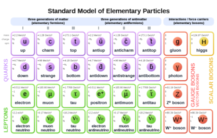

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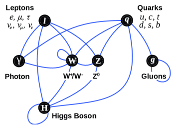

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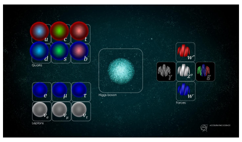

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Leptons			
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neutral	electron neutrino	muon neutrino	tau neutrino

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