Research on the Relationship between Solid Physics and Quantum Mechanics Based on Computer

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Abstract. Solid state physics is the basis of quantum mechanics to study the microstructure and macro properties of crystal materials. The combination of the two can promote the further improvement and development of the structure and properties of solid materials. Under the background of computer application, the development of quantum mechanics is inseparable from the effective support of solid-state physics. It can be seen that the relationship between solid-state physics and quantum mechanics is mutual promotion and correlation. Based on this, this paper first studies the key points of quantum mechanics and its relationship with solid state physics, and then analyses the concrete relationship between quantum mechanics and solid state physics based on computer.

Keywords: Relationship, Solid Physics, Quantum Mechanics, Computer

1. Introduction

With the continuous iteration of computer technology, its in-depth application in the field of quantum physics has greatly promoted the research progress of force particle mechanics, and the research results of solid-state physics are also constantly emerging. As a discipline to study the structure and composition of solids, solid physics focuses on the analysis of the laws and phenomena of the motion and interaction of solid particles¹. The analysis and research of solid-state physics is helpful to clarify the properties and uses of solids, thus promoting the development of many basic disciplines, such as metals, semiconductors and materials. In addition, some modern technologies based on the research results of solid state physics have also achieved many successes. These modern technologies are shown in Figure 1 below.
In addition, solid-state physics promotes the continuous progress of many disciplines and fields, but also makes its research subject to many challenges, such as the connection between traditional solid-state physics and modern frontier physics, and the effective connection between the disciplines of quantum mechanics, etc\cite{2}. These aspects need further research and development with the help of modern computer technology, so as to promote the continuous innovation and progress of corresponding disciplines and fields.

On the one hand, quantum mechanics has obtained remarkable application and development achievements with the help of modern computer technology. For example, the typical applications of quantum mechanics in physics include but are not limited to thermoelectric materials, atomic clocks for precise timing of satellite navigation systems, quantum communication and encryption, which are closely related to people's daily life; On the other hand, the development of quantum mechanics is also inseparable from solid mechanics, so as to further lay the foundation for its development.

As a new application of computer and quantum science, quantum computer has great advantages compared with traditional computer. With its powerful parallel processing ability, quantum computer can handle multiple tasks. The development of quantum computer is inseparable from the effective support of solid-state physics. It can be seen that the relationship between solid-state physics and quantum mechanics is mutual promotion and correlation. Therefore, it is of great practical value to study the relationship between solid state physics and quantum mechanics based on computer.

2. Key points of quantum mechanics and its relationship with solid state physics

2.1. Key points of quantum mechanics

At present, the main points of quantum mechanics include wave function, wave interference, symmetry and homogeneity, and semi integer spin particles. At the wave function level, the quantum mechanical system needs wave function representation to calculate the possible value of observable quantity. Based on the probability of space volume, the analysis of momentum is obtained, and the fuzzy probability image is obtained. This is one of the core contents of quantum mechanics.

2.1.1. Blackbody radiation

In thermal equilibrium, the energy density of cavity radiation is the distribution curve of radiation wavelength. Its shape and position are only related to the absolute temperature T of blackbody, but not to the shape and material of blackbody\cite{3}. The relationship between energy density and wavelength is shown in Figure 2 below. The radiation emitted by such holes in the cavity is called blackbody radiation.

In addition, the vibration energy of the oscillator in the blackbody radiation cavity is not directly proportional to the square of the amplitude and changes continuously, but is proportional to the frequency of the oscillator and can only take discrete values, as shown in the following formula 1:
In order to explain the experimental law of the interaction between the radiation field and the cavity wall material, it must be assumed that the energy exchanged between the cavity electromagnetic field and the cavity wall material is intermittent, part by part, $h\nu$, $2h\nu$, $3h\nu$, which should be assumed that the corresponding energy for all frequencies is quantized.

$$\varepsilon(\nu)d\nu = \frac{8\pi h\nu^3}{c^3} \frac{d\nu}{e^{h\nu/kT} - 1}$$  \hspace{1cm} (1)$$

Figure 2. Energy density of cavity radiation.

The discussion of Planck radiation law is shown in the following equation 2. Electromagnetic radiation not only appears in the form of particles with energy $h\nu$ during emission and absorption, but also propagates in this form in space at the speed of light $C$. such particles are called quantum of light.

$$\rho_\nu d\nu = \frac{8\pi h\nu^3}{c^3} \left( \frac{1}{\exp(h\nu/kT) - 1} \right) d\nu$$ \hspace{1cm} (2)$$

2.1.2. Photoelectric effect

For example, only when the frequency of light is greater than a certain value $V_0$, can photoelectrons be emitted. If the light frequency is less than this value, no electron will be produced no matter how strong the light intensity is and how long the irradiation time is\(^4\). This frequency $V_0$ of light is called the critical frequency. The energy of electron is only related to the frequency of light, and has nothing to do with the light intensity. The light intensity only determines the number of electrons. According to the electromagnetic theory of light, the energy of light depends only on the intensity of light, but not on the frequency.

The concept of light quantum can effectively explain the law of photoelectric effect, as shown in formula below:

$$\frac{1}{2} \mu v^2 = h\nu - A$$ \hspace{1cm} (3)$$

It can be seen from Formula 3 that the energy of photoelectron is only related to the frequency $\nu$ of light, and the intensity of light only determines the number of photons, thus determining the number of photoelectrons. Therefore, the photoelectric effect has been effectively explained and explained. Photons have not only definite energy but also momentum. The velocity of V is based on the velocity of the particle as follows:
$E = \frac{\mu_0 c^2}{\sqrt{1 - \frac{V^2}{C^2}}}$  \hspace{1cm} (4)

2.1.3. Compton scattering problem
Compton Effect refers to the effect of X-ray scattering by light element electrons. Classical electrodynamics cannot explain the emergence of this new wavelength\cite{5}. It is necessary to regard the process of X-ray scattering by electrons as the collision process between photons and electrons, so the effect can be easily understood. Based on the energy and momentum conservation of the system in the collision process, there are:

\[
\begin{align*}
\hbar \omega - \hbar \omega' &= mc^2 - m_0 c^2 \\
\hbar \vec{k} - \hbar \vec{k}' &= m\vec{v} \\
\omega &= 2\pi \nu = \frac{2\pi c}{\lambda} = \frac{c}{\lambda'} = k c
\end{align*}
\]  \hspace{1cm} (5)

2.2. Wave function and Schrodinger equation
If a particle moves in a force field which changes with time and position, its momentum and energy are no longer constant, and its state cannot be described by plane wave, but by more complex wave. The expression of the wave function is as follows:

\[
\Psi = A \exp \left[ \frac{i}{\hbar} (\vec{p} \cdot \vec{r} - Et) \right]
\]  \hspace{1cm} (6)

The wave particle duality observed in the electron diffraction experiment shows that the intensity of the incident electron flow is small, and the particle property of the electron is displayed, and the diffraction pattern is also displayed for a long time; the intensity of the incident electron flow is large, and the diffraction pattern is displayed quickly, as shown in Figure 3 below.

![Figure 3](image)

**Figure 3.** Electron diffraction experiment.

The quantum state of micro particles is fully described by wave function. After the determination of wave function, the average value of any mechanical quantity of a particle, the possible value of its measurement and the corresponding probability distribution are also completely determined. The wave function completely describes the state of micro particles. The evolution of wave function follows Schrodinger equation.

2.3. The connection between quantum mechanics and solid state physics
As an important branch of physics, quantum mechanics and solid state physics are closely related. As a basic discipline of natural science, physics reveals the most basic laws of nature. Quantum mechanics is one of the most basic theories of modern natural science and technology. The relationship between the basic properties of materials and the microstructure of solid is based on the fundamental research of material mechanics.

The basis of quantum mechanics includes wave function and Schrödinger equation, steady state Schrödinger equation and one-dimensional steady state problem, as well as the mechanical quantity and central force field problem in quantum mechanics and the approximate solution of hydrogen atom and Schrödinger equation. Solid state physics includes solid structure, crystal vibration, crystal combination and solid electronic theory.

3. The connection between solid state physics and quantum mechanics based on computer

3.1. The current situation of solid state physics and quantum mechanics
With the rapid iteration and development of computer technology, the current solid state physics mainly includes the basic theory part and the specialized part. The former mainly includes crystal structure and combination, vibration and thermodynamic properties, defects, band theory and free electron theory, while the latter includes the latest frontier of semiconductors, superconductors, amorphous solids and solid magnetism. At present, the related content of solid state physics involves more contents in the field of materials science. However, there is a lack of connection between the physical knowledge of quantum mechanics and other aspects, which leads to some problems in the cognition of solid state physics. This requires that the content of solid physics and quantum mechanics should be further strengthened, especially the crystal structure and combination.

In addition, the current content of solid-state physics pursues theoretical ideas too much and ignores the understanding and enough attention to the process of mathematical derivation, which limits the processing ideas of quantum mechanics. In the aspect of strengthening the connection between solid physics and quantum mechanics, it is necessary to further combine the frontier application and development of condensed matter physics and material science, so as to make the correlation and practical application of both closer.

3.2. Connection between solid state physics and quantum mechanics based on computer
With the gradual deepening of the application of computer technology in the field of solid state physics and quantum mechanics, the relationship between them is more and more close in material science and engineering application. For example, in the practical application of condensed matter physics, superconducting materials, semiconductors and other fields and engineering, the degree of correlation and research integration between the two sides has an important value and role in promoting the development of these fields and disciplines. The combination of quantum mechanics and solid-state physics can not only better reveal the laws of physics, but also promote the development of modern natural science and technology. In addition, solid-state physics is the basis of quantum mechanics to study the microstructure and macroscopic properties of crystal materials. The combination of the two can promote the further improvement and development of the structure and properties of solid materials.

4. Conclusion
In summary, the typical applications of quantum mechanics in physics include but are not limited to thermoelectric materials, atomic clocks for precise timing of satellite navigation systems, quantum communication and encryption, which are closely related to people's daily life. The development of quantum mechanics is also inseparable from solid mechanics as a support, so as to further lay the foundation for its development. It can be seen that solid physics is closely related to quantum mechanics. Through the analysis of the key contents of quantum mechanics and solid state physics, and the analysis of the relationship between them, this paper points out that under the background of
the deepening application of computer technology, the relationship between the two sides can promote the application of related disciplines and engineering.

Acknowledgments
1. Basic research project of basic scientific research business expenses of heilongjiang provincial department of education, project number: 2018-KYYWF-0958;
2. Jiamusi University school-level general project project number project number: 13Z1201587.

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