Fermions can also produce super-radiation phenomena

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According to traditional theory, the Fermions does not produce super radiation. If the boundary conditions are set in advance, the possibility is combined with the wave function of the coupling of the Fermions and Fermions can also produce super-radiation phenomena. This article proposes a new possibility that Fermions can produce superradiation phenomena. It implies that super radiation and boundary conditions have a broader research space.

Keywords: Fermions, superradiance, Wronskian determinant

I. INTRODUCTION

In quantum optics, superradiation is a phenomenon that occurs when a group of N emitters (such as excited atoms) interact with a common light field. If the wavelength of the light is much greater than the distance between the emitters, the emitters will interact with the light in a collective and coherent manner, causing the group to emit light with high intensity pulses. This is a surprising result, completely different from the expected exponential decay for a set of independent atoms (see spontaneous emission). Since then, super radiation has been demonstrated in various physical and chemical systems, such as quantum dot arrays and aggregates. This effect has recently been used to produce superradiative lasers.

Rotating superradiation is related to the acceleration or movement of nearby objects (the object provides energy and momentum for this). It is sometimes described as the result of the "effective" field difference around the body (for example, the effect of tidal forces). Even if no obvious classical mechanism occurs, this allows objects with angular momentum or linear momentum concentration to move to a lower energy state. In this sense, this effect has some similarities with quantum tunneling (for example, although there is no obvious classical mechanism, waves and particles "find a way" to take advantage of the tendency of energy potential).

In classical physics, it is usually expected that the movement or rotation of an object in a granular medium will cause momentum and energy to be transferred to the surrounding particles. Therefore, as the trajectory moves, it implies the statistical possibility of the particle removed from the particle. Momentum from the body. In quantum mechanics, the principle extends to the case where an object moves, accelerates, or rotates in a vacuum—in the case of quantum, it is said that quantum fluctuations with appropriate vectors are stretched and distorted, and energy and momentum are provided by the motion of nearby objects. Through this selective amplification, real physical radiation is generated around the human body.

The classical description of a rotating isolated weightless ball in a vacuum tends to say that due to the lack of

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frictional effects or any other form of apparent coupling with a smooth empty environment, the ball will continue to rotate infinitely under quantum mechanics. The area around the vacuum is not completely smooth, and the field of the sphere couples with quantum fluctuations and accelerates them to produce real radiation. The imaginary virtual wavefront has a proper path around the human body, and will be stimulated and amplified into a real physical wavefront through the coupling process. The description sometimes refers to the effects of these fluctuations “ticking”.

In the theoretical study of black holes, this effect is sometimes described as the result of the gravitational and tidal forces surrounding the strong gravitational body pulling the virtual particle pairs apart. Otherwise, these virtual particle pairs will quickly annihilate each other, thus in the area outside the black hole. Produce a large number of real particles horizon.

A black hole bomb is an exponentially increasing instability in the interaction between a huge boson field and a rotating black hole.

In astrophysics, a potential example of superradiation is Zeldovich radiation. The first to describe this effect in 1971 was Yakov Zel’dovich, and Igor Novikov of Moscow University further developed this theory. Yakov Borisovich Zel’dovich chose a case in Quantum Electrodynamics ("QED"), in which the region around the equator of a rotating metal ball is expected to throw away electromagnetic radiation tangentially, and proposed a rotation of gravitational mass Situations such as the Kerr black hole should produce a similar coupling effect and should radiate in a similar way.

This is followed by the argument of Stephen Hawking et al. that accelerating observers near the black hole (for example, the observer carefully lowering to the horizon at the end of the rope) should see that the area is occupied by "real" radiation, while far away At the same time, the observer can say that this radiation is "virtual." If an accelerating observer near the event horizon captures nearby particles and throws them to a distant observer for capture and research, then for a distant observer, the appearance of the particle can be explained by the following way: the physical acceleration of the particle It has been turned from virtual particles to "real" particles. And we know that black holes need to meet one condition for classical superradiation instability:

The incident perturbation field is the Bose field;

Among it is the condition for generating super radiation. In 1972, Press and Teukolsky[14] proposed that It is possible to add a mirror to the outside of a black hole to make a black hole bomb (according to the current explanation, this is a scattering process involving classical mechanics and quantum mechanics[1, 3, 10–13, 15]).Regge and Wheeler proved that the spherically symmetric Schwarzschild black hole is stable under disturbance. Due to the significant influence of super radiation, the stability of rotating black holes is more complicated. Superradiation effects can occur in classical and quantum scattering processes. When a boson wave hits a rotating black hole, if certain conditions are met, the black hole may be as stable as a Schwarzschild black hole. When a boson wave hits a rotating black hole, if the frequency range of the wave is under superradiation conditions, the wave reflected by the event horizon will be amplified.

Associate Professor Hasegawa Yuji of the Vienna University of Technology and Professor Masaaki Ozawa of Nagoya University and other scholars published empirical results against Heisenberg’s uncertainty principle on January 15, 2012[9]. They used two instruments to measure the rotation angle of the neutron and calculated it. The error of the measurement results obtained was smaller than the Heisenberg uncertainty principle, thus proving the measurement results advocated by the Heisenberg uncertainty principle. The restriction is wrong. However, the uncertainty principle
is still correct, because this is the inherent quantum property of particles.

In the article[7] follows the method I used to study superradiation and connects the uncertainty principle with the superradiation effect. I found that under the superradiation effect, the measurement limit of the uncertainty principle can be smaller. From that article, we can know that if the boundary conditions are not preset, then for the incident interference of the black hole and the coupling wave function of the black hole, the probability flow density equation is equal on both sides. However, if the boundary conditions of the incident Fermions are set in advance, then the two sides of the probability flow density equation are not equal, because setting the boundary conditions implies a certain probability. According to the traditional theory, the fermions does not produce superradiation. And if the boundary conditions are preset, the probability of generation is combined with the wave function of the fermions coupling, and fermions can produce superradiation phenomenon.

II. FERMIonic SCATTERING

Now[2] let us consider the Dirac equation for a spin-$\frac{1}{2}$ massless fermion $\Psi$, minimally coupled to the same EM potential $A_\mu$ as in Eq.  

$$\gamma^\mu \Psi_{,\mu} = 0,$$  \hspace{1cm}  (1)

where $\gamma^\mu$ are the four Dirac matrices satisfying the anticommutation relation $\{\gamma^\mu, \gamma^\nu\} = 2g^{\mu\nu}$. The solution to takes the form $\Psi = e^{-i\omega t} \chi(x)$, where $\chi$ is a two-spinor given by

$$\chi = \begin{pmatrix} f_1(x) \\ f_2(x) \end{pmatrix}. \hspace{1cm} (2)$$

Using the representation

$$\gamma^0 = \begin{pmatrix} i & 0 \\ 0 & -i \end{pmatrix}, \quad \gamma^1 = \begin{pmatrix} 0 & i \\ -i & 0 \end{pmatrix},$$  \hspace{1cm}  (3)

the functions $f_1$ and $f_2$ satisfy the system of equations:

$$df_1/dx - i(\omega - eA_0)f_2 = 0, \quad df_2/dx - i(\omega - eA_0)f_1 = 0.$$  \hspace{1cm}  (4)

One set of solutions can be once more formed by the ‘in’ modes, representing a flux of particles coming from $x \to -\infty$ being partially reflected (with reflection amplitude $|R|^2$) and partially transmitted at the barrier

$$\left(f_1^{in}, f_2^{in}\right) = \left(\mathcal{I}e^{i\omega x} - \mathcal{R}e^{-i\omega x}, \mathcal{I}e^{i\omega x} + \mathcal{R}e^{-i\omega x}\right) \quad \text{as} \quad x \to -\infty$$  \hspace{1cm}  (5)

$$\left(\mathcal{T}e^{ikx}, \mathcal{T}e^{ikx}\right) \quad \text{as} \quad x \to +\infty$$  \hspace{1cm}  (6)

On the other hand, the conserved current associated with the Dirac equation is given by $j^\mu = -e\Psi^\dagger \gamma^0 \gamma^\mu \Psi$ and, by equating the latter at $x \to -\infty$ and $x \to +\infty$, we find some general relations between the reflection and the transmission coefficients, in particular,

$$|R|^2 = |\mathcal{I}|^2 - |\mathcal{T}|^2.$$  \hspace{1cm}  (7)
Therefore, $|R|^2 \leq |I|^2$ for any frequency, showing that there is no superradiance for fermions. The same kind of relation can be found for massive fields.

The reflection coefficient and transmission coefficient depend on the specific shape of the potential $A_0$. However one can easily show that the Wronskian

$$W = \tilde{f}_1 \frac{d\tilde{f}_2}{dx} - \tilde{f}_2 \frac{d\tilde{f}_1}{dx},$$

(8)

between two independent solutions, $\tilde{f}_1$ and $\tilde{f}_2$, is conserved. From the equation on the other hand, if $f$ is a solution then its complex conjugate $f^*$ is another linearly independent solution. We find $|R|^2 = |I|^2 - \frac{\omega - eV}{\omega} |T|^2$. Thus, for $0 < \omega < eV$, it is possible to have superradiant amplification of the reflected current, i.e., $|R| > |I|$. There are other potentials that can be completely resolved, which can also show superradiation explicitly.

The difference between fermions and bosons comes from the intrinsic properties of these two kinds of particles. Fermions have positive definite current densities and bounded transmission amplitudes $0 \leq |T|^2 \leq |I|^2$, while for bosons the current density can change its sign as it is partially transmitted and the transmission amplitude can be negative, $-\infty < \frac{\omega - eV}{\omega} |T|^2 \leq |I|^2$. From the point of view of quantum field theory, due to the existence of strong electromagnetic fields, one can understand this process as a spontaneous pair generation phenomenon (see for example). The number of spontaneously produced iron ion pairs in a given state is limited by the Poly’s exclusion principle, while bosons do not have this limitation.

We can pre-set the boundary conditions $eA_0(x) = -y\omega$ (which can be $\mu = -y\omega$)\[4][5][6][8], and we see that when $y$ is relatively large (according to the properties of the Fermions, $y$ can be very large), $|R|^2 \leq |I|^2$ may not hold. In the end, we can get $\Delta x \Delta p \geq 1/2$ may not hold (in natural unit system). If the boundary conditions of the incident Fermions are set in advance, the two sides of the probability flow density equation are not equal, because setting the boundary conditions implies a certain probability.

### III. FERMIONS CAN ALSO PRODUCE SUPER-RADIATION PHENOMENA

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### IV. SUMMARY

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