Grasp the New Image of the Spin Angular Momentum

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This paper presents a new image of the angular momentum of electrons that could not have clear images until now. As the movement of electrons is similar to a Slinky, we would proceed with a discussion following the movement of the Slinky. Then, the influence of the spin angular momentum due to the magnetic field gradient would be in the slinky motion which travels down the stairway inclined toward the advancing direction. Using the contents of the paper of the previous work, we extend the model to a particle which makes a single virtual photon oscillate at a linear motion toward one direction moving. All the mass energy of electrons is thermal potential energy, and particles having this energy are spinor particles. This particle emits all the energy by radiation and the total released energy is absorbed by the paired spinor particles. This transfer of energy radiation is done by a virtual photon enveloping spinor particles. Assuming that one electron particle composite composed of these three particles, 1) Emitter, 2) Absorber and 3) Transmitter, the electron could be discretely moved like Slinky.

I. INTRODUCTION

Studying about quantum spin has made remarkable progress in the past 100 years. So far the spin angular momentum has been explained using the concept of rigid bodies particle or wave concept. However, the electron has no magnitude in the elementary particle model; hence the particle with no magnitude of radius must have an infinite rotation speed in order to have angular momentum.

In 1922, Otto Stern and Walter Gerlach demonstrated and measured the magnetic moment of the silver atom[1]. The rotation of the electron, which is the idea that Ralph Kronig conceived at 1295, never was announced as a thesis because Pauli ridiculed the idea of spin. Several months after this incident, the paper on the image of the spin was in public by in lieu of Uhlenbeck and Goudsmit.

In this way, it has been difficult to have an image of angular momentum of spinors on the point that if the electrons were rigid, or if an electron were waves. In this study, we shall have the image of angular momentum without having the image that a rigid rotator turns around an axis. At least two mass points would be required for that. Fortunately, in the previous study, we have created the model in which one electron would be consisted of three particles, and try to have the image using this model.

By transferring thermal potential energy between bare electrons by absorbing and radiating, electrons with constant linear motion move discretely with focusing on bare electrons' behavior. This movement could be compared to the movement of Slinky. The Slinky is a toy that can be played in various forms. When the Slinky moves down the stairs, it takes with a tricky rhythm. With this image in mind, we would imagine the Slinky which is shifting to the right end and the left end of the stairs gradually. That shifting in two directions would have a similarity to the beam of silver atoms passed through a magnetic field due to up and down angular momentum in the Stern-Gerlach experiment.

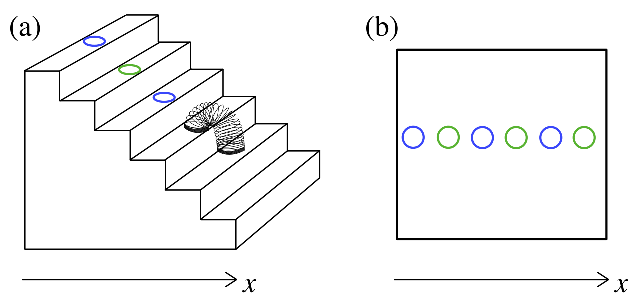

FIG. 1. (a) A state where the Slinky which painted blue and green on both sides of spring moves stairs. (b) The footprints of the Slinky that saw the stairs from directly above.

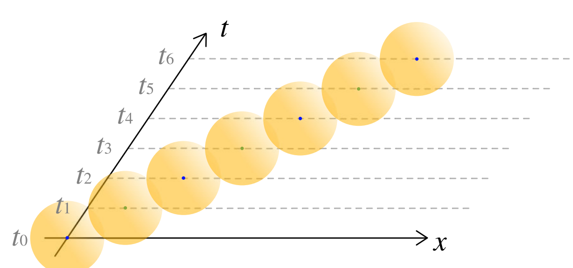

FIG. 2. Modified image of an electron in this study with moving along with one direction on axis x. During time t_n to t_{n+1}, this electron travels a distance r.

II. METHODS

A. Extension of the electronic model

In the previous paper, we created the model in which discretely existing bare electrons reciprocate between at

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location $x = a$ and $x = -a$ as a simple vibration. These bare electron on the two locations were indicated by the following equations respectively:

$$T_{\rm e1} = \int_{\rm all\ space} E_0 \cos^4\left(\frac{\omega t}{2}\right)\ \delta(x-a)dx\ , \qquad \text{(II.1)}$$

$$T_{\rm e2} = \int_{\rm all\ space} E_0 \sin^4\left(\frac{\omega t}{2}\right)\ \delta(x+a)dx\ . \qquad \text{(II.2)}$$

These two delta functions were derived by the V. Eq. V.1 in the previous study [2]. These equations provided to obtain the original image that two particles change the value of its thermal potential energy due to the time change by the fourth power of cosine and sine at the fixed positions.

By this modeling, we have had the image that one electron has bare electrons with potential energy and a virtual photon with kinetic energy surrounding it. Also, in this model thermal potential energy as a thermal spot could exist discretely. It is because the virtual photon conveys the energy exchange between discretely existing thermal potential energy by radiation.

Indeed, the model has to be developed with more realistic manner. In this study, we modified the bare electrons that had been reciprocating to a model that proceeded in one direction. These bare electrons do not necessarily have to go back and forth as the oscillator between the same positions $x = a$ and $x = -a$.

Figure 2 shows, the electron that was at the origin at time t_0 moves to distance r_1 at time t_1.

We modified Eqs. (II.1 and II.2) as follows:

$$T_{\rm e1} = \int_{\rm all\ space} E_0 \cos^4\left(\frac{\omega t_{e1}}{2}\right)\ \delta(z-2nr)dx \qquad \text{(II.3)}$$
$$(\omega t_{e1} = 2n\pi : n = 0, 1, 2, 3...)\ ,$$

$$T_{\rm e2} = \int_{\rm all\ space} E_0 \sin^4\left(\frac{\omega t_{e2}}{2}\right)\ \delta(z-r(2n+1))dz$$
$$(\omega t_{e2} = (2n+1)\pi : n = 0, 1, 2, 3...)\ . \qquad \text{(II.4)}$$

At time t_n, electrons are represented by the position of electrons in Eq. III.2 when the integer n is an even number , and the positions of electrons are expressed in the Eq. II.4 when the integer n is an odd number as well.

The fact that the time n is represented by integer expresses the discrete movement of electrons. According to the previous study, the state of electrons between time t_n and time t_{n+1} has bare electrons both at position x_n and x_{n+1}. For example, between time t_2 and t_3, there are two thermal spots as bare electrons in both x_2 and x_3, and the state of each thermal spot is different. The bare electron at x_2 radiate their thermal potential energy through the virtual photon and the bare electron at x_3 receive that thermal potential energy from x_2.

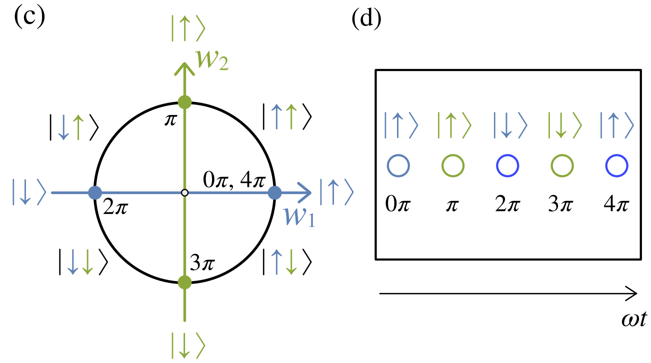

FIG. 3. (c) Appearance of one-state spin and two-state of superposition alternately on an electron's phase. (d)A diagram corresponding Slinky's footprints to the phase on (c).

B. Bare electron's discretely behavior and Slinky's movement

A Slinky® is the helpful toy to image the movement of discrete bare electrons as in the previous subsection.

Let us imagine, applying blue and green paint on both sides of the spring for observing the movement of Slinky's moving on the wooden board with tilting slope or at stairs somewhere. Then, the following pattern is printed on the wooden board by blue and green paint alternatively in Fig. 1.

In a previous study[2], we devised the model in which two spinor oscillators as bare electrons are contained in one electron, and they are spinning based on the principle of superposition. The state change due to the electron's phase was as shown in Fig. 3(c). According to this study, we could apply the blue footprints of Slinky corresponds to Eq. (II.1), and the green footprints corresponds to Eq. (II.2) respectively.

Next, let us correspond the footprints to the phase of the electron. The appearance of the two bare electrons as shown in Fig. 3(d) is corresponding to the footprints of the stairs Fig. 1(b).

The Slinky is placed vertically on the stairs with no elongation of its spring in the phase of $0\pi, \pi, 2\pi, 3\pi, 4\pi....$ That is, the kinetic energy of the spring at the moment is valued zero. In this state is consistent with the previous study that zero kinetic energy of the virtual photons permit carrying kinetic energy in phases $n\pi$ (n is an integer).

III. DISCUSSION

A. Discrete moving objects and angular momentum

In the previous section, electrons having a linear motion with one-way velocity progressed to have the image

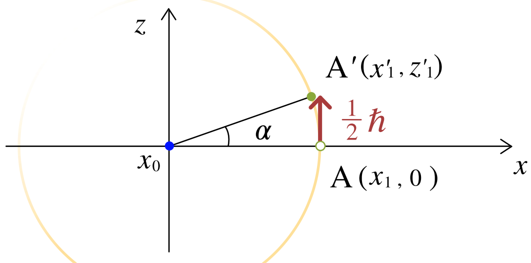

FIG. 4. The electron position x_0 at $t = 0$ (blue dot), the electron spreading to the Compton wavelength (yellow circle), and where the absorbed bare electrons in absorption phase on A′ at the point in time of $\omega t = \pi$. The green dot, A′(x_1', z_1') are affected by the angular momentum.

that how electrons move linearly with taking discrete positions. While keeping the experiment of Stern-Gerlach experiment in mind, we have a discussion of modifying the electron model with spin angular momentum added.

Put the electron at the origin in x-z plane as shown in Fig. 4. Suppose that the electron is moving uniformly accelerated linear motion. The image that this electron moves linearly and discretely along the x-axis direction is caused by as follows. Namely, the bare electrons placed at the origin at $x = x_0$ initially at time $t_0 = 0$ is radiating its potential thermal energy along with its phase. Then, another new bare electron would emerge at the next point of destination at $x = x_1$ in which was absorbing the origin of thermal potential energy instantly.

The length from the origin of the bare electron at $x = x_0$ to the next moving point $x = x_1$ was assumed as the radius of the virtual photon spreading to the Compton wavelength. This was assumed in the previous study[2].

Therefore, the position of bare electrons or the center position of electrons at time t_1 of the phase $\omega t_1 = \pi$ shall be expressed by the following equation.

$$x_1' = \int_{-\infty}^{\infty} E_0 \cos^4\left(\frac{\omega t_1}{2}\right)\ \delta(x - r\cos\alpha)dx\ , \qquad \text{(III.1)}$$

$$z_1' = \int_{-\infty}^{\infty} E_0 \cos^4\left(\frac{\omega t_1}{2}\right)\ \delta(z - r\sin\alpha)dz\ . \qquad \text{(III.2)}$$

where r is the radius of the virtual photon. This is equal to the coordinate of point A′ in Fig. 4. Incidentally, the former study had assumed that $E_0 = h\nu$ is total energy of the electron in the isolated system. In this modification, the system had to extend the premise from the restriction of the isolated system. Without considering a relativistic effect in here, the mass increase of the electron could use the previous study's insights. That is, we assumed that the virtual photon has all the kinetic energy existed within one electron, but the bare electrons could not have the kinetic energy by the assumption. Hence, the locus of the electron could be considered to summation as the kinetic energy of the virtual photon increases.

B. Behavior of electrons in accordance with kinetic energy increases and decreases

In this subsection, consider the two case of electrons' orbits which were passing through the magnetic field gradient.

In the image of classical mechanics, the angular momentum increases when the rotation radius decreases under the condition that the torque of the same condition works. This can be explained by Spinning figure skaters spreading and shrinking their arms. This phenomenon would be explained by replacing it with this electronic model.

As the movement speed of the electron increases, the kinetic energy of the electron increases. And the Compton wavelength becomes shorter according to the speed. The shortening of the Compton wavelength means that the radius of the virtual photon surrounding bare electrons would be shortened in this electronic model. Because we assumed that bare electrons are surrounded by virtual photons with Compton wavelength radius in the previous study shown in V. Appendix.

Figure 5 shows the image of electrons with two different Compton wavelengths. Figure 6 illustrates how the two electrons with radii of different virtual photons. In other words, the two electrons with different kinetic energies traverse under the influence of the magnetic field gradient drawing an orbit.

The point to pay attention in this electron model to here is that, a rigid rotator likes rotating turntable or skating player do not physically rotate due to receiving momentum. We regarded bare electrons as thermal spots with no size of radius. When the thermal spot as located in a certain location moves, when it emits its energy and then an absorber would emerge at the certain point which affected the spin angular momentum. It seems that the point is undergoing rotational moment.

In other words, it becomes easy to understand if you have the image as follows; imagine a stairway that is tilted in a perpendicular direction to the direction of travel. Let us place the Slinky on the top of the stairs, and move Slinky on this inclined staircase. Then the Slinky move to the right or left gradually with respect to the direction of travel. The state of the electrons depicting such two kinds of trajectories is depicted in Fig 7.

That is, the magnetic field gradient corresponds to the inclination of the stairway inclined at right angles to this traveling direction. Also, it corresponds to the radius of the virtual photon assuming that the interval of each step of the staircase corresponds to the Compton wavelength. Electrons which move at low velocity are images of Slinky descending a gentle staircase. However, electrons which move at high velocity electrons are images of the Slinky descending a steep stairway. Indeed, the Slinky descending steeply has a fast-downward speed.

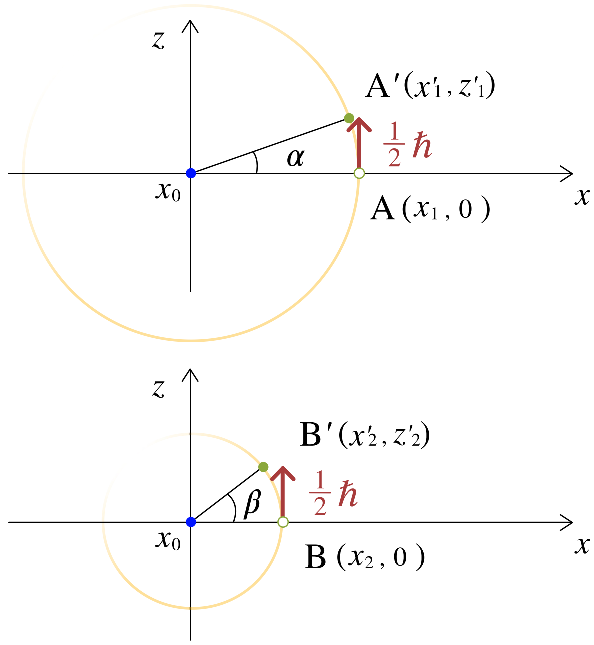

FIG. 5. Place shown the difference where bare electrons are generated as an absorber (green dot) in bare electron as emitter (blue dot) with two different length of its radiation as Compton wavelengths.

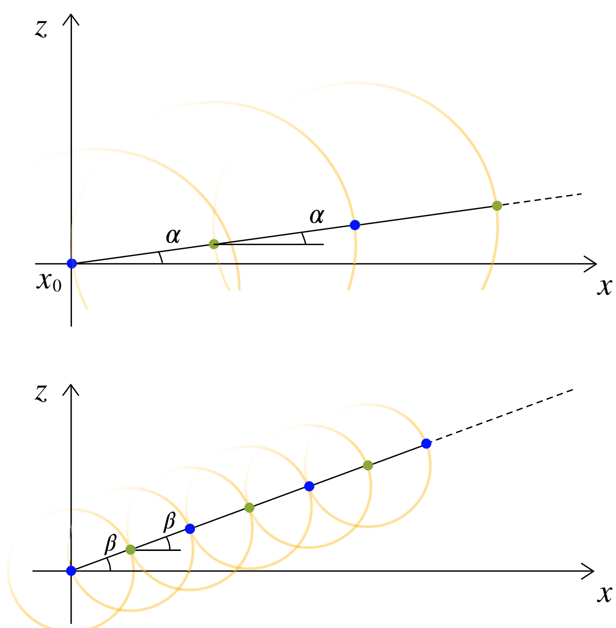

FIG. 6. Differences in the two electrons' orbit. These two figures illustrate the difference in orbits that electrons with different radius undergo the same spin angular momentum. The thermal potential energy as mass of electrons would be transmitted by radiation between blue dots and green dots.

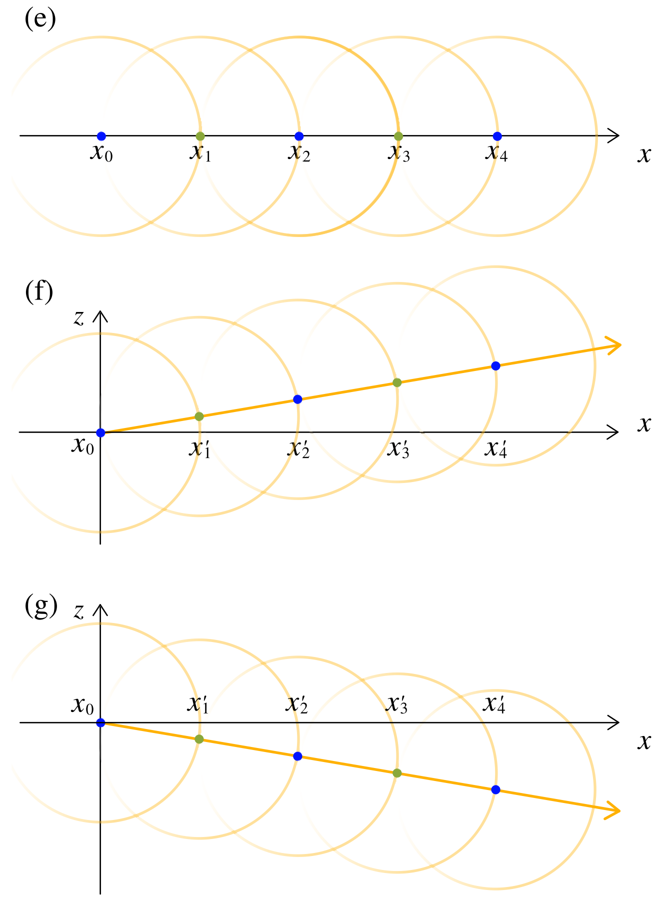

FIG. 7. (e) Linear motion of electrons when not receiving spin angular momentum. (f) The movement of electrons when the upward spin angular momentum works. (g) The movement of electrons when the downward spin angular momentum works as well.

IV. CONCLUSION

Based on the contents examined based on figures so far, it would be successful to have the image of the spin angular momentum that we had never had before. The behavior of bare electrons moving as thermal spots are similar to behavior of the Slinky. The toy takes discrete positions when descending the stairs and moved to a fixed direction.

The magnetic field gradient corresponded to the slope of the child stairway inclined perpendicularly to the direction of ascending and descending the stairs.

Furthermore, the simple vibration of the spring of Slinky which transposes energy to another discrete place could compare to the radiation of thermal energy from the emitter to the absorber that we studied previous paper[2].

Two spinors in one electron particle are classified into a spinor which emit thermal potential energy and a spinor which absorbs the thermal potential energy. The point at which the absorber emerged varies with the kinetic energy of electrons. This variation depends on the Compton wavelength assumed that it has the value equal to the radius of the virtual photon surrounding the electron. Taking these behaviors into the action of Slinky, the point where the spring lands newly would be equal to the point of occurrence of the absorber. This phenomenon would be similar to the step-wise movement taken by the Slinky.

The kinetic energy possessed by the Slinky spring closely resembles the process of mediating the virtual photon. In the previous study, the difference between the value of radiation energy emitted by the emitter and the energy absorbed by the absorber was equal to the kinetic energy of the virtual photon. At the initial phase (0π to $1/2\pi$) of the electron model shown in V. Fig. 9, the energy released from the emitter would be divided into the thermal potential energy absorbed by the absorber and the kinetic energy absorbed by the virtual photon. The sum of these two types of energies would resemble the transfer of the potential energy and the kinetic energy from coil to coil as the Slinky moves down the steps.

In this paper, the primary purpose is to have how to obtain an objective image with affection from spin angular momentum. Therefore, we extended the model with a limitation only to the image from in which the simple oscillating of bare electrons to in which move the electron linearly, compared to the previous study. However, the mechanism of the spin determination either up or down uniquely was not discussed in this paper. Even though, these images cultivated in this research would be useful to refine a model which shall be needed henceforth.

[1] Gerlach, W. and Stern, O. Der experimentelle Nachweis der Richtungsquantelung im Magnetfeld. Z. Phys. 9, 349352 (1922)

[2] S. Hanamura. A Model of an Electron Including Two Perfect Black Bodies, viXra:1811.0312 , (2018)

V. APPENDIX

In this study, one electron particle has been modified as shown in Fig. 8.

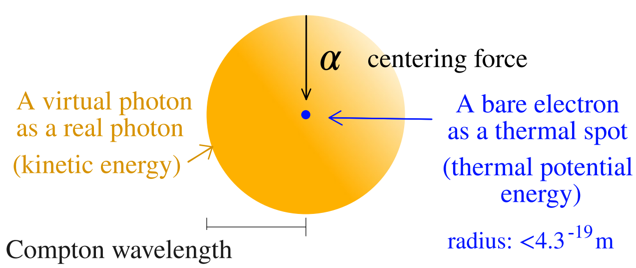

FIG. 8. The electron model modified.

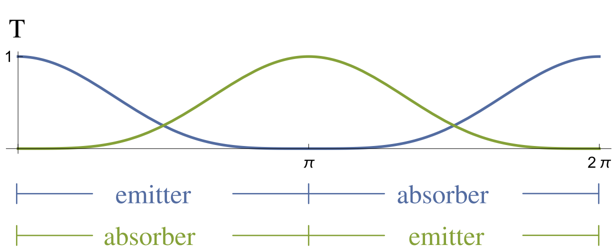

FIG. 9. Plots of $T_{e1} = E_0 \cos^4(\frac{\omega t}{2})$ (blue) and $T_{e2} = E_0 \sin^4(\frac{\omega t}{2})$ (green) with $E_0 = 1$.

In our previous work, we have created an expression of conservation of energy consisting of three transducers, with keeping in mind the formula that one single oscillator preserves kinetic energy and potential energy. The formula is;

$$E_0 = E_0 \left(\frac{1}{2} \sin^2(\omega t) + \cos^4\left(\frac{\omega t}{2}\right) + \sin^4\left(\frac{\omega t}{2}\right) \right) . \tag{V.1}$$

where E_0 is the initial totally energy of the one electron particle. We obtain the following oscillators:

$$(Oscillator\ 1) : \gamma^*_{\text{K.E.}} \equiv \frac{1}{2} E_0 \sin^2(\omega t) , \tag{V.2}$$

$$(Oscillator\ 2) : T'_{\text{T.P.E.}} \equiv E_0 \cos^4\left(\frac{\omega t}{2}\right) , \tag{V.3}$$

$$(Oscillator\ 3) : T''_{\text{T.P.E.}} \equiv E_0 \cos^4\left(\frac{\omega t}{2}\right) . \tag{V.4}$$

where $\gamma^*_{\text{K.E.}}$ as constant is the kinetic energy of the virtual photon as vector particle. $\gamma^*_{\text{K.E.}}$ could be the transmitter of the thermal potential energy by changing it to kinetic energy. Similarly, T$'$ and T$''$ are bare electrons as two spinors. They could be the emitter and absorber. T.P.E. is stands for the thermal potential energy of the electron. FIG. 9 shows how value of the thermal potential energy fluctuate when the oscillator 2 and the oscillator 3 change its phase from the emitter to the absorber alternately. The reason why the value increases or decreases in the Fig. 9 is that the energy of the electron's mass repeatedly increase and decrease as radiation and absorption via thermal energy by themselves.

For the grounds that these three particles work in combination and the virtual photon moves in a simple oscillation, please refer the paper [2]. Fig. 8 and Fig. 9 have quoted by the paper as well.