Preset boundary conditions and the possibility of making time crystals

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Using the quaternion algebraic tools widely used at the end of the 19th century, we deduce a novel theory of space-time unity that can enhance the theories of special relativity and general relativity.When the preset boundary condition-the ratio of the temperature of the two systems is a complex number, then the entropy can be constructed into the ring structure of the algebraic system, and the entropy and the time dimension are in the same direction, then it is possible to construct a time crystal.

Keywords: quaternion, kerr blackhole,time crystal

1. INTRODUCTION

The time crystal is an open system that maintains an unbalanced state with the surrounding environment, showing the characteristics of breaking the symmetry of time translation. A scientific report in March 2017 pointed out that this theoretical concept has been experimentally confirmed; as time goes by, the time crystal still cannot reach thermal equilibrium with the environment.

The concept of time crystals was first proposed by Nobel Prize winner Frank Wilseck in 2012. Compared with ordinary crystals that repeat periodically in space, time crystals repeat periodically in time, showing the state of perpetual motion machines. The time crystal has a spontaneous symmetry breaking phenomenon in the time translation symmetry. Time crystals are also related to zero-point energy and dynamic Casimir effects.

In 2016, the Department of Physics, University of California, Berkeley, Yao Ying (English: Norman Y. Yao) and colleagues proposed a blueprint for building time crystals in the laboratory; this blueprint was subsequently adopted by two groups including Christopher Monroe and the University of Maryland . Mikhail Lukin of Harvard University, both teams successfully created time crystals. The results of the experiment were published in the journal Nature in March 2017.

Conventional crystals are three-dimensional objects in which atoms are arranged repeatedly in a regular manner. Time crystals are crystals with more than four dimensions and have a periodic structure of time and space. Time crystals can spontaneously destroy the symmetry of time translation and perform non-translational movement in space. The composition of time crystals is composed of non-localized particles and interrelated motions in "space". It is the "extra dimension" of energy-saving particles that transcends "fixedness". The energy and momentum of the domain space and the existence of time crystals also reveal the meaning of the existence of "super extra dimensions".

It will change over time, but it will continue to return to its original shape, just as the hands of a clock periodically return to their original positions. Unlike ordinary clocks or other periodic processes, time crystals and space crystals have the least energy. You can think of it as a clock that can keep the time accurate forever, even after the universe heats to death.

We switched from quaternion algebra to quaternion calculus by introducing an appropriate form of quaternion gradient operator. We apply this differentiation process to the general quaternion potential to derive the unified form of the force field and Maxwell's equations. New components in the interaction of electromagnetic and gravitational forces may lead to exciting new discoveries of physical phenomena.

Therefore, using the quaternion algebraic tools widely used at the end of the 19th century, we deduce a novel theory of space-time unity that can enhance the theories of special relativity and general relativity.

When the preset boundary condition-the ratio of the temperature of the two systems is a complex number, then the entropy can be constructed into the ring structure of the algebraic system, and the entropy and the time dimension are in the same direction, then it is possible to construct a time crystal.

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2. THE POSSIBILITY OF TIME CRYSTALS

We make a hypothesis:Thermodynamic phase transition. - The state equation of a charged AdS black hole displays a vdW-like thermodynamic behavior. The SBH-LBH coexistence curve has a parametric form [1]

$$\frac{P}{P_c} = \sum_i a_i \left(\frac{T}{T_c}\right)^i. \tag{1}$$

The concept of entropy was proposed by the German physicist Clausius in 1865. Kjeldahl defines the increase and decrease of entropy in a thermodynamic system: the total amount of heat used at a constant temperature in a reversible process, and can be expressed as:

$$\Delta S = \frac{\Delta Q}{T} \tag{2}$$

if$\frac{T}{T_c} = z$,when z is plural. The Laurent series of the function f(z) with respect to point c is given by:

$$f(z) = \sum_{n=-\infty}^{\infty} a_n (z-c)^n \tag{3}$$

It is defined by the following curve integral, which is a generalization of the Cauchy integral formula:

$$a_n = \frac{1}{2\pi i} \oint_\gamma \frac{f(z)dz}{(z-c)^{n+1}} \tag{4}$$

Since the algebra of real quaternions is the only fourdimensional division algebra, we introduce the fourdimensional quaternion manifold,[2]

$$\tau^4 = (\hat{\tau}_0, \vec{\tau}_1, \vec{\tau}_2, \vec{\tau}_3) = (\hat{\imath}_0\tau_0, \vec{\imath}_1\tau_1, \vec{\imath}_2\tau_2, \vec{\imath}_3\tau_3) \tag{5}$$

$$\begin{cases} \hat{\imath}_0\hat{\imath}_0 = \hat{\imath}_0 = 1 \\ \vec{\imath}_1\vec{\imath}_1 = \vec{\imath}_2\vec{\imath}_2 = \vec{\imath}_3\vec{\imath}_3 = \vec{\imath}_1\vec{\imath}_2\vec{\imath}_3 = -\hat{\imath}_0 = -1 \\ \overrightarrow{\imath_1}\,\overrightarrow{\imath_2} = \overrightarrow{\imath_3}, \quad \overrightarrow{\imath_2}\,\overrightarrow{\imath_3} = \overrightarrow{\imath_1}, \quad \overrightarrow{\imath_3}\,\overrightarrow{\imath_1} = \overrightarrow{\imath_2}, \\ \overrightarrow{\imath_2}\,\overrightarrow{\imath_1} = -\overrightarrow{\imath_3}, \quad \overrightarrow{\imath_3}\,\overrightarrow{\imath_2} = -\vec{\imath}_1, \quad \vec{\imath}_1\overrightarrow{\imath_3} = -\overrightarrow{\imath_2} \end{cases} \tag{6}$$

$$\boldsymbol{t} = \left(\hat{\imath}_0 t_0, \vec{\imath}_1\frac{x_1}{c}, \vec{\imath}_2\frac{x_2}{c}, \vec{\imath}_3\frac{x_3}{c}\right) \tag{7}$$

$$\begin{cases} t = t\left(\frac{t_0}{t}, \frac{\vec{v}}{c}\right) = t(\cos\theta, \vec{\imath}\sin\theta) = t\exp(\vec{\imath}\theta) \\ \bar{t} = t\left(\frac{t_0}{t}, -\frac{\vec{v}}{c}\right) = t(\cos\theta, -\vec{\imath}\sin\theta) = t\exp(-\vec{\imath}\theta) \end{cases} \tag{8}$$

$$\begin{cases} t = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}\exp(\vec{\imath}\theta) \\ \bar{t} = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}\exp(-\vec{\imath}\theta) \end{cases} \tag{9}$$

3. TIME-CRYSTAL, ACTION PATH TO KERR BLACK HOLE

We will prove that the Hawking radiation of the Kerr black hole can be understood as the flux that offsets the gravitational anomaly. The key is that near the horizon, the scalar field theory in the spacetime of a 4-dimensional Kerr black hole can be simplified to a 2-dimensional field theory. Since space-time is not spherically symmetric, this is an unexpected result.

In Boyer-Linquist coordinates, Kerr metric reads[3]

$$\begin{aligned} ds^2 = &-\frac{\Delta - a^2\sin^2\theta}{\Sigma}dt^2 - 2a\sin^2\theta\frac{r^2+a^2-\Delta}{\Sigma}dtd\phi \\ &+\frac{\left(r^2+a^2\right)^2 - \Delta a^2\sin^2\theta}{\Sigma}\sin^2\theta d\phi^2 + \frac{\Sigma}{\Delta}dr^2 + \Sigma d\theta^2 \end{aligned} \tag{10}$$

$$\Sigma=r^2+a^2\cos^2\theta,\Delta=r^2-2Mr+a^2=(r-r_+)(r-r_-)\,. \tag{11}$$

The action for the scalar field in the Kerr spacetime is

$$\begin{aligned}
S[\varphi]=&\frac{1}{2}\int d^4x\sqrt{-g}\varphi\nabla^2\varphi\\
=&\frac{1}{2}\int d^4x\sqrt{-g}\varphi\frac{1}{\Sigma}\left[-\left(\frac{\left(r^2+a^2\right)^2}{\Delta}-a^2\sin^2\theta\right)\partial_t^2\right.\\
&-\frac{2a\left(r^2+a^2-\Delta\right)}{\Delta}\partial_t\partial_\phi+\left(\frac{1}{\sin^2\theta}-\frac{a^2}{\Delta}\right)\partial_\phi^2\\
&\left.+\partial_r\Delta\partial_r+\frac{1}{\sin\theta}\partial_\theta\sin\theta\partial_\theta\right]\varphi
\end{aligned} \tag{12}$$

Taking the limit r $\rightarrow$ r+ and leaving the dominant terms, we have

$$\begin{aligned}
S[\varphi]=&\frac{1}{2}\int d^4x\sin\theta\varphi\left[-\frac{\left(r_+^2+a^2\right)^2}{\Delta}\partial_t^2\right.\\
&\left.-\frac{2a\left(r_+^2+a^2\right)}{\Delta}\partial_t\partial_\phi-\frac{a^2}{\Delta}\partial_\phi^2+\partial_r\Delta\partial_r\right]\varphi
\end{aligned} \tag{13}$$

Now we transform the coordinates to the locally non-rotating coordinate system by

$$\left\{\begin{array}{l}\psi=\phi-\Omega_Ht\\ \xi=t\end{array}\right. \tag{14}$$

where

$$\Omega_H\equiv\frac{a}{r_+^2+a^2}. \tag{15}$$

We can rewrite the action

$$S[\varphi]=\frac{a}{2\Omega_H}\int d^4x\sin\theta\varphi\left(-\frac{1}{f(r)}\partial_\xi^2+\partial_rf(r)\partial_r\right)\varphi \tag{16}$$

We know that when $\sin\theta=0$, the pull equation for action can conform to the above form, but the boundary becomes 0. However, if the boundary conditions are preset, the boundary conditions$\frac{T}{T_c}=z$ act as $\sin\theta$,The effective action form satisfies the effective action form of Hawking radiation, and is not necessarily at the boundary of event horizon. When the boundary condition is preset, a new path is obtained

$$S[z,\varphi]=\frac{a}{2\Omega_H}\int d^4xze^z\varphi\left(-\frac{1}{f(r)}\partial_\xi^2+\partial_rf(r)\partial_r\right)\varphi. \tag{17}$$

4. SUMMARY

In this paper, when the preset boundary condition-the ratio of the temperature of the two systems is a complex number, the entropy can be constructed into the ring structure of an algebraic system, and the entropy is in the same direction as the time dimension, then a time crystal can be constructed.

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