MATTER: International Journal of Science and Technology
ISSN 2454-5880

Takashi Kato, 2015

Volume 1 Issue 1, pp. 12-57

Year of Publication: 2015

DOI- http://dx.doi.org/10.20319/mijst.2015.11.1257

This paper can be cited as: Kato, T., (2015). Relationships between the normal and supercurrents in the various sized materials, MATTER: International Journal of Science and Technology, 1(1), 12-57.

RELATIONSHIPS BETWEEN THE NORMAL AND SUPERCURRENTS IN THE VARIOUS SIZED MATERIALS

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Abstract

In the previous works [1-7], we suggested that in the materials with large HOMO-LUMO gaps, the Cooper pairs are formed by the large HOMO-LUMO gaps as a consequence of the quantization of the orbitals by nature, and by the attractive Coulomb interactions between two electrons with opposite momentum and spins occupying the same orbitals via the positively charged nuclei. We also suggest the reasonable mechanism of the occurrence of granular high temperature superconductivity in the graphite powder treated by water or exposed to the hydrogen plasma, discovered by Esquinazi et al. (Scheike et. al; 2012), on the basis of our previous theoretical works described above [1-7], which can be well confirmed by the recent experimental work (Wehlitz et. al; 2012). We also suggest the general guiding principle towards high temperature superconductivity. On the basis of these previous studies, we compare the normal metallic states with the superconducting states. Furthermore, in this article, we elucidate the mechanism of the Faraday's law (experimental rule discovered in 1834) in normal metallic states and the Meissner effects (discovered in 1933) in superconductivity, on the basis of the theory suggested in our previous researches. Because of the very large stabilization energy of about 35 eV for the Bose–Einstein condensation, the Faraday's law, Ampère's law, and the Meissner effects can be observed.

Index Terms

Faraday's Law, A Bosonic Electron, Electromotive Force, Meissner Effect, Normal Metals

1. Introduction

In modern physics and chemistry, the effect of electron–phonon interactions [1–7] in molecules and crystals has been an important topic. In the Bardeen–Cooper–Schrieffer (BCS) theory of superconductivity [8, 9], electron–phonon coupling [1–7] is the consensus mechanism for attractive electron–electron interactions. On the other hand, the macroscopic sized room-temperature has not yet been discovered even though many researchers have tried to realize the occurrence of high-temperature superconductivity for more than 100 years.

Related to seeking for the room-temperature superconductivity, in this article, we compare the normal metallic states with the superconducting states. In superconductivity, two electrons behave only as a Bose particle. On the other hand, in the normal metallic states, an electron behaves as bosonic as well as fermionic under the applied external magnetic or electric field.

According to the Lenz's law, the magnetic field would penetrate into the sample completely even below T_C since the magnetic field does not change during temperature decreasing process. On the other hand, it has been well known that the magnetic field cannot penetrate into the sample at all well below T_C, according to the Meissner effect. At this time, this phenomenon does not obey the Lenz's law. That is, even in superconductivity, the electronic properties usually obey the Lenz's law, on the other hand, sometimes do not obey the Lenz's law. This is because the Meissner effect can be always dominantly applied even in the case where the electronic states cannot obey the Lenz's law. That is, since the discovery of the Meissner effect, it has been considered that the superconductivity as well as the normal metallic states basically obey the Lenz's law, on the other hand, if there is discrepancy between the Lenz's law and the Meissner effect, the Meissner effect can be considered to be more dominant than the Lenz's law in superconductivity. The Meissner effect is independent basic property and cannot be derived from the zero resistivity. This means that the Meissner effect is more essential than the Lenz's law, and the Lenz's law should be explained in terms of more fundamental Meissner effects in the normal metallic states as well as in the superconducting states. In other words, the observation of the Lenz's law is considered as a special case of the Meissner effect in the normal metallic states. That is, the unified interpretation between the Lenz's law and the Meissner effect, that is, between the normal metallic states and superconducting states has not been completely established. Therefore, we try to establish the unified interpretations between them.

Furthermore, in this article, we elucidate the mechanism of the Faraday's law (experimental rule discovered in 1834) in normal metallic states and the Meissner effects (discovered in 1933) in superconductivity, on the basis of the theory suggested in our previous researches.

I. THE ORIGIN OF THE FARADAY'S LAW

A. Theoretical Background

The wave function for an electron occupying the highest occupied crystal orbital (HOCO) in a material under the external applied field ($x_{\mathrm{in}} = B_{\mathrm{in}}$ or E_{in}) can be expressed as

$$\begin{aligned}
&\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((B_{\mathrm{out}}, B_{\mathrm{in}}); (E_{\mathrm{out}}, E_{\mathrm{in}}); B_{\boldsymbol{k}_{\mathrm{HOCO}}}; I_{\boldsymbol{k}_{\mathrm{HOCO}}}\right)\right\rangle \\
&= \sqrt{P_{\mathrm{ground}}(T)}\left|\boldsymbol{k}_{\mathrm{HOCO,\,ground},0}(x_{\mathrm{in}})\right\rangle \\
&+ \sqrt{P_{\mathrm{excited}}(T)}\left|\boldsymbol{k}_{\mathrm{HOCO,excited},0}(x_{\mathrm{in}})\right\rangle, \qquad (1)
\end{aligned}$$

where

$$\begin{aligned}
&\left|\boldsymbol{k}_{\mathrm{HOCO,excited},0}(x_{\mathrm{in}})\right\rangle \\
&= c_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(x_{\mathrm{in}})\left|+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow\right\rangle \\
&+ c_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(x_{\mathrm{in}})\left|-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow\right\rangle. \qquad (2)
\end{aligned}$$

$$\begin{aligned}
&\left|\boldsymbol{k}_{\mathrm{HOCO,ground},0}(x_{\mathrm{in}})\right\rangle \\
&= c_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(x_{\mathrm{in}})\left|-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow\right\rangle \\
&+ c_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(x_{\mathrm{in}})\left|+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow\right\rangle. \qquad (3)
\end{aligned}$$

$$P_{\mathrm{ground}}(T) + P_{\mathrm{excited}}(T) = 1, \qquad (4)$$

$$c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(x_{\mathrm{in}}) + c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0,0}(x_{\mathrm{in}}) = 1, \qquad (5)$$

$$c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(x_{\mathrm{in}}) + c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(x_{\mathrm{in}}) = 1, \qquad (6)$$

The magnetic field ($B_{\boldsymbol{k}_{\mathrm{HOCO}}}(x_{\mathrm{out}}, x_{\mathrm{in}})(= B_{\mathrm{in}})$) at the condition of the external applied field x_{out} and the field felt by an electron x_{in} can be expressed as

$$B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(x_{\mathrm{out}}, x_{\mathrm{in}}\right)$$
$$= B_{\boldsymbol{k}_{\mathrm{HOCO}}\uparrow}\left(x_{\mathrm{out}}, x_{\mathrm{in}}\right) - B_{\boldsymbol{k}_{\mathrm{HOCO}}\downarrow}\left(x_{\mathrm{out}}, x_{\mathrm{in}}\right), \qquad (7)$$

where

$$B_{\boldsymbol{k}_{\mathrm{HOCO}}\uparrow}\left(x_{\mathrm{out}}, x_{\mathrm{in}}\right)$$
$$= P_{\mathrm{excited}}(T)\, c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow, x_{\mathrm{in}}}\left(x_{\mathrm{out}} - x_{\mathrm{in}}\right)$$
$$+ P_{\mathrm{ground}}(T)\, c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow, x_{\mathrm{in}}}\left(x_{\mathrm{out}} - x_{\mathrm{in}}\right), \qquad (8)$$

$$B_{\boldsymbol{k}_{\mathrm{HOCO}}\downarrow}\left(x_{\mathrm{out}}, x_{\mathrm{in}}\right)$$
$$= P_{\mathrm{excited}}(T)\, c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow, x_{\mathrm{in}}}\left(x_{\mathrm{out}} - x_{\mathrm{in}}\right)$$
$$+ P_{\mathrm{ground}}(T)\, c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow, x_{\mathrm{in}}}\left(x_{\mathrm{out}} - x_{\mathrm{in}}\right). \qquad (9)$$

The electric field ($I_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(x_{\mathrm{out}}, x_{\mathrm{in}}\right)\left(= E_{\mathrm{in}}\right)$) at the condition of the external applied field x_{out} and the field felt by an electron x_{in} can be expressed as

$$I_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(x_{\mathrm{out}}, x_{\mathrm{in}}\right)$$
$$= I_{+\boldsymbol{k}_{\mathrm{HOCO}}}\left(x_{\mathrm{out}}, x_{\mathrm{in}}\right) - I_{-\boldsymbol{k}_{\mathrm{HOCO}}}\left(x_{\mathrm{out}}, x_{\mathrm{in}}\right), \qquad (10)$$

$$I_{+\boldsymbol{k}_{\mathrm{HOCO}}}\left(x_{\mathrm{out}}, x_{\mathrm{in}}\right)$$
$$= P_{\mathrm{excited}}(T)\, c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow, x_{\mathrm{in}}}\left(x_{\mathrm{out}} - x_{\mathrm{in}}\right)$$
$$+ P_{\mathrm{ground}}(T)\, c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow, x_{\mathrm{in}}}\left(x_{\mathrm{out}} - x_{\mathrm{in}}\right), \qquad (11)$$

$$I_{-\boldsymbol{k}_{\mathrm{HOCO}}}\left(x_{\mathrm{out}}, x_{\mathrm{in}}\right)$$
$$= P_{\mathrm{excited}}(T)\, c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow, x_{\mathrm{in}}}\left(x_{\mathrm{out}} - x_{\mathrm{in}}\right)$$
$$+ P_{\mathrm{ground}}(T)\, c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow, x_{\mathrm{in}}}\left(x_{\mathrm{out}} - x_{\mathrm{in}}\right). \qquad (12)$$

Let us look into the energy levels for various electronic states when the applied field increases from 0 to x_{out} at 0 K in superconductor, in which the HOCO is partially occupied by an electron. The stabilization energy as a consequence of the electron–phonon interactions can be expressed as

$$E_{\text{SC,electronic}}(x_{\text{out}}, x_{\text{in}}) - E_{\text{NM,electronic}}(0,0) = -2V_{\text{one}} f_{\text{Bose},\,0}(x_{\text{in}}), \quad (13)$$

Where the $-2V_{\text{one}}$ denotes the stabilization energy for the electron–phonon coupling interactions between an electron occupying the HOCO and the vibronically active modes [1–7] (Fig. 1).

The $f_{\text{Bose},\,\Delta E_{\text{unit}}}(0)$ denotes the ratio of the bosonic property under the internal field x_{in} ($c_{+\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(x_{\text{in}}) = c_{+\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(x_{\text{in}}) = c_{+\boldsymbol{k}_{\text{HOCO}},0}(x_{\text{in}})$ and $c_{-\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(x_{\text{in}}) = c_{-\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(x_{\text{in}}) = c_{-\boldsymbol{k}_{\text{HOCO}},0}(x_{\text{in}})$), and can be estimated as

$$f_{\text{Bose},\,0}(x_{\text{in}}) = \frac{1}{2} + c_{-\boldsymbol{k}_{\text{HOCO}},0}(x_{\text{in}})\sqrt{1 - c^2_{-\boldsymbol{k}_{\text{HOCO}},0}(x_{\text{in}})}. \quad (14)$$

The $f_{\text{Bose},\,\Delta B_{\text{unit}}}(0)$ denotes the ratio of the bosonic property under the internal field x_{in} ($c_{+\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(x_{\text{in}}) = c_{-\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(x_{\text{in}}) = c_{\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(x_{\text{in}})$ and $c_{+\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(x_{\text{in}}) = c_{-\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(x_{\text{in}}) = c_{\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(x_{\text{in}})$), and can be estimated as

$$f_{\text{Bose},0}(x_{\text{in}}) = \frac{1}{2} + c_{\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(x_{\text{in}})\sqrt{1 - c^2_{\boldsymbol{k}_{\text{HOCO}}\downarrow,0,}(x_{\text{in}})}. \quad (15)$$

B. *New Interpretation of the Faraday's Law in the Normal Metallic States*

Let us next apply the Higgs mechanism to the Faraday's law in the normal metallic states. Let us next consider the superconductor, the critical magnetic field of which is B_c. Below T_C, the bosonic Cooper pairs are in the superconducting states. We consider the case where the

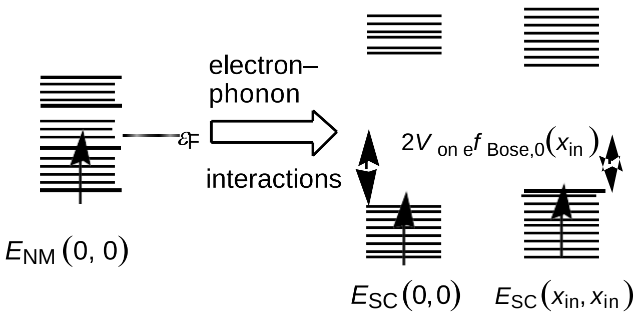

Fig. 1. Stabilization energy as a cons equence of the electron–phonon interactions as a function of the external applied field.

HOCO is partially occupied by an electron. We consider that the magnetic field is quantized by $\Delta B_{\text{unit}}(= B_c / n_c)$. The n_c value is very large and the quantization value of B_c / n_c is very small ($B_c / n_c \approx 0$) (Fig. 2). That is, the jth quantized magnetic field B_j with respect to the zero magnetic field can be defined as

$$B_j = j\Delta B_{\text{unit}} \tag{16}$$

The ratio of the bosonic property under the internal magnetic field B_{excited} with respect to the ground state for the magnetic field B_γ ($B_{\text{in}} = B_\gamma + B_{\text{excited}}$) can be denoted as $f_{\text{Bose},\, B_\gamma}(B_{\text{excited}})$. In particular, the ratio of the bosonic property under the internal magnetic field B_{in} with respect to the ground state for the zero magnetic field can be denoted as $f_{\text{Bose},\,0}(B_{\text{in}})$ .We define the electronic $\boldsymbol{k}_{\text{HOCO}}(T)\left((B_{\text{out}}, B_{\text{in}}); (E_{\text{out}}, E_{\text{in}}); B_{\boldsymbol{k}_{\text{HOCO}}}; I_{\boldsymbol{k}_{\text{HOCO}}}\right)$ state, where the E_{out} denotes the induced electric field applied to the specimen, the E_{in} the induced electric field felt by the electron, the $B_{\boldsymbol{k}_{\text{HOCO}}}$ the induced magnetic moment from the electron (the induced magnetic field $B_{\text{induced},\boldsymbol{k}_{\text{HOCO}}}$ or the change of the spin magnetic moment of an electron $\sigma_{\text{spin},\boldsymbol{k}_{\text{HOCO}}}$ from the each ground state), and the $I_{\boldsymbol{k}_{\text{HOCO}}}$ the induced electric moment of an electron (canonical electric momentum $\boldsymbol{p}_{\text{canonical},\boldsymbol{k}_{\text{HOCO}}}$ or the electric momentum of an electron $\boldsymbol{v}_{\text{em},\boldsymbol{k}_{\text{HOCO}}}$). Without any external applied magnetic field ($j = 0$; $B_{\text{out}} = B_{\text{in}} = 0$), the ratio of the bosonic property under the internal magnetic field 0 can be estimated to be $f_{\text{Bose},\,0}(0) = 1$. Therefore, the electronic state pairing of an electron behaves as a boson,

$$f_{\text{Bose},0}(0) = 1 \tag{17}$$

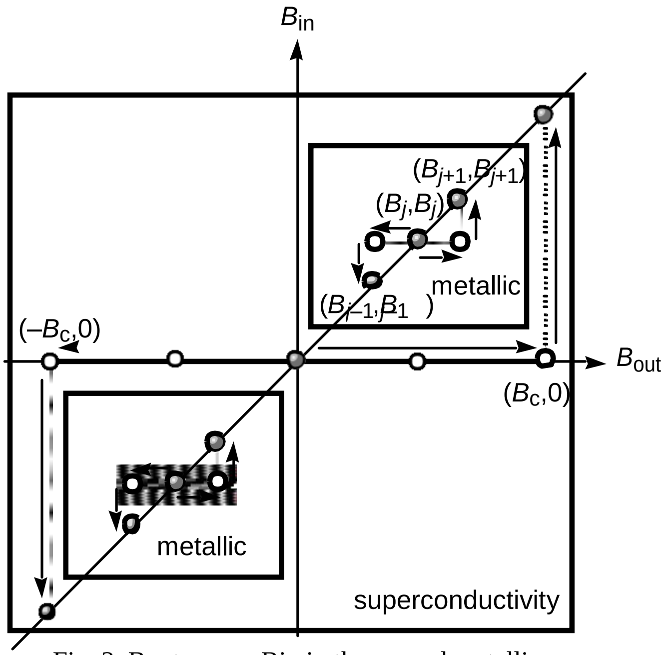

Fig. 2. Bout versus Bin in the normal metallic and superconducting states

In such a case ($c_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(0)= c_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(0)= c_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(0) = c_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(0)= 1/\sqrt{2}$), there is no induced current and the magnetic fields, as expected,

$$\begin{aligned}
&B_{\boldsymbol{k}_{\mathrm{HOCO}}}(0,0) = B_{\boldsymbol{k}_{\mathrm{HOCO}}\uparrow}(0,0) - B_{\boldsymbol{k}_{\mathrm{HOCO}}\downarrow}(0,0)\\
&= \left\{P_{\mathrm{excited}}(T)c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(0) + P_{\mathrm{ground}}(T)c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(0)\right.\\
&-\left\{P_{\mathrm{excited}}(T)c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(0) + P_{\mathrm{ground}}(T)c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(0)\right.\\
&= 0, \qquad (18)
\end{aligned}$$

$$\begin{aligned}
&I_{\boldsymbol{k}_{\mathrm{HOCO}}}(0,0) = I_{+\boldsymbol{k}_{\mathrm{HOCO}}}(0,0) - I_{-\boldsymbol{k}_{\mathrm{HOCO}}}(0,0)\\
&= \left\{P_{\mathrm{excited}}(T)c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(0) + P_{\mathrm{ground}}(T)c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(0)\right.\\
&-\left\{P_{\mathrm{excited}}(T)c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(0) + P_{\mathrm{ground}}(T)c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(0)\right.\\
&= 0. \qquad (19)
\end{aligned}$$

This can be in agreement with the fact that charges at rest feel no magnetic forces and create no magnetic fields. This is the bosonic ground normal metallic state for $j = 0$ ($\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$) (Figs. 3 and 4 (a)). It should be noted that the electronic states are in the ground normal metallic states when all the $\boldsymbol{p}_{\mathrm{canonica}}$, $\boldsymbol{v}_{\mathrm{em}}$, σ_{spin}, and B_{induce} values are 0 ($\boldsymbol{p}_{\mathrm{canonical}} = 0$, $\boldsymbol{v}_{\mathrm{em}} = 0$, $\sigma_{\mathrm{spin}} = 0$, and $B_{\mathrm{induced}} = 0$), and the are in the excited normal metallic states when the $\boldsymbol{p}_{\mathrm{canonica}}$, $\boldsymbol{v}_{\mathrm{em}}$, σ_{spin}, or B_{induce} values are not 0 ($\boldsymbol{p}_{\mathrm{canonical}} \neq 0$, $\boldsymbol{v}_{\mathrm{em}} \neq 0$, $\sigma_{\mathrm{spin}} \neq 0$, or $B_{\mathrm{induced}} \neq 0$).

Let us next consider the case where the applied magnetic field (B_{out}) increases from 0 to ΔB_{unit} (Fig. 3). Soon after the external magnetic field is applied, the momentum of the electronic state pairing of an electron cannot be changed but the electromotive force can be induced, because of the Nambu–Goldstone boson formed by the fluctuation of the bosonic electronic state pairing of an electron $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$. In such a case, the $B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(\Delta B_{\mathrm{unit}},0\right)$ and $I_{\boldsymbol{k}}\left(\Delta B_{\mathrm{unit}},0\right)_{\mathrm{HOCO}}$ values for the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);0;0\right)\right\rangle$ state can be estimated as

$$
\begin{aligned}
B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(\Delta B_{\mathrm{unit}},0\right) = \Big\{ & P_{\mathrm{excited}}(T)c^{2}_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}\left(\Delta B_{\mathrm{unit}}\right) \\
& + P_{\mathrm{ground}}(T)c^{2}_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}\left(\Delta B_{\mathrm{unit}}\right) \\
& - \Big\{ P_{\mathrm{excited}}(T)c^{2}_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}\left(\Delta B_{\mathrm{unit}}\right) \\
& + P_{\mathrm{ground}}(T)c^{2}_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}\left(\Delta B_{\mathrm{unit}}\right) \\
& = 0, \qquad (20)
\end{aligned}
$$

and thus

$$
\begin{aligned}
I_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(\Delta B_{\mathrm{unit}},0\right) = \Big\{ & P_{\mathrm{excited}}(T)c^{2}_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}\left(\Delta B_{\mathrm{unit}}\right) \\
& + P_{\mathrm{ground}}(T)c^{2}_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}\left(\Delta B_{\mathrm{unit}}\right) \\
& - \Big\{ P_{\mathrm{excited}}(T)c^{2}_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}\left(\Delta B_{\mathrm{unit}}\right) \\
& + P_{\mathrm{ground}}(T)c^{2}_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}\left(\Delta B_{\mathrm{unit}}\right) \\
& = 2P_{\mathrm{excited}}(T)\Big\{^{2}_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}\left(\Delta B_{\mathrm{unit}}\right)
\end{aligned}
$$

$$-c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(\Delta B_{\mathrm{unit}})\Big\}$$

$$= I_{\boldsymbol{k}_{\mathrm{HOCO}},\mathrm{emf}}(\Delta B_{\mathrm{unit}},0) = \Delta E_{\mathrm{unit}}. \quad (21)$$

Large Bose–Einstein condensation energy ($V_{\mathrm{kin,Fermi},\boldsymbol{k}_{\mathrm{HOCO}}}\sigma(0) \approx 35\,\mathrm{eV}$) may be related to the Newton's third law and the conventional principle that nature does not like the immediate change.

When the electromotive force ($I_{\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta B_{\mathrm{unit}}, 0) = \Delta E_{\mathrm{unit}}$) is induced, a Nambu–Goldstone boson formed by the fluctuation of the electronic state pairing of an electron $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);0;0)\right\rangle$ is absorbed by a photon (electric field) (Fig. 4 (b)). Therefore, a photon (electric field) has finite mass as a consequence of interaction with the Nambu–Goldstone boson formed by the fluctuation of the bosonic electronic state pairing of an electron. Soon after the external electric field is induced, the momentum of the bosonic electronic state pairing of an electron cannot be changed but the magnetic field can be induced. In such a case, the $I_{\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}}, 0)$ and $B_{\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}}, 0)$ values for the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);B_{\mathrm{induced}};0)\right\rangle$ state (Fig. 4 (c)) can be estimated as

$$\begin{aligned}
I_{\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},0) = \Big\{ & P_{\mathrm{excited}}(T)c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(\Delta E_{\mathrm{unit}}) \\
& + P_{\mathrm{ground}}(T)c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(\Delta E_{\mathrm{unit}}) \\
& - \Big\{P_{\mathrm{excited}}(T)c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(\Delta E_{\mathrm{unit}}) \\
& + P_{\mathrm{ground}}(T)c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(\Delta E_{\mathrm{unit}})\Big\} \\
& = 0, \qquad (22)
\end{aligned}$$

and thus

$$\begin{aligned}
B_{\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},0) = \Big\{ & P_{\mathrm{excited}}(T)c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(\Delta E_{\mathrm{unit}}) \\
& + P_{\mathrm{ground}}(T)c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(\Delta E_{\mathrm{unit}}) \\
& - \Big\{P_{\mathrm{excited}}(T)c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(\Delta E_{\mathrm{unit}}) \\
& + P_{\mathrm{ground}}(T)c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(\Delta E_{\mathrm{unit}})
\end{aligned}$$

$$= 2P_{\text{excited}}(T)\left\{c^2_{+\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(\Delta E_{\text{unit}})\right.$$

$$\left. - c^2_{-\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(\Delta E_{\text{unit}})\right\}$$

$$= B_{\text{induced},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, 0) = -\Delta B_{\text{unit}}. \qquad (23)$$

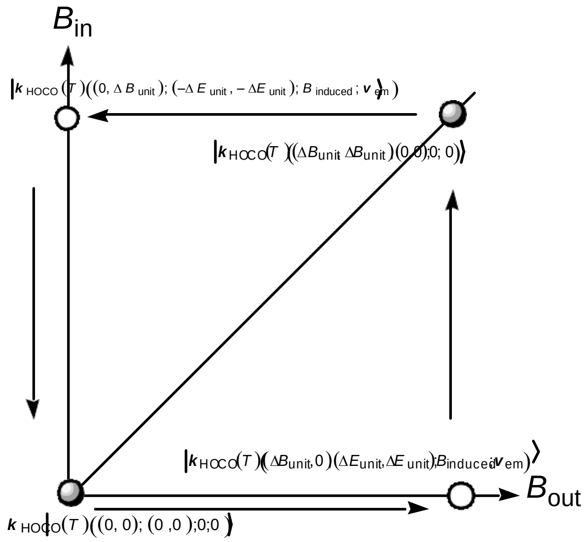

Fig. 3. The B_{in} versus B_{out} between $\gamma = 0$ and $\gamma = 1$

The induced magnetic field $B_{\text{induced},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, 0)$ expels the initially applied external magnetic field ΔB_{unit} from the normal metallic specimen (Fig. 4 (c)). Therefore, the induced magnetic field $B_{\text{induced},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, 0)$ is the origin

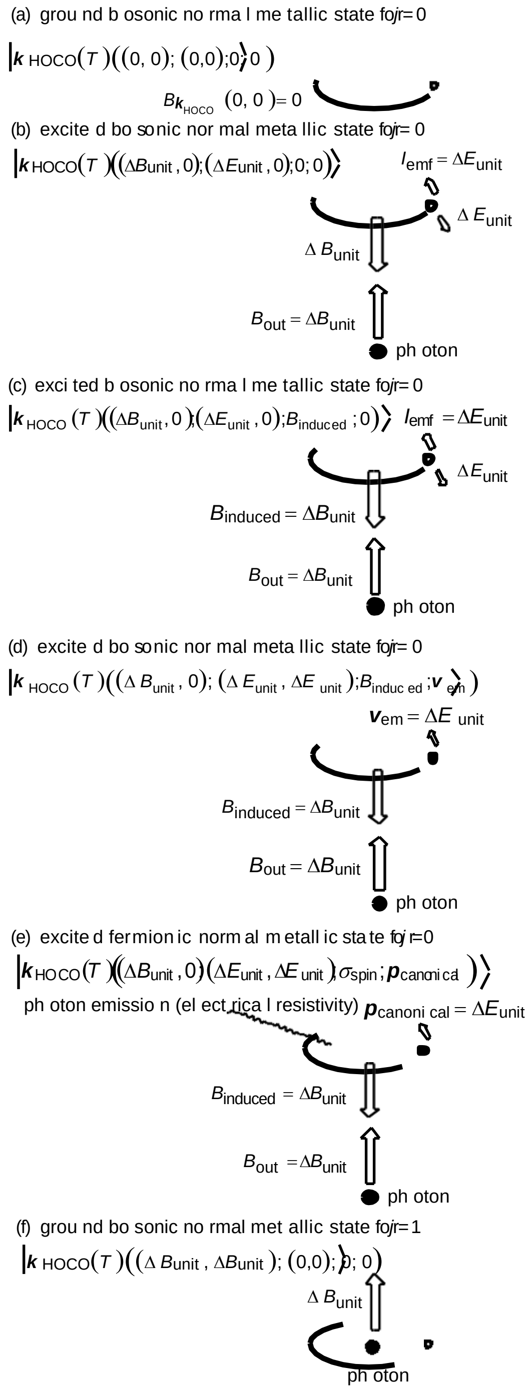

Fig. 4. The electronic s tates between j =0 and j = 1

of the Faraday's law in the normal metallic states and the Meissner effects in the superconducting states.

It should be noted that the magnetic field $B_{\mathrm{induced}}, \boldsymbol{k}_{\mathrm{HOCO}}(\Delta E_{\mathrm{unit}}, 0)(\neq 0)$ is induced but the spin magnetic moment of an electron with opened-shell electronic structure is not changed ($\sigma_{\mathrm{spin}} = 0$).This is very similar to the diamagnetic currents in the superconductivity in that the supercurrents are induced ($\boldsymbol{v}_{\mathrm{em}} \neq 0$) but the total canonical momentum is zero ($\boldsymbol{p}_{\mathrm{canonical}}= 0$). The magnetic field is induced not because of the change of each element of the spin magnetic moment σ_{spin} of an electron (similar to the $\boldsymbol{p}_{\mathrm{canonica}}$ in the superconducting states) but because of the change of the total magnetic momentum as a whole B_{induce} (similar to the $\boldsymbol{v}_{\mathrm{em}}$ in the superconducting states).

On the other hand, such excited bosonic electronic state pairing of an electron with the induced magnetic fields $|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);B_{\mathrm{induced}};0)\rangle$ can be immediately destroyed because the induced electric field penetrates into the normal metallic specimen, and the electronic state becomes another bosonic excited supercurrent state for $j=0$ ($|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}})\rangle$) (Fig. 4(d)). In the $|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}})\rangle$ state, an electron receives the electromotive force ΔE_{unit}, and thus the superconducting current can be induced, and thus there is kinetic energy ($E_{\mathrm{kinetic}}(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}})$) of the supercurrent. In such a case, the $B_{\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}})$ and $I_{\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}})$ values for the $|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}})\rangle$ state can be estimated as

$$
\begin{aligned}
B_{\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}}) &= B_{\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},0)\\
&= \{P_{\mathrm{excited}}(T)c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(\Delta E_{\mathrm{unit}})\\
&\quad + P_{\mathrm{ground}}(T)c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(\Delta E_{\mathrm{unit}})\\
&\quad - \{P_{\mathrm{excited}}(T)c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(\Delta E_{\mathrm{unit}})\\
&\quad + P_{\mathrm{ground}}(T)c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(\Delta E_{\mathrm{unit}})\\
&= 2P_{\mathrm{excited}}(T)\{c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(\Delta E_{\mathrm{unit}})\\
&\quad - c^2_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow,0}(\Delta E_{\mathrm{unit}})\\
&= B_{\mathrm{induced},\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},0) = -\Delta B_{\mathrm{unit}}, \qquad (24)
\end{aligned}
$$

$$
\begin{aligned}
I_{\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}}) &= I_{\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta B_{\mathrm{unit}},0)\\
&= \{P_{\mathrm{excited}}(T)c^2_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow,0}(\Delta B_{\mathrm{unit}})
\end{aligned}
$$

$$+ P_{\text{ground}}(T) c^2_{+\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(\Delta B_{\text{unit}})$$

$$- \{ P_{\text{excited}}(T) c^2_{-\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(\Delta B_{\text{unit}})$$

$$+ P_{\text{ground}}(T) c^2_{-\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(\Delta B_{\text{unit}})$$

$$= 2P_{\text{excited}}(T) \{ c^2_{+\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(\Delta B_{\text{unit}})$$

$$- c^2_{-\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(\Delta B_{\text{unit}}) \}$$

$$= \boldsymbol{v}_{\text{em},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}}) = \Delta E_{\text{unit}}. \quad (25)$$

That is, the energy of the electromotive force ΔE_{unit} for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},0);B_{\text{induced}};0)\right\rangle$ state is converted to the kinetic energy of the supercurrent for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}})\right\rangle$ state. Both the supercurrent ($\boldsymbol{v}_{\text{em},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}},\Delta E_{\text{unit}})$) and the magnetic field ($B_{\text{induced},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}},\Delta E_{\text{unit}})$) can be induced under the condition of the opened-shell electronic structure with zero spin magnetic momentum and canonical momentum ($\sigma_{\text{spin}} = 0$; $\boldsymbol{p}_{\text{canonical}} = 0$).

On the other hand, such excited bosonic normal metallic states with supercurrents ($\left|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}})\right\rangle$) can be immediately destroyed because of the unstable opened-shell electronic states subject to the external applied magnetic field, and the electronic state becomes another excited fermionic normal metallic states for $j = 0$ ($\left|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});\sigma_{\text{spin}};\boldsymbol{p}_{\text{canonical}})\right\rangle$) (Fig. 4 (e)). In such a case, the $B_{\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}},\Delta E_{\text{unit}})$ and $I_{\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}},\Delta E_{\text{unit}})$ values for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});\sigma_{\text{spin}};\boldsymbol{p}_{\text{canonical}})\right\rangle$ state can be estimated as

$$B_{\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}}) = B_{\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, 0)$$

$$= \{ P_{\text{excited}}(T) c^2_{+\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(\Delta E_{\text{unit}})$$

$$+ P_{\text{ground}}(T) c^2_{-\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(\Delta E_{\text{unit}})$$

$$- \{ P_{\text{excited}}(T) c^2_{-\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(\Delta E_{\text{unit}})$$

$$+ P_{\text{ground}}(T) c^2_{+\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(\Delta E_{\text{unit}})$$

$$= 2P_{\text{excited}}(T)\Big\{c^2_{+\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(\Delta E_{\text{unit}})$$

$$-c^2_{-\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(\Delta E_{\text{unit}})$$

$$= \sigma_{\text{spin},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}}) = -\Delta B_{\text{unit}}, \qquad (26)$$

$$I_{\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}}) = I_{\boldsymbol{k}_{\text{HOCO}}}(\Delta B_{\text{unit}}, 0)$$

$$= \Big\{P_{\text{excited}}(T) c^2_{+\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(\Delta B_{\text{unit}})$$

$$+ P_{\text{ground}}(T) c^2_{+\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(\Delta B_{\text{unit}})$$

$$- \Big\{P_{\text{excited}}(T) c^2_{-\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(\Delta B_{\text{unit}})$$

$$+ P_{\text{ground}}(T) c^2_{-\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(\Delta B_{\text{unit}})$$

$$= 2P_{\text{excited}}(T)\Big\{c^2_{+\boldsymbol{k}_{\text{HOCO}}\uparrow,0}(\Delta B_{\text{unit}})$$

$$-c^2_{-\boldsymbol{k}_{\text{HOCO}}\downarrow,0}(\Delta B_{\text{unit}})\Big\}$$

$$= \boldsymbol{p}_{\text{canonical},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}}) = \Delta E_{\text{unit}}. \; (27)$$

It should be noted that the electronic $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}}, 0); (\Delta E_{\text{unit}}, \Delta E_{\text{unit}}); \sigma_{\text{spin}}; \boldsymbol{p}_{\text{canonical}})\rangle$ state is now somewhat fermionic because the $\boldsymbol{p}_{\text{canonica}}$ value is not 0. In other words, the $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}}, 0); (\Delta E_{\text{unit}}, \Delta E_{\text{unit}}); \sigma_{\text{spin}}; \boldsymbol{p}_{\text{canonical}})\rangle$ state is closely related to the normal conducting states in that the normal metallic current with $\boldsymbol{p}_{\text{canonical}} \neq 0$ and $\boldsymbol{v}_{\text{em}} = 0$ is induced by the induced electromotive forces.

Such excited fermionic normal metallic states with currents and the induced magnetic field ($\boldsymbol{k}_{\text{HOCO}}$ $(|T)((\Delta B_{\text{unit}}, 0); (\Delta E_{\text{unit}}, \Delta E_{\text{unit}}); \sigma_{\text{spin}}; \boldsymbol{p}_{\text{canonical}})\rangle$) can be immediately destroyed because of the unstable opened-shell electronic states subject to the external applied magnetic field, and the induced current and the magnetic field can be immediately destroyed, and thus the initially external applied magnetic field can start to penetrate into the normal metallic specimen. Therefore, the electronic state tries to become another ground bosonic metallic state for $j = 1$ ($|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}}, \Delta B_{\text{unit}}); (0, 0); 0; 0)\rangle$) (Fig. 4 (f)). In such a case, the $B_{\boldsymbol{k}_{\text{HOCO}}}(\Delta B_{\text{unit}}, \Delta B_{\text{unit}})$ and $I_{\boldsymbol{k}_{\text{HOCO}}}(\Delta B_{\text{unit}}, \Delta B_{\text{unit}})$ values for the $\boldsymbol{k}_{\text{HO}}|\text{CO}(T)((\Delta B_{\text{unit}}, \Delta B_{\text{unit}}); (0, 0); 0; 0)\rangle$ state can be estimated as

$$\begin{aligned}
I_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(\Delta B_{\mathrm{unit}}, \Delta B_{\mathrm{unit}}\right) = &\left\{P_{\mathrm{excited}}(T) c^{2}_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow, \Delta B_{\mathrm{unit}}}(0)\right. \\
&+ P_{\mathrm{ground}}(T) c^{2}_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow, \Delta B_{\mathrm{unit}}}(0) \\
&- \left\{P_{\mathrm{excited}}(T) c^{2}_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow, \Delta B_{\mathrm{unit}}}(0)\right. \\
&+ P_{\mathrm{ground}}(T) c^{2}_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow, \Delta B_{\mathrm{unit}}}(0) \\
&= 0, \qquad (28)
\end{aligned}$$

and thus

$$\begin{aligned}
B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(\Delta B_{\mathrm{unit}}, \Delta B_{\mathrm{unit}}\right) = &\left\{P_{\mathrm{excited}}(T) c^{2}_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow, \Delta B_{\mathrm{unit}}}(0)\right. \\
&+ P_{\mathrm{ground}}(T) c^{2}_{-\boldsymbol{k}_{\mathrm{HOCO}}\uparrow, \Delta B_{\mathrm{unit}}}(0) \\
&- \left\{P_{\mathrm{excited}}(T) c^{2}_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow, \Delta B_{\mathrm{unit}}}(0)\right. \\
&+ P_{\mathrm{ground}}(T) c^{2}_{+\boldsymbol{k}_{\mathrm{HOCO}}\downarrow, \Delta B_{\mathrm{unit}}}(0) \\
&= 2P_{\mathrm{excited}}(T)\left\{c^{2}_{+\boldsymbol{k}_{\mathrm{HOCO}}\uparrow, \Delta E_{\mathrm{unit}}}(0)\right. \\
&\qquad - c^{2}_{-\boldsymbol{k}_{\mathrm{HOCO}}\downarrow, \Delta E_{\mathrm{unit}}}(0) \\
&= \sigma_{\mathrm{spin}, \boldsymbol{k}_{\mathrm{HOCO}}}\left(\Delta B_{\mathrm{unit}}, \Delta B_{\mathrm{unit}}\right) = \Delta B_{\mathrm{unit}}. \qquad (29)
\end{aligned}$$

It should be noted that the ground bosonic $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left(\left(\Delta B_{\mathrm{unit}}, \Delta B_{\mathrm{unit}}\right); (0,0); 0; 0\right)\right\rangle$ state is unstable with respect to the ground bosonic state for zero magnetic field $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((0,0); (0,0); 0; 0\right)\right\rangle$.

The $f_{\mathrm{Bose}, \Delta B_{\mathrm{unit}}}(0)$ value is smaller than the $f_{\mathrm{Bose},0}(0)$ value. It should be noted that the $f_{\mathrm{Bose}, B_{\mathrm{in}}}(0)$ value decreases with an increase in the $|B_{\mathrm{in}}|$ value. That is, the bosonic and fermionic properties decrease and increase with an increase in the $|B_{\mathrm{in}}|$ value, respectively. The London penetrating length $\lambda_{\mathrm{L}}\left(\Delta B_{\mathrm{unit}}, \Delta B_{\mathrm{unit}}\right)$ value and the mass of a photon $m_{\mathrm{photon}}\left(\Delta B_{\mathrm{unit}}, \Delta B_{\mathrm{unit}}\right)$ for the ground bosonic normal metallic $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left(\left(\Delta B_{\mathrm{unit}}, \Delta B_{\mathrm{unit}}\right); (0,0); 0; 0\right)\right\rangle$ state can be estimated to be $+\infty$ and 0, respectively. That is, a photon becomes massless at the ground bosonic electronic states ($\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left(\left(B_{\mathrm{in}}, B_{\mathrm{in}}\right); (0,0); 0; 0\right)\right\rangle$) under the magnetic field of $B_{\boldsymbol{k}_{\mathrm{HOCO}}}(B_{\mathrm{in}}, B_{\mathrm{in}})$, and thus the external applied magnetic field can penetrate into the normal metallic medium.

In summary, because of the very large stabilization energy ($V_{\mathrm{kin,\,Fermi},\boldsymbol{k}_{\mathrm{HOCO}}\sigma}(0) \approx 35$ eV) for the Bose–Einstein condensation ($\boldsymbol{p}_{\mathrm{canonical}}=0$; $V_{\mathrm{kin,Bose},\boldsymbol{k}_{\mathrm{HOCO}}\sigma}(0)=0$ eV), the magnetic momentum of an electron cannot be changed but electromotive force (ΔE_{unit}) can be induced soon after the external magnetic field is applied. This is the excited bosonic normal metallic state for $j=0$ ($\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);0;0\right)\right\rangle$). In such a case, the induced electric field as well as the applied external magnetic field is expelled from the normal metallic specimen. It should be noted that the electronic $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);0;0\right)\right\rangle$ state is still bosonic since the $\boldsymbol{p}_{\mathrm{canonica}}$ value is 0. The electric and magnetic momentum of a bosonic electronic state pairing of an electron cannot be changed but the magnetic field can be induced soon after the electromotive force is induced. Therefore, the electronic state becomes $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);B_{\mathrm{induced}};0\right)\right\rangle$ This is the origin of the Ampère's law. This induced magnetic field B_{induce} can expel the initially external applied magnetic field $B_{\mathrm{out}}(=\Delta B_{\mathrm{unit}})$ from the normal metallic specimen. That is, the B_{induce} and $B_{\mathrm{out}}(=\Delta B_{\mathrm{unit}})$ values are completely compensated by each other. This is the origin of the Lenz's law. On the other hand, such excited bosonic supercurrent states with the induced magnetic fields $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);B_{\mathrm{induced}};0\right)\right\rangle$ can be immediately destroyed because the induced electric field penetrates into the normal metallic specimen, and the electronic state becomes another bosonic excited supercurrent state for $j=0$ ($\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$). In the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ state, the supercurrent can be induced, and thus there is kinetic energy ($E_{\mathrm{kinetic}}(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}})$). This is the origin of the Faraday's law. That is, the energy of the electromotive force ΔE_{unit} for the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);B_{\mathrm{induced}};0\right)\right\rangle$ state is converted to the kinetic energy of the supercurrent for the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ state. Both the supercurrent ($\boldsymbol{v}_{\mathrm{em},\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}})$) and the magnetic field ($B_{\mathrm{induced},\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}})$) can be induced under the condition of the opened-shell electronic structure with zero spin magnetic momentum and canonical momentum ($\sigma_{\mathrm{spin}}=0$; $\boldsymbol{p}_{\mathrm{canonical}}=0$). This is the origin of the Faraday's and Ampère's law. Such excited bosonic states with supercurrents $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ can be immediately destroyed because of the unstable opened-shell electronic states, and the induced supercurrent can be immediately destroyed, and the electronic state becomes another excited fermionic normal metallic state for $j = 0$ ($\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}}, 0);(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}});\sigma_{\mathrm{spin}};\boldsymbol{p}_{\mathrm{canonical}}\right)\right\rangle$) (Fig. 1 (c)). The excited fermionic normal metallic $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}}, 0);(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}});\sigma_{\mathrm{spin}};\boldsymbol{p}_{\mathrm{canonical}}\right)\right\rangle$ state is very unstable and try to become another ground bosonic metallic state for $j = 1$, and the induced electrical current and the induced magnetic field can be immediately dissipated, and thus the initially applied external magnetic field can penetrate into the ground bosonic normal metallic state ($\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}}, \Delta B_{\mathrm{unit}});(0, 0); 0; 0\right)\right\rangle$) medium.

II. ENERGY LEVELS FOR VARIOUS ELECTRONIC STATES

Let us look into the energy levels for various electronic states when the applied magnetic field (B_{out}) increases from 0 to ΔB_{unit} at 0 K in superconductor, in which the HOCO is partially occupied by an electron. The total energy $E_{\mathrm{total}}(x_{\mathrm{out}}, x_{\mathrm{in}})$ for various electronic states with respect to the Fermi level before electron–phonon interactions at 0 K and $x_{\mathrm{out}} = x_{\mathrm{in}} = 0$ (Fig. 1) can be expressed as

$$
\begin{aligned}
&E_{\mathrm{total}}(x_{\mathrm{out}}, x_{\mathrm{in}}) = E_{\mathrm{SC}}(x_{\mathrm{out}}, x_{\mathrm{in}}) - E_{\mathrm{NM}}(0,0) \\
&= E_{\mathrm{electronic}}(x_{\mathrm{out}}, x_{\mathrm{in}}) + E_{\mathrm{magnetic}}(x_{\mathrm{out}}, x_{\mathrm{in}}). \qquad (30)
\end{aligned}
$$

At $B_{\mathrm{out}} = B_{\mathrm{in}} = 0$, the electronic state is in the ground normal metallic $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((0, 0);(0,0); 0; 0\right)\right\rangle$ state for $j = 0$. The electronic and magnetic energies for the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((0, 0);(0,0); 0; 0\right)\right\rangle$ state can be expressed as

$$
E_{\mathrm{electronic}}(0,0) = -2V_{\mathrm{one}} f_{\mathrm{Bose},0}(0) = -2V_{\mathrm{one}}. \qquad (31)
$$

$$
E_{\mathrm{magnetic}}(0,0) = 0. \qquad (32)
$$

The $E_{\mathrm{electronic}}(\Delta B_{\mathrm{unit}}, 0)$ value for the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}}, 0);(\Delta E_{\mathrm{unit}}, 0); 0; 0\right)\right\rangle$ state can be estimated as

$$
\begin{aligned}
&E_{\mathrm{electronic}}(\Delta B_{\mathrm{unit}}, 0) \\
&= -2V_{\mathrm{one}} f_{\mathrm{Bose},0}(0) + E_{I_{k_{\mathrm{HOCO}}}}(\Delta B_{\mathrm{unit}}, 0) \\
&= -2V_{\mathrm{one}} f_{\mathrm{Bose},0}(\Delta B_{\mathrm{unit}}), \qquad (33)
\end{aligned}
$$

where the $E_{I_{\boldsymbol{k}_{\mathrm{HOCO}}}}(\Delta B_{\mathrm{unit}}, 0)$ value denotes the energy of the electromotive force, and is estimated as

$$
\begin{aligned}
&E_{I_{\boldsymbol{k}_{\mathrm{HOCO}}}}(\Delta B_{\mathrm{unit}}, 0) \\
&= 2V_{\mathrm{one}}\left(f_{\mathrm{Bose},0}(0) - f_{\mathrm{Bose},0}(\Delta B_{\mathrm{unit}})\right) \\
&= 2V_{\mathrm{one}}\left(1 - f_{\mathrm{Bose},0}(\Delta B_{\mathrm{unit}})\right). \qquad (34)
\end{aligned}
$$

Furthermore, we must consider the magnetic energy ($E_{\mathrm{magnetic}}(\Delta B_{\mathrm{unit}}, 0)$) as a consequence of the expelling of the external initially applied magnetic field ΔB_{unit},

$$
\begin{aligned}
E_{\mathrm{magnetic}}(\Delta B_{\mathrm{unit}}, 0) &= E_{\mathrm{expel}}(\Delta B_{\mathrm{unit}}, 0) \\
&= \frac{1}{2}\mu_0 \Delta B_{\mathrm{unit}}^2 v_{\mathrm{SC}}, \qquad (35)
\end{aligned}
$$

where the μ_0 denotes the magnetic permeability in vacuum, and the v_{SC} denotes the volume of the specimen. The total energy level for the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}}, 0);(\Delta E_{\mathrm{unit}}, 0);0;0)\right\rangle$ state can be estimated as

$$
\begin{aligned}
&E_{\mathrm{total}}(\Delta B_{\mathrm{unit}}, 0) \\
&= E_{\mathrm{electronic}}(\Delta B_{\mathrm{unit}}, 0) + E_{\mathrm{magnetic}}(\Delta B_{\mathrm{unit}}, 0) \\
&= -2V_{\mathrm{one}} f_{\mathrm{Bose},0}(\Delta B_{\mathrm{unit}}) + \frac{1}{2}\mu_0 \Delta B_{\mathrm{unit}}^2 v_{\mathrm{SC}}. \qquad (36)
\end{aligned}
$$

We can consider from Eqs 33–36 that the energy for the excited normal metallic $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}}, 0);(\Delta E_{\mathrm{unit}}, 0);0;0)\right\rangle$ state is $-2V_{\mathrm{one}}$ with the energy of the electromotive force $2V_{\mathrm{one}}\left(f_{\mathrm{Bose},0}(0) - f_{\mathrm{Bose},0}(\Delta E_{\mathrm{unit}})\right)$ and the energy of the expelling of the external initially applied magnetic field $E_{\mathrm{magnetic}}(\Delta E_{\mathrm{unit}}, 0)$, and thus the total energy for the bosonic excited normal metallic $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}}, 0);(\Delta E_{\mathrm{unit}}, 0);0;0)\right\rangle$ state is $-2V_{\mathrm{one}} f_{\mathrm{Bose},0}(\Delta E_{\mathrm{unit}}) + E_{\mathrm{expel}}(\Delta B_{\mathrm{unit}}, 0)$. In other words, the energy for the applied magnetic field ΔB_{unit} is converted to the energy of the induced electric field

$2V_{\text{one}}\left(f_{\text{Bose},0}(0) - f_{\text{Bose},0}(\Delta E_{\text{unit}})\right)$ and the energy of the expelling of the external initially applied magnetic field $E_{\text{expel}}(\Delta B_{\text{unit}}, 0)$.

The $E_{\text{electronic}}(\Delta E_{\text{unit}}, 0)$ value for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},0);B_{\text{induced}};0)\right\rangle$ state can be estimated as

$$
\begin{aligned}
&E_{\text{electronic}}(\Delta E_{\text{unit}}, 0) \\
&= -2V_{\text{one}} f_{\text{Bose},0}(0) + E_{I_{k_{\text{HOCO}}}}(\Delta E_{\text{unit}}, 0) \\
&= -2V_{\text{one}} f_{\text{Bose},0}(\Delta E_{\text{unit}}). \qquad (37)
\end{aligned}
$$

Furthermore, we must consider the magnetic energy ($E_{\text{magnetic}}(\Delta E_{\text{unit}}, 0)$) as a consequence of the induced magnetic field $E_{B_{k_{\text{HOCO}}}}(\Delta E_{\text{unit}}, 0)$,

$$
\begin{aligned}
E_{\text{magnetic}}(\Delta E_{\text{unit}}, 0) &= E_{B_{k_{\text{HOCO}}}}(\Delta E_{\text{unit}}, 0) \\
&= \frac{1}{2}\mu_0 \Delta B_{\text{unit}}^2 v_{\text{SC}} . \qquad (38)
\end{aligned}
$$

The total energy level for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},0);B_{\text{induced}};0)\right\rangle$ state can be estimated as

$$
\begin{aligned}
&E_{\text{total}}(\Delta E_{\text{unit}}, 0) \\
&= E_{\text{electronic}}(\Delta E_{\text{unit}}, 0) + E_{\text{magnetic}}(\Delta E_{\text{unit}}, 0) \\
&= -2V_{\text{one}} f_{\text{Bose},0}(\Delta B_{\text{unit}}) + \frac{1}{2}\mu_0 \Delta B_{\text{unit}}^2 v_{\text{SC}} . \qquad (39)
\end{aligned}
$$

We can consider from Eqs 37–39 that the energy for the normal metallic $\left|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},0);B_{\text{induced}};0)\right\rangle$ state is $-2V_{\text{one}}$ with the expelling energy of the electric field $2V_{\text{one}}\left(f_{\text{Bose},0}(0) - f_{\text{Bose},0}(\Delta E_{\text{unit}})\right)$ and the energy of the induced magnetic field $E_{B_{k_{\text{HOCO}}}}(\Delta E_{\text{unit}}, 0)$, and thus the total energy for the bosonic excited normal metallic $\left|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},0);B_{\text{induced}};0)\right\rangle$ state is $-2V_{\text{one}} f_{\text{Bose},0}(\Delta E_{\text{unit}}) + E_{B_{k_{\text{HOCO}}}}(\Delta E_{\text{unit}}, 0)$. In other words, the energy for the applied magnetic field ΔB_{unit} is converted to the energy of the electromotive force $2V_{\text{one}}\left(f_{\text{Bose},0}(0) - f_{\text{Bose},0}(\Delta E_{\text{unit}})\right)$ and the induced magnetic field $E_{B_{k_{\text{HOCO}}}}(\Delta E_{\text{unit}}, 0)$.

The $E_{\mathrm{electronic}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}})$ value for the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right\rangle$ state can be estimated as

$$\begin{aligned}
&E_{\mathrm{electronic}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}) \\
&= -2V_{\mathrm{one}} f_{\mathrm{Bose},0}(0) + E_{\boldsymbol{v}_{\mathrm{em}}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}) \\
&= -2V_{\mathrm{one}} f_{\mathrm{Bose},0}(\Delta E_{\mathrm{unit}}),
\end{aligned} \qquad (40)$$

where the $E_{\boldsymbol{v}_{\mathrm{em}}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}})$ value denotes the kinetic energy of the supercurrent, and is estimated as

$$\begin{aligned}
&E_{\boldsymbol{v}_{\mathrm{em}}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}) \\
&= 2V_{\mathrm{one}}\left(f_{\mathrm{Bose},0}(0) - f_{\mathrm{Bose},0}(\Delta E_{\mathrm{unit}})\right) \\
&= 2V_{\mathrm{one}}\left(1 - f_{\mathrm{Bose},0}(\Delta E_{\mathrm{unit}})\right).
\end{aligned} \qquad (41)$$

Furthermore, we must consider the magnetic energy ($E_{\mathrm{magnetic}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}})$) as a consequence of the induced magnetic field $E_{B_{\boldsymbol{k}_{\mathrm{HOCO}}}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}})$,

$$\begin{aligned}
E_{\mathrm{magnetic}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}) &= E_{B_{\boldsymbol{k}_{\mathrm{HOCO}}}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}) \\
&= \frac{1}{2}\mu_0 \Delta B^2_{\mathrm{unit}} v_{\mathrm{SC}}.
\end{aligned} \qquad (42)$$

The total energy level for the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right\rangle$ state can be estimated as

$$\begin{aligned}
&E_{\mathrm{total}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}) \\
&= E_{\mathrm{electronic}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}) + E_{\mathrm{magnetic}}(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}) \\
&= -2V_{\mathrm{one}} f_{\mathrm{Bose},0}(\Delta E_{\mathrm{unit}}) + \frac{1}{2}\mu_0 \Delta B^2_{\mathrm{unit}} v_{\mathrm{SC}}.
\end{aligned} \qquad (43)$$

We can consider from Eqs 40–43 that the energy level for the excited normal metallic $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right\rangle$ state is $-2V_{\mathrm{one}}$ with the kinetic energy of the supercurrent

$2V_{\text{one}}\left(f_{\text{Bose},0}(0)-f_{\text{Bose},0}(\Delta E_{\text{unit}})\right)$ and the energy of the induced magnetic field $E_{B_{\boldsymbol{k}_{\text{HOCO}}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$, and thus the total energy for the bosonic excited normal metallic $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}}\right)\right\rangle$ state is $-2V_{\text{one}}f_{\text{Bose},0}(\Delta E_{\text{unit}})+E_{B_{\boldsymbol{k}_{\text{HOCO}}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$. In other words, the energy for the initially applied magnetic field ΔB_{unit} is converted to the kinetic energy of the supercurrent $2V_{\text{one}}\left(f_{\text{Bose},0}(0)-f_{\text{Bose},0}(\Delta E_{\text{unit}})\right)$ and the energy of the induced magnetic field $E_{B_{\boldsymbol{k}_{\text{HOCO}}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$.

The $E_{\text{electronic}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$ value for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});\sigma_{\text{spin}};\boldsymbol{p}_{\text{canonical}}\right)\right\rangle$ state can be estimated as

$$\begin{aligned}
&E_{\text{electronic}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})\\
&=-2V_{\text{one}}f_{\text{Bose},0}(0)+E_{\boldsymbol{p}_{\text{canonical}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})\\
&=-2V_{\text{one}}f_{\text{Bose},0}(\Delta E_{\text{unit}}),
\end{aligned} \tag{44}$$

where the $E_{\boldsymbol{p}_{\text{canonical}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$ value denotes the kinetic energy of the normal current, and is estimated as

$$\begin{aligned}
&E_{\boldsymbol{p}_{\text{canonical}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})\\
&=2V_{\text{one}}\left(f_{\text{Bose},0}(0)-f_{\text{Bose},0}(\Delta E_{\text{unit}})\right)\\
&=2V_{\text{one}}\left(1-f_{\text{Bose},0}(\Delta E_{\text{unit}})\right).
\end{aligned} \tag{45}$$

Furthermore, we must consider the magnetic energy ($E_{\text{magnetic}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$) as a consequence of the induced spin magnetic moment $E_{\sigma_{\text{spin,HOMO}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$,

$$\begin{aligned}
&E_{\text{magnetic}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})\\
&=E_{\sigma_{\text{spin,HOMO}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})=\frac{1}{2}\mu_0\Delta B^2_{\text{unit}}v_{\text{SC}}.
\end{aligned} \tag{46}$$

The total energy level for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});\sigma_{\text{spin}};\boldsymbol{p}_{\text{canonical}}\right)\right\rangle$ state can be estimated as

$$E_{\text{total}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$$

$$= E_{\text{electronic}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}}) + E_{\text{magnetic}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$$
$$= -2V_{\text{one}} f_{\text{Bose},0}(\Delta E_{\text{unit}}) + \frac{1}{2}\mu_0 \Delta B^2 v_{\text{unit SC}}. \quad (47)$$

The $E_{\text{electronic}}(\Delta B_{\text{unit}}, \Delta B_{\text{unit}})$ and $E_{\text{magnetic}}(\Delta B_{\text{unit}}, \Delta B_{\text{unit}})$ values for the $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}}, \Delta B_{\text{unit}});(0,0);0;0)\rangle$ state can be estimated as

$$E_{\text{electronic}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}}) = -2V_{\text{one}} f_{\text{Bose},\Delta B_{\text{unit}}}(0), \quad (48)$$

$$E_{\text{magnetic}}(\Delta B_{\text{unit}}, \Delta B_{\text{unit}}) = 0. \quad (49)$$

The total energy level for the $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}}, \Delta B_{\text{unit}});(0,0);0;0)\rangle$ state can be estimated as

$$E_{\text{total}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$$
$$= E_{\text{electronic}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}}) + E_{\text{magnetic}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$$
$$= -2V_{\text{one}} f_{\text{Bose},\Delta B_{\text{unit}}}(0). \quad (50)$$

The energy for the excited normal metallic $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}}, \Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}})\rangle$ state is $-2V_{\text{one}}$ with kinetic energy of super current $2V_{\text{one}}(1 - f_{\text{Bose},0}(\Delta B_{\text{unit}}))$, and thus the total electronic energy for the bosonic excited normal metallic $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}}, \Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}})\rangle$ state is $-2V_{\text{one}} f_{\text{Bose},0}(\Delta B_{\text{unit}})$. The electronic energy level for the bosonic ground normal metallic $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}}, \Delta B_{\text{unit}});(0,0);0;0)\rangle$ state is the same with those for the bosonic and fermionic excited normal metallic $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}}, \Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}})\rangle$ and $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}}, \Delta E_{\text{unit}});\sigma_{\text{spin}};\boldsymbol{p}_{\text{canonical}})\rangle$ states, respectively. On the other hand, it should be noted that even though the electronic energies are conserved between them, the kinds of energies are different. The electronic energy level itself for the $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}}, \Delta B_{\text{unit}});(0,0);0;0)\rangle$ is $-2V_{\text{one}} f_{\text{Bose},0}(\Delta B_{\text{unit}})$ with zero kinetic energy for the supercurrent, while those for the $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}}, \Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}})\rangle$ and $|\boldsymbol{k}_{\text{HOCO}}(T)((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}}, \Delta E_{\text{unit}});\sigma_{\text{spin}};\boldsymbol{p}_{\text{canonical}})\rangle$ states are $-2V_{\text{one}}$ with the kinetic energy of super current

$2V_{\text{one}}\left(1-f_{\text{Bose},0}(\Delta B_{\text{unit}})\right)$. That is, the bosonic $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}}\right)\right\rangle$ and fermionic $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});\sigma_{\text{spin}};\boldsymbol{p}_{\text{canonical}}\right)\right\rangle$ excited normal metallic states are unstable with respect to the ground bosonic state for zero magnetic field, in the space of the ground bosonic state for zero magnetic field $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$ This is because the kinetic energy of currents ($2V_{\text{one}}\left(1-f_{\text{Bose},0}(\Delta B_{\text{unit}})\right)$) for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}}\right)\right\rangle$ and $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});\sigma_{\text{spin}};\boldsymbol{p}_{\text{canonical}}\right)\right\rangle$ states are larger than that (0) for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$ state, while the electronic energy level for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}}\right)\right\rangle$ and $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});\sigma_{\text{spin}};\boldsymbol{p}_{\text{canonical}}\right)\right\rangle$ states are the same ($-2V_{\text{one}}$) with that for $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$. The bosonic $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},\Delta B_{\text{unit}});(0,0);0;0\right)\right\rangle$ ground state is unstable with respect to the ground bosonic state for zero magnetic field, in the space of the ground bosonic state for zero magnetic field $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$. This is because the electronic energy level ($-2V_{\text{one}}f_{\text{Bose},0}(\Delta B_{\text{unit}})$) for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},\Delta B_{\text{unit}});(0,0);0;0\right)\right\rangle$ is higher than that $-2V_{\text{one}}$ for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$ state, while the kinetic energies for both the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},\Delta B_{\text{unit}});(0,0);0;0\right)\right\rangle$ and $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$ states are zero. That is, the total electronic energy is conserved when the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}}\right)\right\rangle$ state is converted to the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},\Delta B_{\text{unit}});(0,0);0;0\right)\right\rangle$ state via the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});\sigma_{\text{spin}};\boldsymbol{p}_{\text{canonical}}\right)\right\rangle$ state. During this conversion, the kinetic energy for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}}\right)\right\rangle$ and $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});\sigma_{\text{spin}};\boldsymbol{p}_{\text{canonical}}\right)\right\rangle$ states can be changed to the higher electronic state energy for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},\Delta B_{\text{unit}});(0,0);0;0\right)\right\rangle$ state by the penetration of the magnetic field (ΔB_{unit}).

On the other hand, the magnetic energy for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}}\right)\right\rangle$ state ($E_{\text{magnetic}}(\Delta B_{\text{unit}},0)$) with respect to the next ground normal metallic ground $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},\Delta B_{\text{unit}});(0,0);0;0\right)\right\rangle$ state ($E_{\text{magnetic}}(\Delta B_{\text{unit}},\Delta B_{\text{unit}})$) can be expressed as $\mu_0\Delta B^2_{\text{unit}}V_{\text{SC}}/2$. Therefore, because of the magnetic energy $E_{\text{magnetic}}(\Delta B_{\text{unit}},0) > E_{\text{magnetic}}(\Delta B_{\text{unit}},\Delta B_{\text{unit}})$, such excited normal metallic $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}}\right)\right\rangle$ state is not stable, and thus the bosonic excited normal metallic $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\Delta B_{\text{unit}},0);(\Delta E_{\text{unit}},\Delta E_{\text{unit}});B_{\text{induced}};\boldsymbol{v}_{\text{em}}\right)\right\rangle$ electronic state is converted to the next bosonic ground normal metallic ground $|k_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},\Delta B_{\mathrm{unit}});(0,0);0;0)\rangle$ state via the another fermionic excited normal metallic $|k_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});\sigma_{\mathrm{spin}};p_{\mathrm{canonical}})\rangle$ state.

The total energy level ($E_{\mathrm{total}}(B_{\mathrm{out}},B_{\mathrm{in}})$) for the fermionic excited normal metallic $|k_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});\sigma_{\mathrm{spin}};p_{\mathrm{canonical}})\rangle$ state can be estimated to be the same with that for the bosonic excited normal metallic $|k_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};v_{\mathrm{em}})\rangle$ state even though the potential energy V_{potentia} for the bosonic state is converted to the kinetic energy $V_{\mathrm{kin,Fermi},k_{\mathrm{LUCO}}\sigma}(0)$ for the fermionic state.

We can consider that the $E_{\mathrm{total}}(\Delta B_{\mathrm{unit}},0)$ values for the $|k_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};v_{\mathrm{em}})\rangle$ and $|k_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});\sigma_{\mathrm{spin}};p_{\mathrm{canonical}})\rangle$ states are larger than that for the $|k_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},\Delta B_{\mathrm{unit}});(0,0);0;0)\rangle$ state by the $E_{\mathrm{magnetic}}(\Delta B_{\mathrm{unit}},0)-E_{\mathrm{magnetic}}(\Delta B_{\mathrm{unit}},\Delta B_{\mathrm{unit}})\ (=\mu_0\Delta B^2_{\mathrm{unit}}v_{\mathrm{SC}}/2)$ value. Therefore, the conversion from the unstable $|k_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});\sigma_{\mathrm{spin}};p_{\mathrm{canonical}})\rangle$ state to the stable $|k_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},\Delta B_{\mathrm{unit}});(0,0);0;0)\rangle$ state occurs by the first-order process of the electron– phonon interactions. In other words, the unstable $|k_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});\sigma_{\mathrm{spin}};p_{\mathrm{canonical}})\rangle$ state is converted to the stable $|k_{\mathrm{HOCO}}(T)((\Delta B_{\mathrm{unit}},\Delta B_{\mathrm{unit}});(0,0);0;0)\rangle$ state as a consequence of the energy conversion from the magnetic energy ($E_{\mathrm{magnetic}}(\Delta B_{\mathrm{unit}},0)-E_{\mathrm{magnetic}}(\Delta B_{\mathrm{unit}},\Delta B_{\mathrm{unit}})\ (=\mu_0\Delta B^2_{\mathrm{unit}}v_{\mathrm{SC}}/2)$) to the photon emission V_{photo} (electrical resistivity (Joule’s heats)) energy. The magnetic expelling energy ($E_{\mathrm{magnetic}}(\Delta B_{\mathrm{unit}},0)-E_{\mathrm{magnetic}}(\Delta B_{\mathrm{unit}},\Delta B_{\mathrm{unit}})\ (=\mu_0\Delta B^2_{\mathrm{unit}}v_{\mathrm{SC}}/2)$) has been basically created from the energy originating from the dynamic change of the magnetic field (generation of electricity). Therefore, we can conclude that initially dynamically created energy originating from the dynamic change of the magnetic field (generation of electricity) is the origin of the Joule’s heats finally observed.

The energy for the magnetic field itself, which has not been considered to be origin of the electromotive forces, is closely related to the electromotive forces, the electrical current, and the resistivity. On the other hand, the dynamically created energy originating from the dynamic change of the magnetic field (generation of electricity), which has been considered to originate from the electromotive forces, is closely related to the Joule’s heats, but not directly related to the electromotive forces.

As discussed in the previous studies, the Stern–Gerlach effect is the main reason why the even one electron can be in the bosonic state at usual low temperatures. And the very large stabilization energy

($V_{\text{kin,Fermi},\boldsymbol{k}_{\text{HOCO}}\sigma}(0) \approx 35$ eV) for the Bose–Einstein condensation ($\boldsymbol{p}_{\text{canonical}} = 0$; $V_{\text{kin, Bose},\boldsymbol{k}_{\text{HOCO}}\sigma}(0) = 0$ eV) originating from the disappearance of the kinetic energy of an electron ($\boldsymbol{p}_{\text{canonical}} = 0$; $V_{\text{kin,Bose},\boldsymbol{k}_{\text{HOCO}}\sigma}(0) = 0$ eV) is the main reason why the magnetic momentum of an electron cannot be changed but electrical currents can be induced soon after the external magnetic field is applied. If an electron were not in the bosonic state, the applied magnetic field would immediately penetrate into the specimen as soon as the magnetic field is applied, and we would not observe any electrical current even in the normal metals. This bosonic electron is closely related to the concepts of the Higgs boson.

The electronic energy is conserved and thus the change of the electronic states is not directly related to the Joule's heats. Therefore, applied energy for the electromotive forces as a consequence of the change of the magnetic field strength itself are not dissipated. In other words, electrical resistivity can be observed because of the electronic properties (the disappearance of total momentum $\boldsymbol{p}_{\text{canonical}} = 0$ and $\boldsymbol{v}_{\text{em}} = 0$ under the statistic magnetic field), on the other hand, the Joule's heats can be observed not because of the electronic properties but because of the magnetic properties (the disappearance of the expelling energy of the magnetic fields originating from the energy for the change of the magnetic field at the beginning, created dynamically (generation of electricity)). We dynamically create the energy for the dynamic change of the magnetic field (generation of electricity) at the beginning, related to the Joule's heats, in addition to the energy for the magnetic field itself, related to the electromotive force, kinetic energy of an electron, and electrical resistivity.

III. THE DIRECTION OF THE ELECTRICAL CURRENTS AND KINETIC ENERGIES

Let us next look into the energy levels for various electronic states when the applied magnetic field (B_{out}) changes from $\gamma\Delta B_{\text{unit}}$ to $(\gamma \pm 1)\Delta B_{\text{unit}}$ at 0 K in superconductor (Figs. 5 and 6), but in which the HOCO is partially occupied by an electron.

The energies for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\gamma\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}); (0, 0); 0; 0\right)\right\rangle$ state can be expressed as

$$E_{\text{electronic}}(\gamma\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}})$$
$$= -2V_{\text{one}} f_{\text{Bose},\gamma\Delta B_{\text{unit}}}(0), \qquad (51)$$

$$E_{\text{magnetic}}\left(\gamma\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) = 0, \quad (52)$$

$$\begin{aligned} E_{\text{total}}\left(\gamma\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) &= E_{\text{electronic}}\left(\gamma\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) \\ &+ E_{\text{magnetic}}\left(\gamma\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) \\ &= -2V_{\text{one}} f_{\text{Bose},\gamma\Delta B_{\text{unit}}}(0). \quad (53) \end{aligned}$$

The energies for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right); \left(\pm\Delta E_{\text{unit}}, \pm\Delta E_{\text{unit}}\right); B_{\text{induced}}; \boldsymbol{v}_{\text{em}}\right)\right\rangle$ state can be estimated as

$$\begin{aligned} &E_{\text{electronic}}\left((\gamma \pm 1)\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) \\ &= -2V_{\text{one}} f_{\text{Bose},\gamma\Delta B_{\text{unit}}}(0) + E_{\boldsymbol{v}_{\text{em}}}\left((\gamma \pm 1)\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) \\ &= -2V_{\text{one}} f_{\text{Bose},\gamma\Delta B_{\text{unit}}}\left(\pm\Delta B_{\text{unit}}\right), \quad (54) \end{aligned}$$

$$\begin{aligned} &E_{\boldsymbol{v}_{\text{em}}}\left((\gamma \pm 1)\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) \\ &= 2V_{\text{one}}\left(f_{\text{Bose},\gamma\Delta B_{\text{unit}}}(0) - f_{\text{Bose},\gamma\Delta B_{\text{unit}}}\left(\pm\Delta B_{\text{unit}}\right)\right). \quad (55) \end{aligned}$$

$$\begin{aligned} &E_{\text{magnetic}}\left((\gamma \pm 1)\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) \\ &= E_{B_{\boldsymbol{k}_{\text{HOCO}}}}\left((\gamma \pm 1)\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) \\ &= \frac{1}{2}\mu_0 \Delta B_{\text{unit}}^2 v_{\text{SC}}, \quad (56) \end{aligned}$$

$$\begin{aligned} &E_{\text{total}}\left((\gamma \pm 1)\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) \\ &= E_{\text{electronic}}\left((\gamma \pm 1)\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) \\ &+ E_{\text{magnetic}}\left((\gamma \pm 1)\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right) \\ &= -2V_{\text{one}} f_{\text{Bose},\gamma\Delta B_{\text{unit}}}\left(\pm\Delta B_{\text{unit}}\right) + \frac{1}{2}\mu_0 \Delta B_{\text{unit}}^2 v_{\text{SC}}. \quad (57) \end{aligned}$$

The energies for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right); \left(\pm\Delta E_{\text{unit}}, \pm\Delta E_{\text{unit}}\right); \sigma_{\text{spin}}; \boldsymbol{p}_{\text{canonical}}\right)\right\rangle$ state can be estimated as

$$E_{\text{electronic}}\left((\gamma \pm 1)\Delta B_{\text{unit}}, \gamma\Delta B_{\text{unit}}\right)$$

$$= -2V_{\mathrm{one}} f_{\mathrm{Bose},\gamma\Delta B_{\mathrm{unit}}}(0)$$
$$+E_{\boldsymbol{p}_{\mathrm{canonical}}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},\ \gamma\Delta B_{\mathrm{unit}}\right)$$
$$= -2V_{\mathrm{one}} f_{\mathrm{Bose},\gamma\Delta B_{\mathrm{unit}}}(\pm\Delta B_{\mathrm{unit}}), \qquad (58)$$

$$E_{\boldsymbol{p}_{\mathrm{canonical}}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},\ \gamma\Delta B_{\mathrm{unit}}\right)$$
$$= 2V_{\mathrm{one}}\left(f_{\mathrm{Bose},\gamma\Delta B_{\mathrm{unit}}}(0) - f_{\mathrm{Bose},\gamma\Delta B_{\mathrm{unit}}}(\pm\Delta B_{\mathrm{unit}})\right), \qquad (59)$$

$$E_{\mathrm{magnetic}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},\ \gamma\Delta B_{\mathrm{unit}}\right)$$
$$= E_{\sigma_{\mathrm{spin}},\mathrm{HOCO}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},\gamma\Delta B_{\mathrm{unit}}\right)$$
$$= \frac{1}{2}\mu_0 \Delta B_{\mathrm{unit}}^2 v_{\mathrm{SC}}. \qquad (60)$$

$$E_{\mathrm{total}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},\ \gamma\Delta B_{\mathrm{unit}}\right)$$
$$= E_{\mathrm{electronic}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},\ \gamma\Delta B_{\mathrm{unit}}\right)$$
$$+ E_{\mathrm{magnetic}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},\gamma\Delta B_{\mathrm{unit}}\right)$$
$$= -2V_{\mathrm{one}} f_{\mathrm{Bose},\gamma\Delta B_{\mathrm{unit}}}(\pm\Delta B_{\mathrm{unit}}) + \frac{1}{2}\mu_0 \Delta B_{\mathrm{unit}}^2 v_{\mathrm{SC}}. \qquad (61)$$

The energies for the $\left|\Psi_{\mathrm{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},\ (\gamma \pm 1)\Delta B_{\mathrm{unit}}\right);(0,0);0;0\right)\right\rangle$ state can be expressed as

$$E_{\mathrm{electronic}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},\ (\gamma \pm 1)\Delta B_{\mathrm{unit}}\right)$$
$$= -2V_{\mathrm{one}} f_{\mathrm{Bose},(\gamma \pm 1)\Delta B_{\mathrm{unit}}}(0), \qquad (62)$$

$$E_{\mathrm{magnetic}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},\ (\gamma \pm 1)\Delta B_{\mathrm{unit}}\right) = 0, \qquad (63)$$

$$E_{\mathrm{total}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},\ (\gamma \pm 1)\Delta B_{\mathrm{unit}}\right)$$
$$= E_{\mathrm{electronic}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},(\gamma \pm 1)\Delta B_{\mathrm{unit}}\right)$$
$$+ E_{\mathrm{magnetic}}\left((\gamma \pm 1)\Delta B_{\mathrm{unit}},(\gamma \pm 1)\Delta B_{\mathrm{unit}}\right)$$
$$= -2V_{\mathrm{one}} f_{\mathrm{Bose},(\gamma \pm 1)\Delta B_{\mathrm{unit}}}(0). \qquad (64)$$

It should be noted that the ground bosonic $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\mathrm{unit}}, (\gamma \pm 1)\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ state as well as the excited bosonic $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);\left(\pm\Delta E_{\mathrm{unit}}, \pm\Delta E_{\mathrm{unit}}\right); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ and fermionic $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);\left(\pm\Delta E_{\mathrm{unit}}, \pm\Delta E_{\mathrm{unit}}\right); \sigma_{\mathrm{spin}}; \boldsymbol{p}_{\mathrm{canonical}}\right)\right\rangle$ states are unstable with respect to the ground bosonic $\left| k_{\mathrm{HOCO}}(T)\left(\left(\gamma\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ state under the magnetic field $\gamma\Delta B_{\mathrm{unit}}$ (in the $\left| k_{\mathrm{HOCO}}(T)\left(\left(\gamma\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ superconducting space).That is, the ground bosonic $\left| k_{\mathrm{HOCO}}(T)\left(\left(\gamma\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ state is more stable than any other electronic state under the magnetic field $\gamma\Delta B_{\mathrm{unit}}$ (in the $\left| k_{\mathrm{HOCO}}(T)\left(\left(\gamma\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ superconducting space). That is, even though the electronic $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\mathrm{unit}}, (\gamma \pm 1)\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$, $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);\left(\pm\Delta E_{\mathrm{unit}}, \pm\Delta E_{\mathrm{unit}}\right); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$, and $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);\left(\pm\Delta E_{\mathrm{unit}}, \pm\Delta E_{\mathrm{unit}}\right); \sigma_{\mathrm{spin}}; \boldsymbol{p}_{\mathrm{canonical}}\right)\right\rangle$ states are less stable than the $\left| k_{\mathrm{HOCO}}(T)\left(\left(\gamma\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ state under the magnetic field $\gamma\Delta B_{\mathrm{unit}}$ (in the $\left| k_{\mathrm{HOCO}}(T)\left(\left(\gamma\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ superconducting space), once the electronic state becomes $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\mathrm{unit}}, (\gamma \pm 1)\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ state under the magnetic field $(\gamma \pm 1)\Delta B_{\mathrm{unit}}$ (in the $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\mathrm{unit}}, (\gamma \pm 1)\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ superconducting space), the $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma \pm 1)\Delta B_{\mathrm{unit}}, (\gamma \pm 1)\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ state becomes more stable than any other electronic state.

The electronic energy level for the $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma + 1)\Delta B_{\mathrm{unit}}, (\gamma + 1)\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$, $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma + 1)\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);\left(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}\right); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$, and $\left| k_{\mathrm{HOCO}}(T)\left(\left((\gamma + 1)\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);\left(\Delta E_{\mathrm{unit}}, \Delta E_{\mathrm{unit}}\right); \sigma_{\mathrm{spin}}; \boldsymbol{p}_{\mathrm{canonical}}\right)\right\rangle$ states are higher than that for the $\left| k_{\mathrm{HOCO}}(T)\left(\left(\gamma\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ state in the $\left| k_{\mathrm{HOCO}}(T)\left((0, 0); (0,0); 0; 0\right)\right\rangle$ space where we live (i.e., real space) (Figs. 7 and 8). This can be understood as follows. When the electronic state changes from the $\left| k_{\mathrm{HOCO}}(T)\left((0, 0); (0,0); 0; 0\right)\right\rangle$ to the $\left| k_{\mathrm{HOCO}}(T)\left(\left(\gamma\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}}\right);(0, 0); 0; 0\right)\right\rangle$ state, an electron receives the electric field ΔE_{unit}, γ times, and thus the total kinetic energy for this electronic state changing is $2V_{\mathrm{one}}\left(1 - f_{\mathrm{Bose}, \gamma\Delta B_{\mathrm{unit}}}(0)\right)$ for counter-clockwise moving. When the electronic state changes from the

$\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\gamma\Delta B_{\mathrm{unit}},\gamma\Delta B_{\mathrm{unit}});(0,0);0;0\right)\right\rangle$ to the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left(((\gamma+1)\Delta B_{\mathrm{unit}},(\gamma+1)\Delta B_{\mathrm{unit}});(0,0);0;0\right)\right\rangle$ state, an electron receives the electric field ΔE_{unit}, one time, and thus the total kinetic energy for this electronic state changing is $2V_{\mathrm{one}}\left(f_{\mathrm{Bose},\gamma\Delta B_{\mathrm{unit}}}(0)-f_{\mathrm{Bose},(\gamma+1)\Delta B_{\mathrm{unit}}}(0)\right)$ for counter-clockwise moving. That is, when the electronic state changes from the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$ to the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left(((\gamma+1)\Delta B_{\mathrm{unit}},(\gamma+1)\Delta B_{\mathrm{unit}});(0,0);0;0\right)\right\rangle$ state, an electron receives the electric field ΔE_{unit}, $\gamma+1$ times, and thus the total kinetic energy for this electronic state changing is $2V_{\mathrm{one}}\left(1-f_{\mathrm{Bose},(\gamma+1)\Delta B_{\mathrm{unit}}}(0)\right)$ for counter-clockwise moving. The kinetic energy of the $2V_{\mathrm{one}}\left(1-f_{\mathrm{Bose},\gamma\Delta B_{\mathrm{unit}}}(0)\right)$ is smaller than that of the $2V_{\mathrm{one}}\left(1-f_{\mathrm{Bose},(\gamma+1)\Delta B_{\mathrm{unit}}}(0)\right)$. This is the reason why the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left(((\gamma+1)\Delta B_{\mathrm{unit}},(\gamma+1)\Delta B_{\mathrm{unit}});(0,0);0;0\right)\right\rangle$ state is less stable than the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\gamma\Delta B_{\mathrm{unit}},\gamma\Delta B_{\mathrm{unit}});(0,0);0;0\right)\right\rangle$ state in energy in the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$ space. That is, we can define the kinetic energy for the change from the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\gamma\Delta B_{\mathrm{unit}},\gamma\Delta B_{\mathrm{unit}});(0,0);0;0\right)\right\rangle$ state to the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left(((\gamma+1)\Delta B_{\mathrm{unit}},(\gamma+1)\Delta B_{\mathrm{unit}});(0,0);0;0\right)\right\rangle$ state in the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$ space as

$$
\begin{aligned}
&2V_{\mathrm{one}}\left(1-f_{\mathrm{Bose},0}\left((\gamma+1)\Delta B_{\mathrm{unit}}\right)\right)\\
&-2V_{\mathrm{one}}\left(1-f_{\mathrm{Bose},0}\left(\gamma\Delta B_{\mathrm{unit}}\right)\right)\\
&=2V_{\mathrm{one}}\left(f_{\mathrm{Bose},0}\left(\gamma\Delta B_{\mathrm{unit}}\right)-f_{\mathrm{Bose},0}\left((\gamma+1)\Delta B_{\mathrm{unit}}\right)\right)>0.
\end{aligned}
\tag{65}
$$

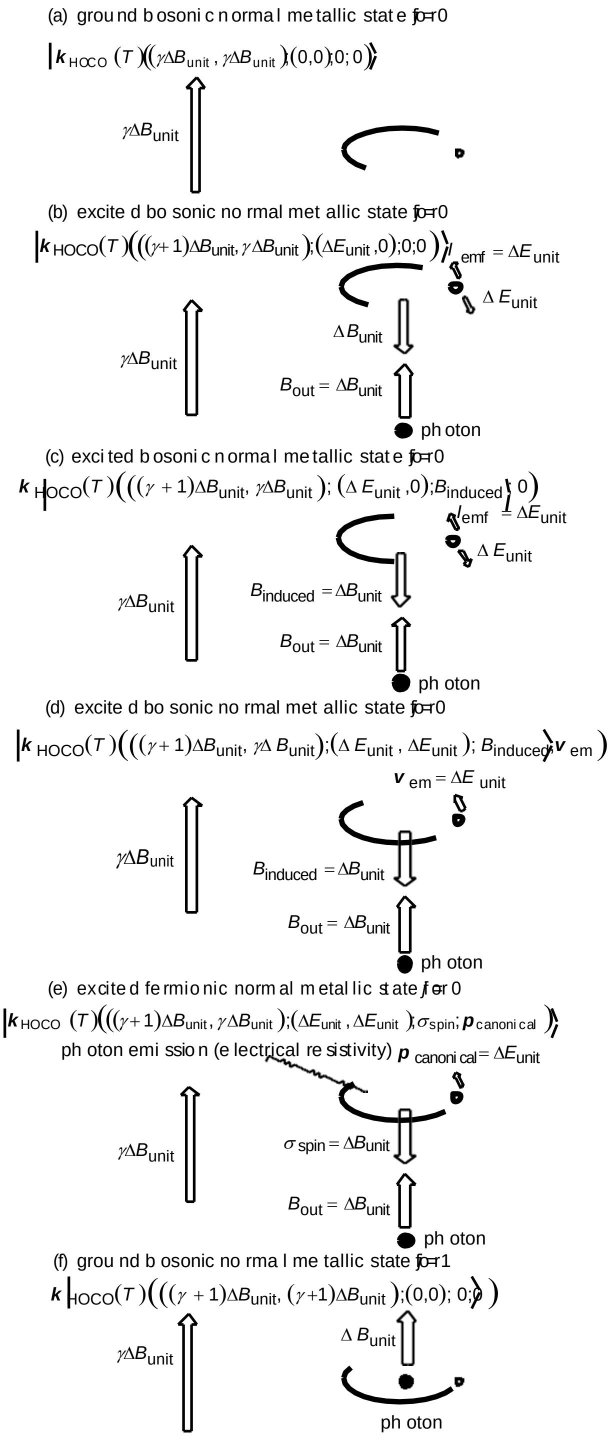

Fig. 5. The electronic states between $j = \gamma$ and $j = \gamma+1$

On the other hand, the electronic energy level for the $|\boldsymbol{k}_{\mathrm{HOCO}}(T)(((\gamma-1)\Delta B_{\mathrm{unit}}, (\gamma-1)\Delta B_{\mathrm{unit}});(0,0);0;0)\rangle$, $|\boldsymbol{k}_{\mathrm{HOCO}}(T)(((\gamma-1)\Delta B_{\mathrm{unit}}, \gamma\Delta B_{\mathrm{unit}});(-\Delta E_{\mathrm{unit}}, -\Delta E_{\mathrm{unit}}); B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}})\rangle$, and

$\left|\boldsymbol{k}_{\text{HOCO}}(T)\left(((\gamma-1)\Delta B_{\text{unit}},\ \gamma\Delta B_{\text{unit}});(-\Delta E_{\text{unit}},\ -\Delta E_{\text{unit}});\ \sigma_{\text{spin}};\ \boldsymbol{p}_{\text{canonical}}\right)\right\rangle$ states are lower than that for the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\gamma\Delta B_{\text{unit}},\ \gamma\Delta B_{\text{unit}});(0,\ 0);\ 0;\ 0\right)\right\rangle$ state in the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((0,\ 0);(0,0);\ 0;\ 0\right)\right\rangle$ space where we live (i.e., real space) (Figs. 9 and 10). This can be understood as follows. When the electronic state changes from the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((0,0);(0,0);\ 0;\ 0\right)\right\rangle$ to the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\gamma\Delta B_{\text{unit}},\ \gamma\Delta B_{\text{unit}});(0,\ 0);\ 0;\ 0\right)\right\rangle$ state, an electron receives the electric field ΔE_{unit}, γ times, and thus the total kinetic energy for this electronic state changing is $2V_{\text{one}}\left(1-f_{\text{Bose},\gamma\Delta B_{\text{unit}}}(0)\right)$ for counter-clockwise moving. When the electronic state changes from the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\gamma\Delta B_{\text{unit}},\ \gamma\Delta B_{\text{unit}});(0,\ 0);\ 0;\ 0\right)\right\rangle$ to the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left(((\gamma-1)\Delta B_{\text{unit}},(\gamma-1)\Delta B_{\text{unit}});(0,0);\ 0;\ 0\right)\right\rangle$ state, an electron receives the electric field $-\Delta E_{\text{unit}}$, one time, and thus the total kinetic energy for this electronic state changing is $2V_{\text{one}}\left(f_{\text{Bose},\gamma\Delta B_{\text{unit}}}(0)-f_{\text{Bose},(\gamma-1)\Delta B_{\text{unit}}}(0)\right)<0$ for counter-clockwise moving ($\left|2V_{\text{one}}\left(f_{\text{Bose},\gamma\Delta B_{\text{unit}}}(0)-f_{\text{Bose},(\gamma-1)\Delta B_{\text{unit}}}(0)\right)\right|>0$ for clockwise moving). That is, when the electronic state changes from the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((0,0);(0,0);\ 0;\ 0\right)\right\rangle$ state to the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left(((\gamma-1)\Delta B_{\text{unit}},(\gamma-1)\Delta B_{\text{unit}});(0,0);\ 0;\ 0\right)\right\rangle$, an electron receives the electric field ΔE_{unit}, $\gamma-1$ times, and thus the total kinetic energy for this electronic state changing is $2V_{\text{one}}\left(1-f_{\text{Bose},(\gamma-1)\Delta B_{\text{unit}}}(0)\right)$ for counter-clockwise moving. The kinetic energy of the $2V_{\text{one}}\left(1-f_{\text{Bose},\gamma\Delta B_{\text{unit}}}(0)\right)$ is larger than that of the $2V_{\text{one}}\left(1-f_{\text{Bose},(\gamma-1)\Delta B_{\text{unit}}}(0)\right)$. This is the reason why the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\gamma\Delta B_{\text{unit}},\gamma\Delta B_{\text{unit}});(0,0);0;0\right)\right\rangle$ state is less stable than the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left(((\gamma-1)\Delta B_{\text{unit}},(\gamma-1)\Delta B_{\text{unit}});(0,0);\ 0;\ 0\right)\right\rangle$ state in energy in the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((0,\ 0);(0,0);\ 0;\ 0\right)\right\rangle$ space. That is, we can define even negative kinetic energy for the change from the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((\gamma\Delta B_{\text{unit}},\gamma\Delta B_{\text{unit}});(0,0);0;0\right)\right\rangle$ state to the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left(((\gamma-1)\Delta B_{\text{unit}},(\gamma-1)\Delta B_{\text{unit}});(0,0);0;0\right)\right\rangle$ state in the $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((0,0);(0,0);0;0\right)\right\rangle$ space as

$$\begin{aligned}
&2V_{\text{one}}\left(1-f_{\text{Bose},0}\left((\gamma-1)\Delta B_{\text{unit}}\right)\right)\\
&-2V_{\text{one}}\left(1-f_{\text{Bose},0}\left(\gamma\Delta B_{\text{unit}}\right)\right)\\
&=2V_{\text{one}}\left(f_{\text{Bose},0}\left(\gamma\Delta B_{\text{unit}}\right)-f_{\text{Bose},0}\left((\gamma-1)\Delta B_{\text{unit}}\right)\right)<0.
\end{aligned} \tag{66}$$

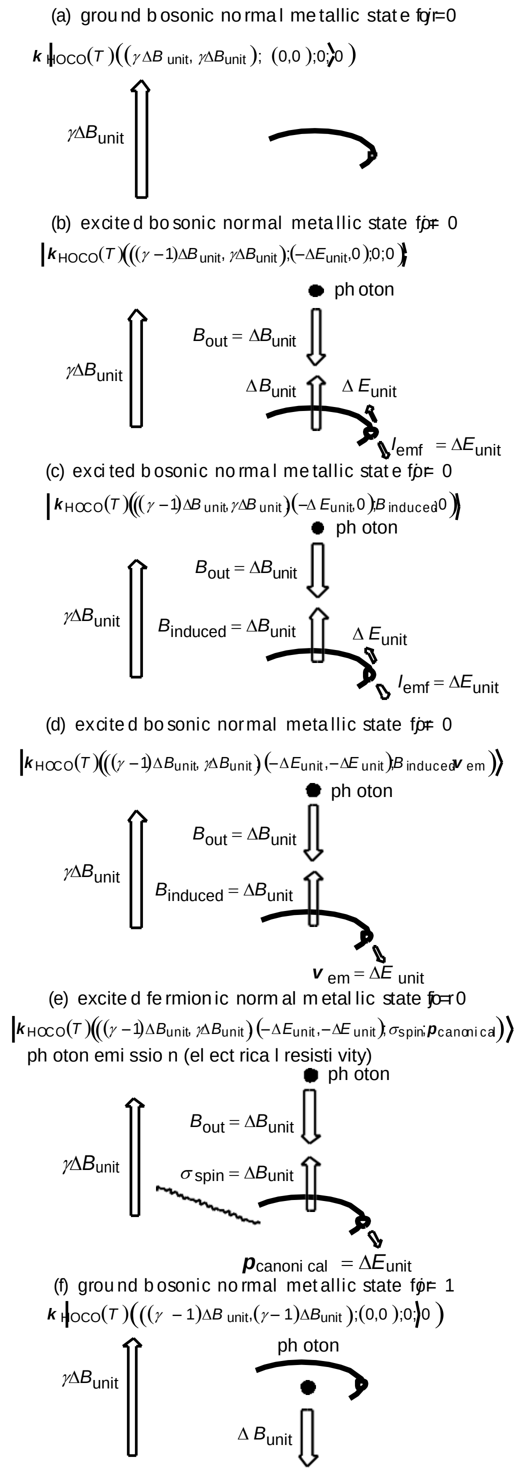

Fig. 6. The electronic states between $j = \gamma$ and $j = \gamma - 1$

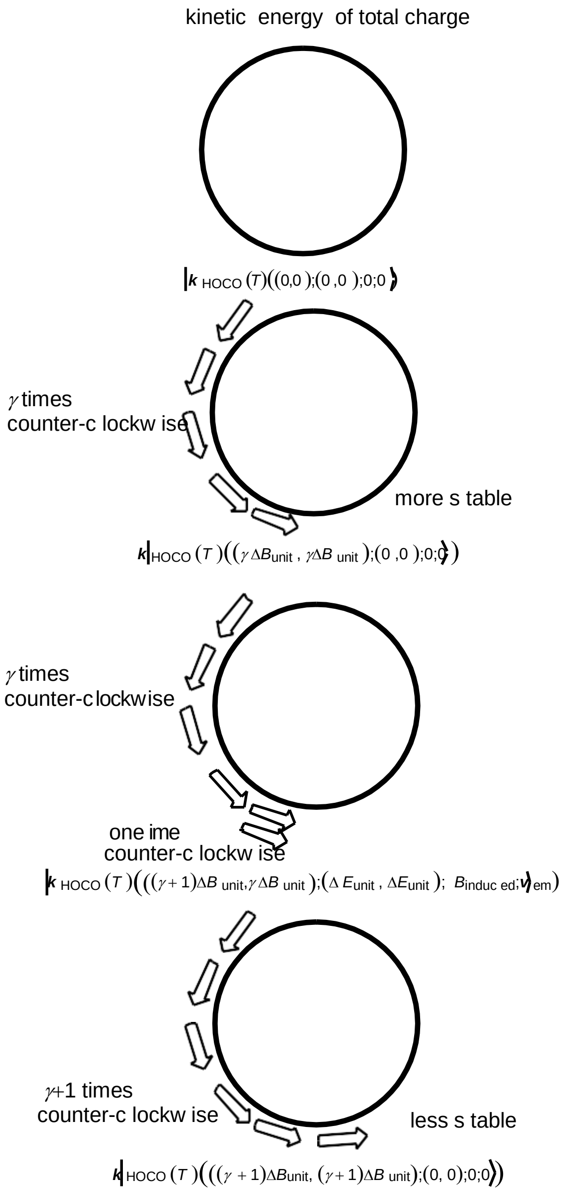

Fig. 7. The electrical currents for $j=\gamma$ and $j=\gamma+1$

In general, the ground bosonic $|k_{\mathrm{HOCO}}(T)((B_{\mathrm{in}},B_{\mathrm{in}});(0,0);0;0\rangle$ state is the most stable in energy under B_{in} magnetic field ($|k_{\mathrm{HOCO}}(T)((B_{\mathrm{in}},B_{\mathrm{in}});(0,0);0;0\rangle$ superconducting space).On the other hand, the $|k_{\mathrm{HOCO}}(T)((B_{\mathrm{in}},B_{\mathrm{in}});(0,0);0;0\rangle$ state becomes more unstable with an increase in the B_{in} value in the $|k_{\mathrm{HOCO}}(T)((0,0);(0,0);0;0\rangle$ space. The Joule's heats originate from the disappearance of the induced magnetic field. The induced magnetic field is generated by the initial dynamic change of the magnetic field (generation of the electricity). The absolute value of the initial change of the magnetic field is related to the Joule's heats. On the other hand, the direction of the electromotive force, the electrical current, and the sign (positive or negative) of the kinetic energy in the $\boldsymbol{k}_{\mathrm{HOCO}}(T)((0, 0); (0,0); 0; 0)$ space depends on the direction of the change of the magnetic field itself. Similar discussion can be made between another two neighboring quantized magnetic fields repeatedly.

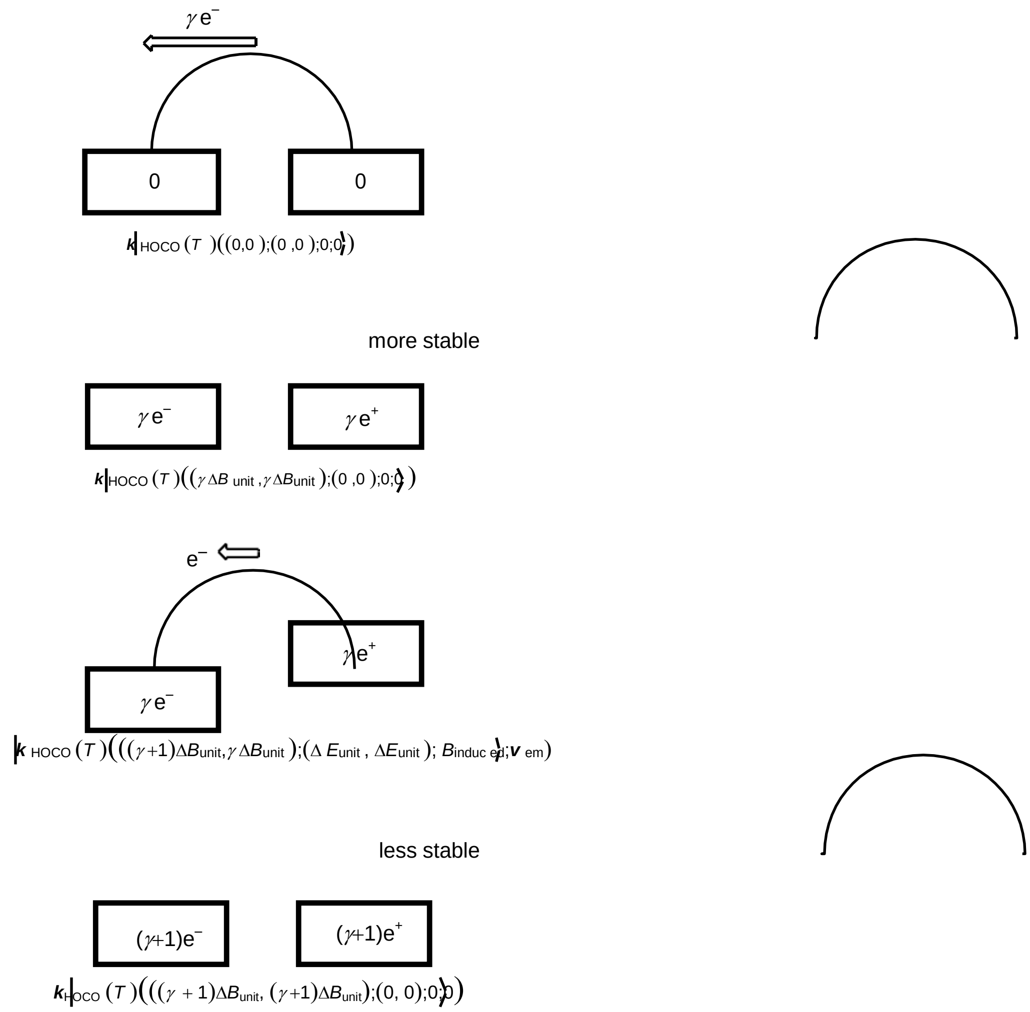

Fig. 8. The total electrical currents for $j = \gamma$ and $j = \gamma+1$

IV. MEISSNER EFFECTS IN THE TWO-ELECTRONS SYSTEMS IN SUPERCONDUCTIVITY

Because of the very large stabilization energy ($2V_{\mathrm{kin,Fermi},\boldsymbol{k}_{\mathrm{HOCO}}\sigma(0)} \approx 70$ eV) for the Bose–Einstein condensation ($\boldsymbol{p}_{\mathrm{canonical}} = 0$; $V_{\mathrm{kin,\,Bose},\boldsymbol{k}_{\mathrm{HOCO}}\sigma(0)} = 0$ eV), the magnetic momentum of a bosonic Cooper pair cannot be changed but electromotive force (ΔE_{unit}) can be induced soon after the external magnetic field is applied. This is the excited bosonic superconducting state for $j = 0$ ($\langle k_{HOCO}(T)((\Delta B_{unit},0);(\Delta E_{unit},0);0;0)\rangle$) (Fig. 11). In such a case, the induced electric field as well as the applied external magnetic field is expelled from the superconducting specimen. It should be noted that the electronic $|k_{HOCO}(T)((\Delta B_{unit},0);(\Delta E_{unit},0);0;0)\rangle$ state is still bosonic

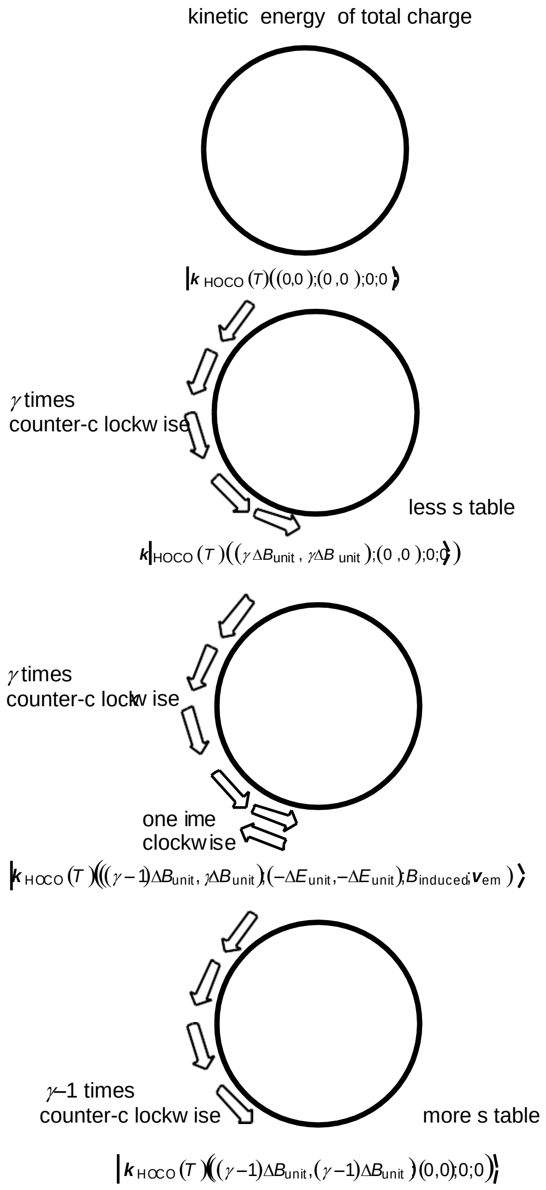

Fig. 9. The electrical currents for $j = \gamma$ and $j = \gamma - 1$

since the $\boldsymbol{p}_{canonica}$ value is 0. The electric and magnetic momentum of a bosonic Cooper pair cannot be changed but the magnetic field can be induced soon after the electromotive force is induced. Therefore, the electronic state becomes $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);B_{\mathrm{induced}};0\right)\right\rangle$. This induced magnetic field B_{induce} can expel the initially external applied magnetic field $B_{\mathrm{out}}(=\Delta B_{\mathrm{unit}})$ from the superconducting specimen. That is, the B_{induce} and $B_{\mathrm{out}}(=\Delta B_{\mathrm{unit}})$ values are completely compensated by each other. This is the origin of the Meissner effect in superconductivity. On the other hand, such excited bosonic supercurrent states with the induced magnetic fields $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);B_{\mathrm{induced}};0\right)\right\rangle$ can be immediately destroyed because the induced electric field

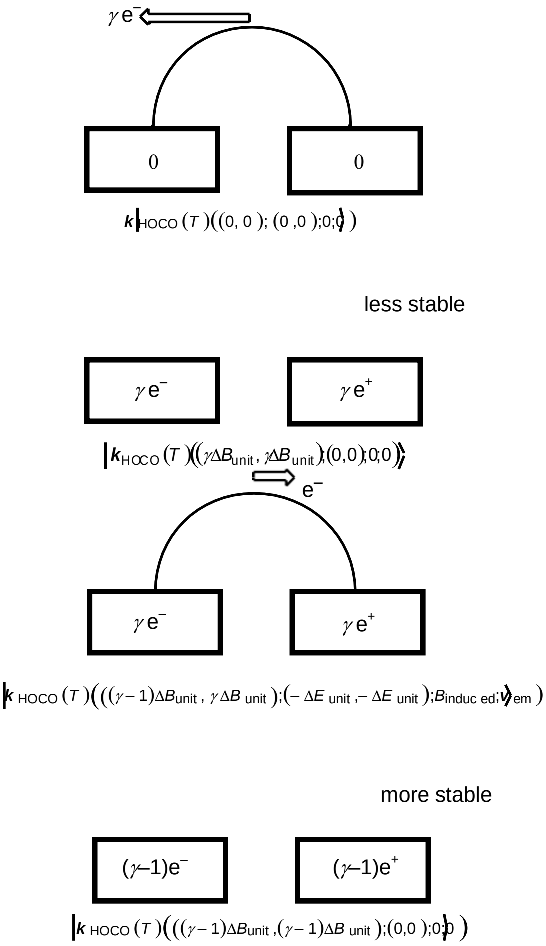

Fig. 10. The total electrical currents for $j=\gamma$ and $j=\gamma-1$

Penetrates into the superconducting specimen, and the electronic state becomes another bosonic excited supercurrent state for $j=0$ ($\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$) (Fig. 1 (c)). In the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ state, the supercurrent can be induced, and thus there is kinetic energy ($E_{\mathrm{kinetic}}(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}})$). That is, the energy of the electromotive force ΔE_{unit} for the

$\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},0);B_{\mathrm{induced}};0\right)\right\rangle$ state is converted to the kinetic energy of the supercurrent for the $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ state. Both the supercurrent ($\boldsymbol{v}_{\mathrm{em},\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}})$) and the magnetic field ($B_{\mathrm{induced},\boldsymbol{k}_{\mathrm{HOCO}}}(\Delta E_{\mathrm{unit}},0)$) can be induced under the condition of the closed-shell electronic structure with zero spin magnetic field and canonical momentum ($\sigma_{\mathrm{spin}}=0$; $\boldsymbol{p}_{\mathrm{canonical}}=0$). This is the origin of the Ampère's law and the Meissner effect in superconductivity. Such excited bosonic states with supercurrents $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((\Delta B_{\mathrm{unit}},0);(\Delta E_{\mathrm{unit}},\Delta E_{\mathrm{unit}});B_{\mathrm{induced}};\boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ cannot be destroyed because of the stable closed-shell electronic states, and the induced supercurrent cannot be destroyed. This is the reason why we can observe non dissipative currents in superconductivity during the applying the magnetic field.

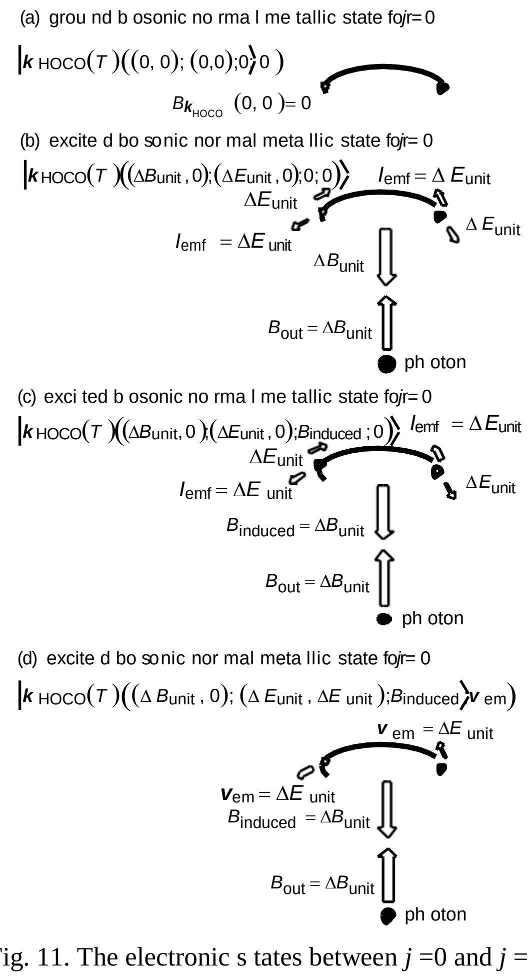

Fig. 11. The electronic states between $j=0$ and $j=1$ in superconductivity

V. RECONSIDERATION OF THE LENZ'S LAW

According to the Lenz's law, it has been considered that the electrical current can be induced when the magnetic field is changed. On the other hand, according to our theory, the electrical current can be induced in order that the photon becomes massive (that is, the magnetic field is expelled from the specimen) by absorbing Nambu–Goldstone boson formed by the fluctuation of the electronic state pairing of an electron, because of the very large stabilization energy ($V_{\mathrm{kin,\,Fermi},\boldsymbol{k}_{\mathrm{LUCO}}\sigma}(0) \approx 35$ eV) for the Bose–Einstein condensation ($\boldsymbol{p}_{\mathrm{canonical}} = 0$; $V_{\mathrm{kin,\,Bose},\boldsymbol{k}_{\mathrm{LUCO}}\sigma}(0) = 0$ eV), and the Stern–Gerlach effect. The initial electronic state tries not to change the electronic structure ($\boldsymbol{p}_{\mathrm{canonical}} = 0$) by induction of the electrical current and magnetic field. After that, the photon becomes massless (magnetic field can penetrate into the specimen), and thus the electrical current can be dissipated. And at the same time, photon is emitted from an electron and this is the origin of the Joule's heats.

The energy for the magnetic field itself, which has not been considered to be origin of the electromotive forces, is closely related to the electromotive force, the electrical current, and the resistivity. On the other hand, the dynamically created energy originating from the dynamic change of the magnetic field (generation of electricity), which has been considered to be origin of the electromotive forces, is closely related to the Joule's heats, but not directly related to the electromotive forces.

As discussed in the previous studies, the Stern–Gerlach effect is the main reason why the even one electron can be in the bosonic state at usual low temperatures. And the very large stabilization energy ($V_{\mathrm{kin,Fermi},\boldsymbol{k}_{\mathrm{LUCO}}\sigma}(0) \approx 35$ eV) for the Bose–Einstein condensation ($\boldsymbol{p}_{\mathrm{canonical}} = 0$; $V_{\mathrm{kin,\,Bose},\boldsymbol{k}_{\mathrm{LUCO}}\sigma}(0) = 0$ eV) originating from the disappearance of the kinetic energy of an electron ($\boldsymbol{p}_{\mathrm{canonical}} = 0$; $V_{\mathrm{kin,Bose},\boldsymbol{k}_{\mathrm{LUCO}}\sigma}(0) = 0$ eV) is the main reason why the magnetic momentum of an electron cannot be changed but electrical currents can be induced soon after the external magnetic field is applied. If an electron were not in the bosonic state, the applied magnetic field would immediately penetrate into the specimen as soon as the magnetic field is applied, and we would not observe any electrical current even in the normal metals. This bosonic electron is closely related to the concepts of the Higgs boson.

VI. COMPARISON OF THE NORMAL METALLIC STATES WITH SUPERCONDUCTING STATES

A. Problems between the Lenz's Law in the Normal Metallic States and the Meissner Effects in the Superconducting States

Let us next compare the normal metallic states with the superconducting states (Fig. 12). In superconductivity, two electrons behave only as a Bose particle. On the other hand, in the normal metallic states, an electron behaves as bosonic as well as fermionic under the applied external magnetic field.

Let us consider the experiment at room temperature, in an applied external magnetic field ($B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_j, B_j\right)\left(= B_j = j\Delta B_{\mathrm{unit}}\right) < B_{\mathrm{c}}$) at the bosonic ground normal metallic state $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}});(0,0);0;0\right)\right\rangle$.

Therefore, the magnetic field $B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_j, B_j\right)$ can completely penetrate into the sample, and the electrical current is not induced ($I_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_j, B_j\right) = 0$). Now cool the specimen in the magnetic field $B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_j, B_j\right)$ to below the T_{C}. In such a case, the ground normal metallic electronic $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}});(0,0);0;0\right)\right\rangle$ states can change and can be in the bosonic excited superconducting states $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\Delta B_{\mathrm{unit}}, 0);(j\Delta E_{\mathrm{unit}}, j\Delta E_{\mathrm{unit}}); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ below T_{C}. Therefore, stable Cooper pairs can be formed below T_{C}, and the ground electronic states $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}});(0,0);0;0\right)\right\rangle$ ($B_{\mathrm{out}} = B_{\mathrm{in}}$) in the normal metallic states ($B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_j, B_j\right)\left(= B_j = j\Delta B_{\mathrm{unit}}\right)$) change to the excited electronic states $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\Delta B_{\mathrm{unit}}, 0);(j\Delta E_{\mathrm{unit}}, j\Delta E_{\mathrm{unit}}); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ ($B_{\mathrm{out}} \neq B_{\mathrm{in}}$) in the superconducting states ($B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_j, 0\right)\left(= 0\right)$). Therefore, according to the Meissner effects, the magnetic field cannot penetrate into the sample anymore ($B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_j, 0\right)\left(= 0\right)$), and the electrical current is induced ($I_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_j, 0\right)\left(\propto B_j = j\Delta B_{\mathrm{unit}}\right)$).

According to the Lenz's law, the magnetic field ($B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_j, B_j\right)\left(= B_j = j\Delta B_{\mathrm{unit}}\right)$) would penetrate into the sample completely even below T_{C} since the magnetic field ($B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_j, B_j\right)\left(= B_j = j\Delta B_{\mathrm{unit}}\right)$) does not change during temperature decreasing process. On the other hand, it has been well known that the magnetic field cannot penetrate into the sample at all well below T_{C}, according to the Meissner effect. At this time, this phenomenon does not obey the Lenz's law. That is, even in superconductivity, the electronic properties usually obey the Lenz's law, on the other hand, sometimes do not obey the Lenz's law. This is because the Meissner effect can be always dominantly applied even in the case where the electronic states cannot obey the Lenz's law. That is, since the discovery of the Meissner effect, it has been considered that the superconductivity as well as the normal metallic states basically obey the Lenz's law, on the other hand, if there is discrepancy between the Lenz's law and the Meissner effect, the Meissner effect can be considered to be more dominant than the Lenz's law in superconductivity. The Meissner effect is independent basic property and cannot be derived from the zero resistivity. This means that the Meissner effect is more essential than the Lenz's law, and the Lenz's law should be explained in terms of more fundamental Meissner effects in the normal metallic states as well as in the superconducting states. In other words, the observation of the Lenz's law can be considered as a special case of the Meissner effect in the normal metallic states. That is, the unified interpretation between the Lenz's law and the Meissner effect, that is, between the normal metallic states and superconducting states has not been completely established. Therefore, we try to establish the unified interpretations between them.

B. The Meissner Effects in Superconductivity in the Two Electrons Systems

There are only two ground states ($j = 0$, n_c) between the magnetic fields 0 ($j = 0$) and B_c ($j = n_c$). Conventional Meissner effects in the superconducting states can be considered that the perfect diamagnetism can be applied in the wide range from the ground $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((0,0);(0,0);0;0)\right\rangle$ states at the zero magnetic field ($B_{\boldsymbol{k}_{\mathrm{HOCO}}}(0,0) = 0$) ($\boldsymbol{p}_{\mathrm{canonical}} = 0$; $\boldsymbol{v}_{\mathrm{em}} = 0$) to the ground $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((B_c, B_c);(0,0);0;0)\right\rangle$ states at the critical magnetic field ($B_{\boldsymbol{k}_{\mathrm{HOCO}}}(\pm B_c, \pm B_c) = \pm B_c = \pm n_c \Delta B_{\mathrm{unit}}$) ($\boldsymbol{p}_{\mathrm{canonical}} = 0$; $\boldsymbol{v}_{\mathrm{em}} = 0$) (Fig. 2). In the various excited superconducting ranges $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((B_j, 0)(E_j, E_j) B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}})\right\rangle$ between $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((0,0);(0,0);0;0)\right\rangle$ and $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((B_c, B_c);(0,0);0;0)\right\rangle$ the supercurrent can be induced ($I_{\boldsymbol{k}_{\mathrm{HOCO}}}(B_{\mathrm{out}}, 0) \propto B_{\mathrm{out}}$) because of very stable bosonic electron Cooper pairs formed by two electrons with opposite momentum and spins occupying the same orbitals.

C. The Lenz's Law in the Normal Metals in the One Electron Systems

On the other hand, there are $n_c + 1$ ground superconducting states ($j = 0, 1, 2, ..., n_c$) between the magnetic fields 0 ($j = 0$) and B_c ($j = n_c$) in the normal metallic states. The Lenz's law in the normal metallic states can be considered that the perfect diamagnetism can be applied only from the initial ground state $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((j\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}});(0,0);0;0)\right\rangle$ under the magnetic field ($B_{\boldsymbol{k}_{\mathrm{HOCO}}}(B_j, B_j) (= B_j = j\Delta B_{\mathrm{unit}})$) ($\boldsymbol{p}_{\mathrm{canonical}} = 0$; $\boldsymbol{v}_{\mathrm{em}} = 0$) to the neighboring quantized ground states $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)(((j \pm 1)\Delta B_{\mathrm{unit}}, (j \pm 1)\Delta B_{\mathrm{unit}});(0,0);0;0)\right\rangle$ under the magnetic field ($B_{\boldsymbol{k}_{\mathrm{HOCO}}}(B_{j\pm1}, B_{j\pm1}) (= B_{j\pm1} = (j \pm 1)\Delta B_{\mathrm{unit}})$) ($\boldsymbol{p}_{\mathrm{canonical}} = 0$; $\boldsymbol{v}_{\mathrm{em}} = 0$) via the excited bosonic $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)(((j \pm 1)\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}}; (\pm\Delta E_{\mathrm{unit}}, \pm\Delta E_{\mathrm{unit}}); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right\rangle$ and fermionic $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)(((j \pm 1)\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}}; (\pm\Delta E_{\mathrm{unit}}, \pm\Delta E_{\mathrm{unit}}); \sigma_{\mathrm{spin}}; \boldsymbol{p}_{\mathrm{canonical}}\right\rangle$ electronic states (Fig. 2). In only very small ranges ($\pm\Delta B_{\mathrm{unit}}$) between $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)((j\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}});(0,0);0;0)\right\rangle$ and

$\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\pm1)\Delta B_{\mathrm{unit}},(j\pm1)\Delta B_{\mathrm{unit}};(0,0);0;0\right)\right\rangle$, the excited supercurrent state ($\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\pm1)\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}}; \left(\pm\Delta E_{\mathrm{unit}},\pm\Delta E_{\mathrm{unit}}\right); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right\rangle\right.$) can be induced ($I_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_{j\pm1}, B_j \left(\propto B_{j\pm1}-B_j = (j\pm1)\Delta B_{\mathrm{unit}} - j\Delta B_{\mathrm{unit}} = \pm\Delta B_{\mathrm{unit}}\right)\right)$ ($\boldsymbol{p}_{\mathrm{canonical}}=0$; $\boldsymbol{v}_{\mathrm{em}}\neq0$). On the other hand, such currents can exist for only very short time and can be immediately dissipated. This is because electronic pairing states in the opened-shell electronic structures are very fragile subject to the external applied field. At the same time, a photon is emitted from such an electronic state $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\pm1)\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}}; \left(\pm\Delta E_{\mathrm{unit}},\pm\Delta E_{\mathrm{unit}}\right); \sigma_{\mathrm{spin}}; \boldsymbol{p}_{\mathrm{canonical}}\right)\right\rangle$, and this is the origin of the electrical resistivity in the normal metallic states. That is, we can interpret that the Lenz's law in the normal metallic states are the continuous Meissner effects between each ground ($\boldsymbol{p}_{\mathrm{canonical}}=0$; $\boldsymbol{v}_{\mathrm{em}}=0$) and excited ($\boldsymbol{p}_{\mathrm{canonical}}=0$; $\boldsymbol{v}_{\mathrm{em}}\neq0$ and $\boldsymbol{p}_{\mathrm{canonical}}\neq0$; $\boldsymbol{v}_{\mathrm{em}}=0$) superconducting states which appears only on small range of the magnetic field ($\pm\Delta B_{\mathrm{unit}}(<< B_{\mathrm{c}})$) between the adjacent quantum ground states $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left(B_j, B_j;(0,0);0;0\right)\right\rangle$ and $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left(B_{j\pm1}, B_{j\pm1};(0,0);0;0\right)\right\rangle$ for only very short time.

Finite $B_{\mathrm{c,SC}}\left(=n_{\mathrm{c}}\,\Delta B_{\mathrm{unit}} >> \Delta B_{\mathrm{unit}}\right)$ values in superconducting states originate from the closed-shell electronic structures formed by two electrons with opposite momentum and spins occupying the same orbital by which the Cooper pairs become stable with respect to the small magnetic field. On the other hand, infinitesimal $B_{\mathrm{c,NM}}\left(=\pm\Delta B_{\mathrm{unit}}\right)$ values in the normal metallic states originate from the opened-shell electronic structures formed by only one electron, by which bosonic electronic state pairing of an electron can be easily destroyed by even very small applied magnetic field. Therefore, the Meissner effects can be observed only for a very short time in the normal metallic states. We can consider that the Lenz's law in the normal metallic states is the continuous phenomenon where the Meissner effects in the superconducting states can be observed for a very short time repeatedly.

VII. RECONSIDERATION OF THE ELECTROMOTIVE FORCES

A. Conventional Lenz's Law

Let us consider the case where we cool the superconducting specimen in the constant magnetic field $B_{\boldsymbol{k}_{\mathrm{HOCO}}}\left(B_j, B_j\right)$ from room temperature to 0 K (Fig. 12). According to the conventional Lenz's law, it has been considered that the electromotive force is induced when the applied magnetic field changes, as $I \propto \mathrm{emf} \propto B_{\mathrm{out}} - B_{\mathrm{intitia}}$. Therefore, when we cool the superconducting specimen in the constant magnetic field $B_{\boldsymbol{k}_{\mathrm{HOCO}}}(B_j, B_j)$ from room temperature to 0 K, the electromotive force would not be induced, as $I \propto \mathrm{emf} \propto B_{\mathrm{out}} - B_{\mathrm{intitial}} = B_j - B_j = 0$. On the other hand, it has been well known for a long time that the perfect diamagnetic supercurrents (and thus electromotive force) can be induced when we cool the superconducting specimen even in the constant magnetic field $B_{\boldsymbol{k}_{\mathrm{HOCO}}}(B_j, B_j)$ from room temperature to 0 K. That is, this phenomenon cannot be explained by the conventional Lenz's law, and the Lenz's law and Meissner effects contradict each other in this case.

B. *New Definition of the Lenz's Law*

However, we can consider that during temperature decreasing process even under the constant magnetic field ($B_{\mathrm{out}} = B_j = \mathrm{const.}$), the electronic states have been changed from the two one-bosonic normal metallic particles ground states $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}}); (0,0); 0; 0\right)\right\rangle$ (B_j) to the one-bosonic superconducting particle excited states $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\Delta B_{\mathrm{unit}}, 0); (j\Delta E_{\mathrm{unit}}, j\Delta E_{\mathrm{unit}}); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ (B_j). According to our theory discussed in the previous studies [1–7] (Fig. 12), the electromotive force can be well explained by considering that the electromotive forces can be induced by the difference between the applied magnetic field (B_{out}) and the magnetic field for the bosonic ground states (B_{ground}), as $I \propto \mathrm{emf} \propto B_{\mathrm{out}} - B_{\mathrm{ground}}$. The magnetic field of the ground states for the two-one-bosonic normal metallic particles ground states $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}}); (0,0); 0; 0\right)\right\rangle$ ($B_{\mathrm{out}} = B_j$) is also B_j ($B_{\mathrm{ground}} = B_j$), on the other hand, that for one-bosonic superconducting particle excited states $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\Delta B_{\mathrm{unit}}, 0); (j\Delta E_{\mathrm{unit}}, j\Delta E_{\mathrm{unit}}); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ ($B_{\mathrm{out}} = B_j$) is 0 ($B_{\mathrm{ground}} = 0$). Therefore, the electromotive force for the normal metallic ground states $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\Delta B_{\mathrm{unit}}, j\Delta B_{\mathrm{unit}}); (0,0); 0; 0\right)\right\rangle$ at room temperatures under the constant magnetic field ($B_{\mathrm{out}} = B_j$) can be estimated as $I \propto \mathrm{emf} \propto B_{\mathrm{out}} - B_{\mathrm{ground}} = B_j - B_j = 0$ at 300 K. On the other hand, that for the superconducting excited states $\left|\boldsymbol{k}_{\mathrm{HOCO}}(T)\left((j\Delta B_{\mathrm{unit}}, 0); (j\Delta E_{\mathrm{unit}}, j\Delta E_{\mathrm{unit}}); B_{\mathrm{induced}}; \boldsymbol{v}_{\mathrm{em}}\right)\right\rangle$ at 0 K under the constant magnetic field ($B_{\mathrm{out}} = B_j$) can be estimated as $I \propto \mathrm{emf} \propto B_{\mathrm{out}} - B_{\mathrm{ground}} = B_j - 0 = B_j$ at 0 K. In other words, we may consider that the *electromotive force is observed* as a consequence of the fact that each excited bosonic ($\boldsymbol{p}_{\mathrm{canonical}} = 0$; $\boldsymbol{v}_{\mathrm{em}} \neq 0$) electronic states try not to be converted to the another ground bosonic ($\boldsymbol{p}_{\mathrm{canonical}} = 0$; $\boldsymbol{v}_{\mathrm{em}} = 0$) electronic states.

The electromotive forces have been considered to originate from the changes of the applied magnetic fields. Therefore, according to the conventional interpretation of the electromotive forces, the electromotive forces would not appear and electrical currents cannot be observed during temperature decreasing process under the constant magnetic field ($B_{\text{out}} = B_j = \text{const.}$). On the other hand, during temperature decreasing process even under the constant magnetic field ($B_{\text{out}} = B_j = \text{const.}$), the electrical currents can be observed. This can be understood by considering that the electronic states have been changed from the two one-bosonic normal metallic particles ground states $\left|\boldsymbol{k}_{\text{HOCO}}(T)\left((j\Delta B_{\text{unit}}, j\Delta B_{\text{unit}});(0,0);0;0\right)\right\rangle(B_j)$ to the one-bosonic superconducting electronic state. That is, the applied magnetic field does not change, but the ground states related to the Meissner effect, to which each electronic state belongs, can change during temperature decreasing process under the constant magnetic field ($B_{\text{out}} = B_j = \text{const.}$). In other words, the difference between the magnetic field which is applied to the excited electronic state, and the magnetic field under which the reference electronic state becomes the ground state, appears during temperature decreasing process under the constant magnetic field ($B_{\text{out}} = B_j = \text{const.}$). Therefore, we can conclude that the difference between the magnetic field which is applied to the excited electronic state (B_{out}), and the magnetic field for the ground states to which the reference electronic state belongs, rather than the changes of the applied magnetic fields ($B_{\text{out}} - B_{\text{intitia}}$), is the origin of the electromotive forces (Fig. 12).

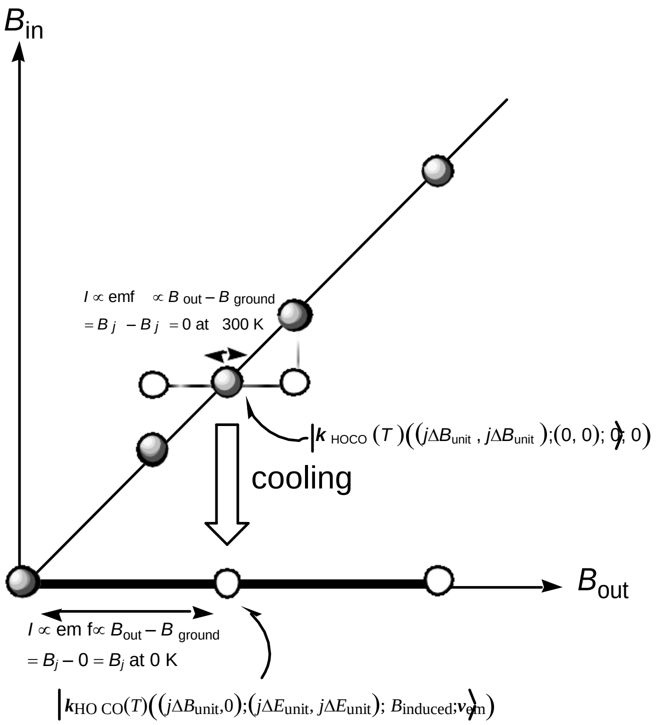

Fig. 12. The origin of the electromotive force.

VIII. CONCLUDING REMARKS

Related to seeking for the room-temperature superconductivity, in this article, we compare the normal metallic states with the superconducting states. Furthermore, in this article, we elucidate the mechanism of the Faraday's law (experimental rule discovered in 1834) in normal metallic states and the Meissner effects (discovered in 1933) in superconductivity, on the basis of the theory suggested in our previous researches.

In superconductivity, two electrons behave only as a Bose particle. On the other hand, in the normal metallic states, an electron behaves as bosonic as well as fermionic under the applied external magnetic or electric field. An electron in the bosonic state with zero kinetic energy ($\boldsymbol{p}_{\text{canonical}} = 0$; $V_{\text{kin,Bose},\boldsymbol{k}_{\text{HOCO}}\sigma}(0) = 0$ eV) is much more stable than an electron in the fermionic state with large kinetic energy of about 35 eV ($\boldsymbol{p}_{\text{canonical}} \neq 0$; $V_{\text{kin,Fermi},\boldsymbol{k}_{\text{HOCO}}\sigma}(0) \approx 35$ eV) by about 35 eV, in the normal metallic state. Two electrons in the bosonic state with zero kinetic energy ($\boldsymbol{p}_{\text{canonical}} = 0$; $2V_{\text{kin,Bose},\boldsymbol{k}_{\text{HOCO}}\sigma}(0) = 0$ eV) is much more stable than two electrons in the fermionic state with large kinetic energy of about 70 eV ($\boldsymbol{p}_{\text{canonical}} \neq 0$; $2V_{\text{kin,Fermi},\boldsymbol{k}_{\text{HOCO}}\sigma}(0) \approx 70$ eV) by about 70 eV, in the superconducting state. Because of the very large stabilization energy ($V_{\text{kin, Fermi},\boldsymbol{k}_{\text{HOCO}}\sigma}(0) \approx 35$ eV) for the Bose–Einstein condensation ($\boldsymbol{p}_{\text{canonical}} = 0$; $V_{\text{kin,Bose},\boldsymbol{k}_{\text{HOCO}}\sigma}(0) = 0$ eV), the magnetic momentum of an electron cannot be changed but electromotive force (ΔE_{unit}) can be induced soon after the external magnetic field is applied. Furthermore, the electric and magnetic momentum of a bosonic electronic state pairing of an electron cannot be changed but the magnetic field can be induced soon after the electromotive force is induced. Both the supercurrent ($\boldsymbol{v}_{\text{em},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$) and the magnetic field ($B_{\text{induced},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, \Delta E_{\text{unit}})$) can be induced under the condition of the opened-shell electronic structure with zero spin magnetic momentum and canonical momentum ($\sigma_{\text{spin}} = 0$; $\boldsymbol{p}_{\text{canonical}} = 0$). This is the origin of the Faraday's and Ampère's law in the normal metallic state. Furthermore, this is the origin of the Meissner effect and Ampère's law in superconductivity. If an electron were not in the bosonic state, the applied magnetic field would immediately penetrate into the specimen as soon as the magnetic field is applied, and we would not observe any electrical current even in the normal metals.

The induced magnetic field $B_{\text{induced},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, 0)$ expels the initially applied external magnetic field ΔB_{unit} from the normal metallic specimen. Therefore, the induced magnetic field $B_{\text{induced},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, 0)$ is the origin of the Faraday's law in the normal metallic states and the Meissner effects in the superconducting states. It should be noted that the magnetic field $B_{\text{induced},\boldsymbol{k}_{\text{HOCO}}}(\Delta E_{\text{unit}}, 0)(\neq 0)$ is induced but the spin magnetic moment of an electron with opened-shell electronic structure is not changed ($\sigma_{\mathrm{spin}} = 0$). This is very similar to the diamagnetic currents in the superconductivity in that the supercurrents are induced ($\boldsymbol{v}_{\mathrm{em}} \neq 0$) but the total canonical momentum is zero ($\boldsymbol{p}_{\mathrm{canonical}}= 0$). The magnetic field is induced not because of the change of each element of the spin magnetic moment σ_{spin} of an electron (similar to the $\boldsymbol{p}_{\mathrm{canonica}}$ in the superconducting states) but because of the change of the total magnetic momentum as a whole B_{induce} (similar to the $\boldsymbol{v}_{\mathrm{em}}$ in the superconducting states).

The electronic energy is conserved and thus the change of the electronic states is not directly related to the Joule's heats. Therefore, applied energy for the electromotive forces as a consequence of the change of the magnetic field strength itself are not dissipated. In other words, electrical resistivity can be observed because of the electronic properties (the disappearance of total momentum $\boldsymbol{p}_{\mathrm{canonical}}= 0$ and $\boldsymbol{v}_{\mathrm{em}} = 0$ under the statistic magnetic field), on the other hand, the Joule's heats can be observed not because of the electronic properties but because of the magnetic properties (the disappearance of the expelling energy of the magnetic fields originating from the energy for the change of the magnetic field at the beginning, created dynamically (generation of electricity)). We dynamically create the energy for the dynamic change of the magnetic field (generation of electricity) at the beginning, related to the Joule's heats, in addition to the energy for the magnetic field itself, related to the electromotive force, kinetic energy of an electron, and electrical resistivity.

Acknowledgment

This work is supported by The Iwatani Naoji Foundation's Research Grant.

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