Proceedings of the 3rd International Conference on Computing Innovation and Applied Physics
DOI: 10.54254/2753-8818/9/20240773

The joint conservation assumption of CPT and weak isospin and color charge

Mudi Wang

Taiyuan University of Technology, No. 79 Yingze West Street, Taiyuan, Shanxi Province, China, 030024

1227188700@qq.com

Abstract. The conservation of CPT is considered applicable to all physical laws, but more and more research has discovered the possibility of CPT violation. This paper attempts to find a more complex and essential conservation than CPT conservation. This paper uses the method of theoretical structural analysis to discover the relationship between C, P, T symmetry, phase rotation symmetry, space rotation symmetry, and time translation symmetry, and prove the relationship between CPT symmetry, charge conservation, angular momentum conservation and energy conservation by studying the transformation modes of phase space, space, and time. Then the composition rules of uncertainty relationships and the fact that charge, weak isospin, and color charge are all related to the internal symmetry of matter are used to provide evidence for the inherent connection between charge, weak isospin rotation, and color charge demonstrating the similarity among these three. Finally, the joint conservation of CPT, weak isospin, and color charge are proposed.

Keywords: CPT Conservation, Symmetry, Conservation Law, Uncertainty Relationship.

1. Introduction

Symmetry is an important concept in modern physics. It can be expressed as a property that remains unchanged under certain transformations. For example, if objects of different masses are placed on both sides of a balance, the balance must tilt towards one end after stabilization. If “exchanging the positions of objects on both sides once” is regarded as a transformation, then after only one such transformation, the balance will tilt towards the opposite end after stabilizing, and the property of “tilting direction when the balance is stable” has changed, resulting in asymmetric balance properties. But when we make an even number of consecutive such transformations, the two objects eventually remain on the same side, and other conditions remain unchanged, the direction of inclination when the balance is stable remains the same as before. The “direction of inclination when the balance is stable” remains unchanged and has symmetry during such transformations.

CPT symmetry is a symmetry that has been found to be applicable to all physical laws. Later, methods such as quantum field theory were introduced to explain the conservation of CPT [1]. And some researchers believe that CPT conservation violation is related to Lorentz violation.

In order to verify the CPT conservation violation, the current research focus on CPT Violation in Neutrino Oscillation, mass differences between top quarks and antitop-quarks, and the different propagating speed of gravitational waves [2-4]. Many experiments have been proposed to test the

DOI: 10.54254/2753-8818/9/20240773

conservation of CPT. Some scientists attempt to use a magnetized iron calorimeter like ICAL to measure CPT damage, researching the direct comparison of the probabilities of a transition and its CPT reverse in the neutral kaon system [5,6].

This paper adopts the method of theoretical structural derivation to investigate whether there is a deeper internal connection between transformations related to CPT, and to test the conservation of CPT in terms of composition.

2. Symmetry and failure of C, P, and T

In physics, it is now found that all laws of physics are related to three main symmetries (not possessing them), namely C, P, and T symmetries.

C-symmetry refers to the conservation of charge conjugation. In mathematics, it can be simply described as: in a physical law, if all charges are taken to the opposite number, $q \rightarrow -q$, $-q \rightarrow q$, the physical law remains unchanged. This means that a physical theory that holds true for objects with negative charges is also true for objects with equal amounts of positive charges which is the same in other properties, and the phenomena they exhibit should be identical.

P-symmetry refers to the conservation of parity, or the invariance of properties under a specific spatial transformation, where the space includes three-dimensional space. It can be represented mathematically as a transformation matrix, mainly changing the chirality in space, that is, the relationship between coordinate axes. Specifically, it is a matrix related to spatial transformations, with a determinant value of -1. It acts not only on three-dimensional space in Cartesian coordinate systems, but also on two-dimensional and spherical coordinate systems. In three-dimensional space, P-reversal can correspond to both simultaneous direction reversal of three axes (a complete reversal of spatial position information) and unchanged direction reversal of two axes and direction reversal of one axis (object in the mirror).

T-symmetry refers to the conservation of time and the invariance of properties under time inversion. Mathematically, it refers to inverting the entire process from t to $-t$ in chronological order, and the details of the process still comply with the laws of physics.

However, all three symmetries were ultimately discovered to be disrupted.

When scientists discovered neutrinos and antineutrinos, they were surprised to find that neutrinos only have left spin, while antineutrinos only have right spin. This means that the existence of neutrinos and antineutrinos is itself a violation of C and P. It can also be said that neutrinos themselves are CP symmetric.

In 1957, Wu found a clear Violation of parity conservation in the beta Decay of cobalt-60 [7]. In 1964, Cronin and Fitch provided clear evidence from kaon decay that CP methodology could be broken and accurately confirmed in subsequent experiments [8]. This means that the symmetry of C, P, and CP is disrupted. T-symmetry violation was also discovered. When a pair of quarks are held together sometimes in two different combinations, they can switch back and forth between these two combinations through weak forces, but switching to one combination takes longer than switching back. Therefore, in the case of time reversal, the time spent on combination switching is not the same. When time is positive, it takes a longer time to switch first, and then a shorter time. When time is reversed, it is the opposite.

The violation of the combination of CT-symmetry and PT-symmetry is very obvious. If CT is conserved, the motion of positive charges repelling each other and causing them to move away from each other will become a motion of negative charges approaching each other, exhibiting the attraction effect of the same type of charge. If PT is conserved, then two small balls that are far away from each other should be close to each other in the mirror image. These two types of symmetry conservation are clearly incompatible with physical theorems.

However, there is currently no clear evidence of simultaneous violation of the combination of CPT symmetry. It is generally believed that CPT is conserved in all physical theorems.

DOI: 10.54254/2753-8818/9/20240773

3. Symmetry of CPT conservation and corresponding continuous symmetry

The reasons for the conservation of CPT can be found by using continuous symmetry similar to the CPT transformation.

CPT can be seen as a combination of three common continuous symmetric discrete transformations. The phase rotation symmetry of the U(1) group can be regarded as an event occurring at any angle in the phase space, and its properties are the same. Spatial translational symmetry and spatial rotational symmetry can be regarded as events occurring at any position and in any posture in space, and their properties are the same. The symmetry of time translation can be regarded as an event occurring at any point on the timeline, and its properties are the same.

According to Noether's theorem, every differentiable symmetry of the action of a physical system with conservative forces has a corresponding conservation law

The phase rotation symmetry of the U(1) group corresponds to charge conservation, spatial rotation symmetry corresponds to angular momentum conservation, and time translation symmetry corresponds to energy conservation. These three types of continuity symmetries respectively indicate the continuity and uniformity of phase space, space, and time. C, P and T transformations are discrete transformations in phase space, space, and time, based on the symmetry of these three types of continuity, so they must have the conservation properties of their corresponding continuity. Therefore, the conservation of C necessarily involves the conservation of charge, the conservation of P necessarily involves the conservation of momentum and angular momentum, and the conservation of T necessarily involves the conservation of energy. The condition for these three corollaries to hold is that C, P, and T must be symmetric separately. However, as mentioned earlier, their symmetry can be disrupted in both individual and pairwise combinations, and no violation of CPT joint conservation has been found so far. So, in the same physical event, the simultaneous conservation of charge, angular momentum, and energy is the foundation of CPT conservation. However, it should be noted that the violation of one or more of C, P, and T does not necessarily mean that their corresponding conservation does not hold in this phenomenon. CPT conservation means that quantities with opposite charges, momentum, and spatial coordinates are reversed, and the physical phenomenon of the process evolving in reverse over time is consistent with before the transformation.

Returning to the essence of C, P and T, P inversion changes the chirality in space. It can be considered that P inversion, spatial translation, and spatial rotation together constitute all transformations that can be made to space. At present, time is still regarded as one-dimensional, and T inversion is equivalent to reversing events that were originally occurring in the positive direction of the time axis to events occurring in the negative direction. Therefore, it can be considered that T inversion and time translation together constitute all the transformations that can be made to time. C inversion is different from the two, as it only changes the charge properties of matter and does not change the spatiotemporal properties outside of matter. It is a reversal of the fundamental physical quantities of matter. The charge conjugation belonging to the U(1) group symmetry is very similar in composition to the weak isospin conjugation and color charge conjugation of SU(2) and SU(3) groups. So, it can be speculated that weak isospin conjugation conservation and color charge conjugation conservation can also be seen as hidden fourth and fifth basic discrete conservation. They may form a more complex conservation relationship together with CPT conservation, which can include all important symmetries that have already been observed. It simultaneously describes the internal structure of time, space, and matter, and should be a more comprehensive conservation.

In order to verify whether the conservation of CPT is a larger part of conservation, it is necessary to study whether the continuity transformations corresponding to these three discrete transformations of CPT have internal connections.

4. The uncertainty relationships of symmetry and conservation

Evidence of an inherent connection between continuity transformations has been found in uncertain relationships.

The equation of uncertainty relationship is $\Delta x \times \Delta P \geq \hbar/2$. Previous studies have shown that uncertainty relationships have more complex expressions, but the physical quantities in uncertainty relationships have not changed [9]. To avoid misunderstandings and involve extensive mathematical calculations, we do not focus on the specific expressions of equations, but only on the composition of equations. It can be seen that the uncertainty relation is composed of the product of two physical quantities and a constant. In the double slit interference experiment, these two physical quantities are Δx and ΔP. Also, there are two similar Combinations , like $\Delta t \times \Delta E \geq \hbar/2$, $\Delta \Phi \times \Delta L \geq \hbar/2$.

According to the Noether's theorem, spatial translational symmetry corresponds to the conservation of momentum, temporal translational symmetry corresponds to the conservation of energy, and spatial rotational symmetry corresponds to the conservation of angular momentum. In addition, there are charge conservation, weak isospin conservation, color charge conservation, and so on.

In the first three symmetries, in mathematical formulas, spatial translation, temporal translation, and spatial rotation correspond to the increment of spatial scale x, the increment of temporal scale t, and the spatial rotation angleΦ, respectively Increment of Δx, Δt, $\Delta \Phi$. The conservation of momentum, energy, and angular momentum correspond to ΔP, ΔE, ΔL. Their products correspond to an uncertain relationship, and their dimensions are all the same, all of which are $kg * m^2/s$.

Based on this idea, it is possible to imagine other symmetric corresponding uncertainty relationships.

Regarding the conservation of charge, there should be an uncertainty relationship of $\Delta \Phi B \times \Delta Q$. If the precision in measuring the quantity of electric charge is increased, the precision in measuring the quantity of Magnetic flux has to be lost. In the Little-Parks effect, magnetic flux is also quantized and there is a similar inequality, but this inequality is not an uncertainty relationship [10].

Weak isospin and color charge, as they are not common physical quantities, exhibit dimensionless behavior and they are all discrete. Therefore, if the above method is followed, the other part of the uncertainty relationship between them should both be quantities with the same dimensions and angular momentum.

In general, Δx, Δt, $\Delta \Phi$ are all continuous, ΔP, ΔE, ΔL are all discrete. Every combination has discovered uncertainty relationship. The changes in charge, magnetic flux, dimensionless weak isospin, and color charge are all discrete. The physical quantity corresponding to the imaginary other part, due to its angular momentum dimension, should behave the same as angular momentum and they are also discrete. This indicates the composition rules of uncertainty relationships, the combination of discrete and continuous quantities, with a dimension of $kg * m^2/s$.

On the other hand, the uncertain relationships of $\Delta x \times \Delta P$, $\Delta t \times \Delta E$, $\Delta \Phi \times \Delta L$ are essentially related to time and space; Charge, weak isospin, and color charge are essentially related to internal properties and are related to phase rotation symmetry.

Uncertainty relationships are only found in physical quantities related to time and space, and no uncertainty relationships are found in physical quantities related to intrinsic properties. Currently, whether there are any underlying deeper physical principles is uncertain. However, in uncertain relationships, time and space are similar, while charge, weak isospin, and color charge are similar.

This indicates that there is an inherent correlation between charge, weak isospin, and color charge. This provides a certain theoretical basis for the weak isospin conjugation conservation and color charge conjugation conservation proposed in Section 3.

5. Conclusion

This paper explores the relationship between C, P, T transformations and their related continuity transformations, and discovers their connections in phase space, space, and time transformations. Thus, the study of CPT conservation will be expanded to the study of its corresponding continuity transformation. Studying the intrinsic relationship between the continuity transformations corresponding to the conservation of CPT in the context of uncertainty, it was found that there is evidence of an intrinsic relationship between charge, weak isospin, and color charge. From this, it can be imagined that a conservation of CPT and weak isospin, color charge joint symmetry. This paper only proves theoretically that there is a certain connection between CPT conservation, weak isospin

DOI: 10.54254/2753-8818/9/20240773

conjugation conservation, and color charge conjugation conservation, logically extending this more complex conservation without further practical formula derivation and experimental verification.

References

[1] Greaves, H. and Thomas, T. (2014/04/20). The CPT theorem. PT, CPT, and Charge Conjugation, 10-12.
[2] Koranga, B. S. and Kumar, S. (2013/07/01). CPT Violation in Neutrino Oscillation and Matter Effects Numerical Results, 2612-2613.
[3] Cembranos, J. A. R. (2013/03/01). CPT analysis with top physics Hadronic colliders, 40-41.
[4] Wang, S. Zhao, Z. C. (2020/11/08). Tests of CPT invariance in gravitational waves with LIGO-Virgo catalog GWTC-1 Theory, 2-3.
[5] Lehnert, R. (2009/09/01). CPT and Lorentz-invariance violation. Experimental tests of Lorentz and CPT symmetry, 278-280.
[6] Chatterjee, A. Gandhi, R. Singh, J. (2014/06/09). Probing Lorentz and CPT violation in a magnetized iron detector using atmospheric neutrinos. Numerical procedure, 8-10.
[7] Wu, C. S. and Ambler, E. and Hayward, R. W. and Hoppes, D. D. and Hudson, R. P. (1957/1/15). Experimental Test of Parity Conservation in Beta Decay. 1413-1414.
[8] Christenson, J. H. and Cronin, J. W. and Fitch, V. L. and Turlay, R. (1964/7/10). Evidence for the 2π Decay of the K_2^0 Meson. 139-140.
[9] Uffink, J. B. M. and Hilgevoord, J. (1985/09/01). Uncertainty principle and uncertainty relations The Double-slit Experiment, 938-939.
[10] Leggett, A. J. (2006). Quantum Liquids: Bose Condensationand Cooper Pairing in Condensed-Matter Systems. Oxford University Press: New York, 223-227.