Some Basic Properties of Higgs Bosons

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Abstract. Known as one of the most hopeful fields to find the new particle—Higgs bosons and become even more important after it is proved by Higgs. Higgs and his colleagues further improve their observation of the Higgs Bosons through the Higgs mechanism. This paper will show the basic properties of the Higgs bosons, and some machines of the Higgs bosons. The spontaneous symmetry breaking, and the Higgs mechanism have also been introduced due to their necessity for the Higgs boson. This paper will be an introduction for anyone who is interested in this field.

Keywords: Higgs Bosons, Particle Physics, Nucleus

1. Introduction

The field of particle physics studies the structure and properties of matter within the atomic nucleus. Under the high energy condition, the matter in the nucleus can be divided into many branches, such as leptons, fermions, bosons and so on [1, 2]. Meanwhile, the applications of particle accelerators, detection methods, data recording and processing, and computing technology continue to develop, which not only brings progress in particle physics itself, but also promotes the development of science and technology as a whole; The fruitful results have played an important role in the study of the evolution of the universe. In particle physics, the Standard Model (SM) is a set of theories that describe the three fundamental forces (the strong, the weak, and the electromagnetism), and the fundamental particles that make up all matter [3, 4]. However, The Standard Model still doesn't explain the Higgs boson. Scientists began a long study of the SM, and then accidentally discovered the Higgs boson, which saved the SSM through the Higgs mechanism [1].

Higgs boson is a boson with zero spins predicted by the SM (there is objection).there is no electric charge, it also does no color charge. Moreover, it is very volatile, and it will disintegrate at once after production [2]. In 1964, the English scientist Peter Higgs suggested the existence of the Higgs field and then foretold the existence of the Higgs bosons. The Higgs field brings about a spontaneous break in symmetric and imparts mass to gauge propagators and fermions in the Higgs mechanism. The Higgs particle is quantified excitement of the Higgs field, which acquires mass through automatic interaction [5-7].

In this article, the properties of the Higgs bosons have been reviewed, which will be helpful for beginners in this field. The second part is about the Higgs boson potential and the Higgs Field. The third part is about spontaneous symmetry breaking and the decay of the Higgs boson. The final is about the Higgs mechanism of classical scalar electrodynamics.

2. The Higgs potential and the Higgs field

The relationship between the Higgs potential and the Higgs field is shaped like a Mexican hat (Figure 1) [8]. The top of the hat is the local maximum value of the Higgs potential, and its Higgs field is zero any position of the bottom of the hat is the minimum value of the Higgs potential, and its Higgs field is not zero. For the rotation around the central axis of the hat, the position of the top of the hat does not change, but any position of the bottom of the hat will change, so the top of the hat has rotational symmetry, and any position of the bottom of the hat does not have rotational symmetry.

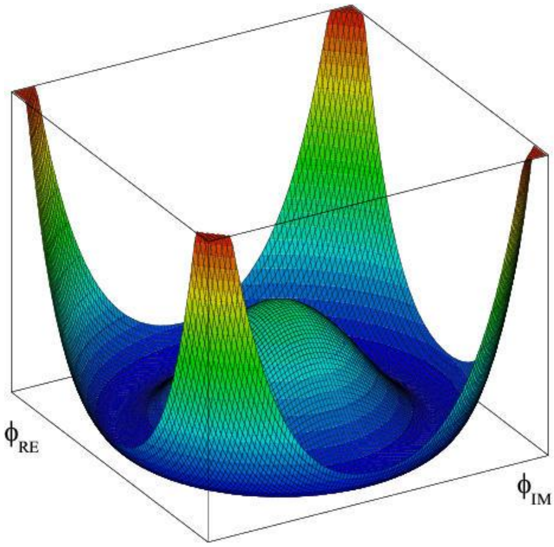

Figure 1. The Mexican Hat Potential [8].

The concept of the vacuum in quantum mechanics is different from the vacuum of general knowledge. In quantum mechanics, a vacuum is not an empty space, and virtual particles will continue to be random generated or annihilated no matter what position you're in, which will cause mysterious quantum effects. After accounting for those quantum effects, the lowest energy state within space is the minimum state of all energy states, also known as the ground state or "vacuum state". The space of the weakest energetic state is the emptiness of quantum mechanics. A description of physical systems has symmetries that the lowest energy state may not have; a phenomenon is known as spontaneous symmetry breaking. In the Standard Model, to satisfy the tonnage invariance, the weightof the gauge bosons must be adjusted to 0, but this does not conform to the experimental observations - both the W boson and the Z boson have been script experimentally, owning their quality. moreover, these bosons must be dependent on other mechanisms or actions to gain mass.

Every weakest energy state position has no rotational symmetry. Among the infinite number of weakest energy states, only one weakest energy status can be achieved. This severs the symmetry of rotation, as a result, a spontaneous symmetry breaking, thus allowing the gauge bosons to gain weight and generating a zero-mass glass Dons, called Goldstone bosons [9]. The Higgs bosons are particles that accompany the Higgs field, the vibrations of the Higgs field. But this Goldstone boson doesn't correspond to actual physics. By choosing an appropriate gauge, the Goldstone bosons must be cancelled out, leaving only the mass-bearing Higgs boson and mass-gauge bosons.

To sum up, the use of spontaneous symmetric rupture allows dipstick bosons to gain mass, this call the Higgs mechanism. Of all the possible mechanisms by which gauge bosons can be given mass while obeying gauge theory, the Higgs mechanism is the most straightforward. Through the Higgs mechanism, the complex-valued Higgs field (two degrees of freedom) and zero-mass gauge bosons (transverse fields, like photons, have two degrees of freedom) are transformed into mass scalar particles. And the gauge boson with mass (the Goldstone boson transforms into a vertical field, plus the previous horizontal field, for a total of three degrees of freedom), the degrees of freedom are conserved. Fermions also gain mass by interacting with the Higgs field. Fermions also gain mass by interacting with the Higgs field, but the way they gain mass is different from the way W bosons and Z bosons do. In gauge field theory, to determine the invariancy of the local gauge, the mass of fermions must be set to zero. Through Yukawa coupling, the fermions can also gain mass due to spontaneous symmetry breaking [10].

3. Spontaneous symmetry breaking

The existence of quantum mechanical symmetry is affected by external or internal factors, and part or all of the original symmetry is lost, which is usually called symmetry breaking. There are three ways to cause symmetry breaking:

1) Obvious destruction-extrinsic action, such as the system Hamiltonian H_0, has symmetry S, the extrinsic action Hamiltonian $H^{'}$

$$H = H_0 + H^{'} \tag{1}$$

$H^{'}$ has broken the symmetry of the original S, and H has only lower symmetry than H0This damage caused by external action is sometimes called apparent damage.

2) Quantization destroys the symmetry S_σ of the Hamiltonian H_σ of a physical system in the unquantized classical case the Hamiltonian of the system H_q after quantization, sometimes there is an additional term Hα

$$H_q = H\sigma + H_\alpha \tag{2}$$

At this time, the symmetry of H_q is lower than that of S_σ, and some symmetry is lost, which is caused by H_α. This situation is called quantum breaking of symmetry, and Hα is often referred to as a quantum anomaly.

3) Spontaneous breaking symmetry - ground state symmetry breaking.

When the quantum system Hamiltonian is H has symmetry S, its ground state can also have Symmetric S. Still, the ground state does not have symmetry S but has a lower symmetry S' than S', and loses the original symmetry of H. This is called the spontaneous breaking of the H symmetry. It can be proved that in this case, the ground state of the system is degenerate, it has multiple degenerate ground states, and each of these ground states has no S symmetry, but the totality of all the degenerate ground states still maintains the original S of H Symmetry, so it is also called "hidden symmetry", or it is "very symmetrical" [11].

4. Higgs mechanism

For the Standard Model, the Higgs mechanism is a mass-generating mechanism that enables elementary particles to acquire mass. The Higgs mechanism applies spontaneous symmetry breaking to impart mass to the gauge bosons. This is the simplest of the possible mechanisms by which gauge bosons can be given mass while obeying gauge theory. According to the Higgs mechanism, the Higgs field pervades the universe, and some elementary particles gain mass due to the interaction with the Higgs field.

To explain more carefully, in gauge field theory, in order to satisfy local gauge invariance, the mass of the gauge boson must be set to zero. Since the vacuum expectation value of the Higgs field is not equal to zero, resulting in spontaneous symmetry breaking, the gauge boson will gain mass and generate a zero-mass boson, called the Goldstone boson, while the Higgs bosons are particles that accompany the Higgs field and are vibrations of the Higgs field. By choosing an appropriate gauge, the Goldstone bosons are cancelled out, leaving only the mass-bearing Higgs bosons and the mass-gauge vector field.

Fermions also gain mass by interacting with the Higgs field, but the way they gain mass is different from the way Wand Z bosons do. In gauge field theory, in order to satisfy local gauge invariance, the mass of fermions must be set to zero. Through Yukawa coupling, fermions can also gain mass due to spontaneous symmetry breaking.

5. The decay of the Higgs boson

The Higgs boson is a massive boson that accompanies the Higgs field, a quantum excitation of the Higgs field. The Higgs boson is an energy evolution in a high-energy extreme environment and is accompanied by decay to generate a symmetry of coupled particles, a real particle that generates a positron-electron collision, a supersymmetric particle coupling excitation, and positive. The coupling of negative electrons to positive and negative particles is called the ' Majorana fermion angel particle' chiral particle, and the excited state is the spectral energy to test the kinetic energy of this kind of particle. Not only that but the Higgs mechanism can also be confirmed to be largely correct.

figure. Parts should not have separate captions.

6. Conclusion

In conclusion, the Higgs boson is very important to the SM, because it explains the origin of mass. It can also be seen that it has been shown to have a strong influence on the nature of particle physics, which means that it plays a crucial role in our understanding of particle physics and the universe itself. In order to get a comprehensive understanding of the Higgs boson, the Higgs potential and the Higgs field have been reviewed. Moreover, spontaneous symmetry breaking, and the Higgs mechanism have also been introduced due to their necessity for the Higgs boson.

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