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Can room temperature superconductivity be reached

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Abstract:

In 1911, scientists first discovered the phenomenon of superconductivity. For more than a century after that, physicists have been committed to the development of new superconducting materials for industrial production and daily life. However, up to now, almost all superconducting materials need to be superconducting under strict pressure and temperature conditions, which greatly limits their application. Therefore, finding the new superconducting materials make it possible to achieve superconducting properties under normal temperature and pressure conditions close to the room, which has become a dream of physicists and material scientists, and it is also an event that the community is eager to pay attention to. So, in the near future, can room temperature superconductivity be achieved? Can it improve human production and life on a large scale? Therefore, this study first reviews the research history of superconducting theory, summarizes and analyzes several popular superconducting materials at present, and analyzes the possibility of applying room temperature superconductivity to production and life, considering the perspective of theory and material combination. The analysis process and results of this paper can play a scientific popularization role for the public concerned about room temperature superconductors and can also be used as an introductory material to help college students interested in superconductors quickly enter the subject.

Keywords: Superconducting, normal temperature and pressure, new materials

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1 Introduction

1.1 Background

In 1911, H.K.Onnes discovered that when he decrease the temperature of the pure mercury to the temperature at around 4.2 Kelvin, the electrical resistance of the pure mercury dropped down to a magnitude that is on the order of 10−5Ω (Onnes, 1911). This phenomenon that violates the common sense of physics immediately aroused everyone ‘s interest. In more subsequent studies, physicists call this zero-resistance and diamagnetism phenomenon superconductivity. Since then, physicists became interested in studying the phenomena of superconductivity. There have been enormous new experimental discoveries and theoretical explanations on this interesting phenomen. It turns out that many metallic materials can transform from a normal electrically conducting state to superconducting state if we provide the right constraints to the material that is under investigation. Such as, temperature, pressure, strength of applied magnetic field.

The phenomena of superconductivity occur in materials when cool it down to certain critical temperature is fascinating and unexpected in many aspects. For a period of time, although people have found that more than one type of materials can achieve superconductivity at extremely low temperatures and high pressures. However, people do not understand the causes and internal principles of this phenomenon. It is not easy to really explain this phenomenon at the atomic level. The first successful microscopic theory is the BCS theory proposed by J. Bardeen, L.N. Cooper and J.R. Schrieffer. This theory explains the reason for the emergence of superconductivity from the perspective of electron-phonon interaction mechanism. However, it only works for some elementary superconductor. It took physicists over 100 years, still the theory is incomplete. In particular, when people realize that ultra-low temperature conditions have become a key factor limiting the application of superconductors, people began to try to find materials that can achieve superconducting transition at higher temperatures. In recent decades, high-temperature and even room-temperature superconductivity has become a goal pursued by people. It can be seen from Table 1 that scientists are constantly trying to increase the critical temperature of superconductors. Since the discovery of copper-based oxide superconductors in 1986 (Bednorz et al., 1986), people have successively found 43K iron-based superconductors, 100K FeSe superconducting materials and up to 287.7K carbonaceous sulfur hydride superconducting materials (Snider et al., 2020). This reflects people’s enthusiasm and strong expectation for room temperature superconducting materials.

Table 1: Timeline of conventional high temperature superconductor

Time	Finding	Reference
1911	Mercury exhibits zero resistance at about 4.2 K.	Onnes et al., 1911
1957	BCS theory	Bardeen et al., 1957
1968	Mcmillan limit	Mcmillan, 1968
1986	Copper-based superconductivity achieves 31k superconductivity	Bednorz et al., 1986
2008	Iron-based superconductivity achieves 43k superconductivity	Takahashi et al., 2008
2015	Superconductivity above 100 K	Ge et al., 2015
2020	Superconductivity above 287.7K	Snider et al., 2020

1.2 Purpose significance

As a literature review paper, this paper hopes to sort out the perfection of superconducting theory in the past few decades by reviewing the discovery process of superconducting phenomena. At the same time, we hope to compare and analyze the current research and development progress of superconducting materials, summarize the characteristics, advantages and disadvantages of superconducting materials concerned by the current scientific frontier, and try to analyze the material characteristics needed to achieve room temperature superconductivity, and evaluate the possibility of room temperature superconductivity in the future. At a time when various superconducting materials are emerging in an endless stream, and various kinds of fake news claiming to achieve room temperature superconductivity are flooding the research field, systematically combing the development of this discipline and sorting out the research progress on room temperature superconductivity can not only provide the public and students interested in superconductivity with a clear understanding of the discipline. More importantly, the review report of this project can help researchers in related fields to clarify their ideas and provide some ideas for future research.

1.3 Reasons for choosing the topic

First of all, the author is very interested in the development of cutting-edge technology, and room temperature superconductivity is the forefront of scientific research. The author hopes that there will be an opportunity to engage in research in related fields in the future. Therefore, the literature review of this topic can help the author to understand the development history and current situation of this field, and lay a good foundation for my future study and research.

On the other hand, in recent years, the news of room temperature superconductivity often appears in the news, which often arouses the strong interest of the scientific and technological community and the general public at the same time. It is mainly because people have great expectations for the development prospects of room temperature superconductivity. However, the blind pursuit of research hotspots will cause fraud and dishonesty to a certain extent, which will not only delay the development of science, but also mislead the public. Therefore, the author hopes to systematically sort out the superconducting research from the beginning of superconducting development to today, provide a scientific material for the general public to understand room temperature superconductors, and provide new ideas for basic researchers to sort out their ideas.

1.4 Structure of the thesis

The paper will be discussed from the following aspects: In the background introduction part, I will sort out the development history of superconducting related theories and show them clearly in the form of tables. In the first part of the text, I will first introduce the theoretical basis of superconductivity, and introduce the more important BCS theory and high temperature superconducting theory in detail. After that, I will classify and discuss the superconducting materials that are more concerned in the existing research, and compare their advantages and disadvantages. In the second part of the main body, I will discuss the research progress of room temperature superconductors, focusing on how front-line researchers explore new room temperature superconducting materials, what methods are available to synthesize new room temperature superconductors, and how to study the properties of room temperature superconductors. In the third part of the text, I will discuss the application prospects of room temperature superconductivity in the future, including magnetic levitation and magnetic resonance imaging. Next, the author will discuss and evaluate the feasibility of room temperature superconductivity in combination with the multidisciplinary research and development progress of physics and superconductivity, and form the conclusion of this paper. Finally, I will reflect on the completion and shortcomings of this project, and propose possible future improvements.

2. Literature review

By searching on the web of science with the keywords of superconductivity, high temperature superconductivity and room temperature superconductivity, it can be found that the literature on superconductivity in the past 25 years has always been more than 3500, of which the literature on high temperature superconductivity has always been around 2000, while the literature on room temperature superconductivity has been increasing year by year since 2018, and it is currently around 240 per year (Fig. 1).

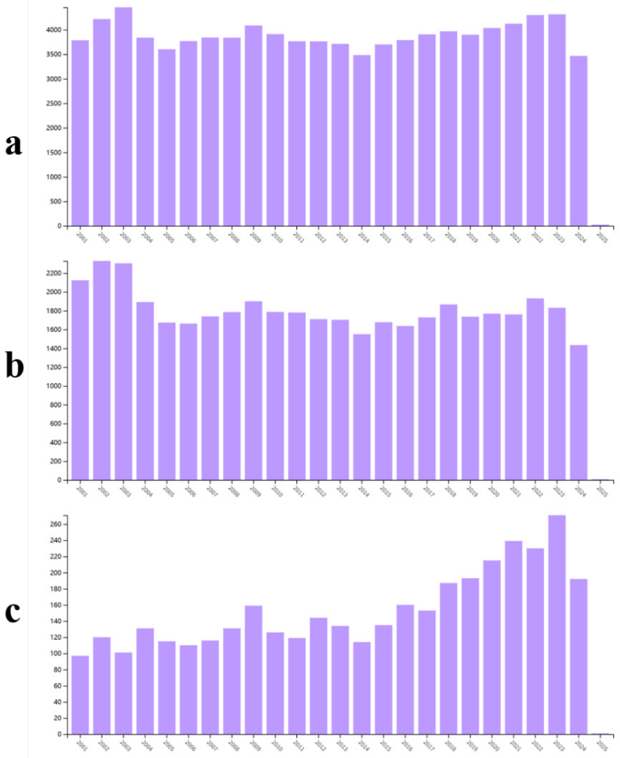

Fig. 1 The number of papers related to superconductivity on web of science in the last 25 years (a. superconductivity, b. high temperature superconductivity, c. room temperature superconductivity)

2.1 The characteristics of superconducting state

Physicists discovered that the process of transformation from normal state to superconducting state is path independent, there they just introduced it as a new thermodynamic state of matter. Firstly, we need to distinguish between two concepts perfect conductor and superconductor. From intrinsic ohm's law:

$$J = \sigma E, E = \frac{1}{\sigma} J = \rho J$$

when a perfect conductor is at electrostatic equilibrium, the inside electric field would be 0. From Faraday's law:

$$\nabla \times E = -\frac{\vartheta B}{\vartheta t}$$

The magnetic field B_i inside the perfect conductor would be constant. However, the internal magnetic field of the superconductor is 0. Therefore, a perfect conductor is not equivalent to a superconductor. Superconductor is more than a perfect conductor. The traditional view is that the transition from normal state of matter to perfectly conducting state of matter is path dependent, however the superconducting phase transition of matter is path independent (Sharma et al., 2022). Therefore, the superconducting state of matter is a thermodynamic state of matter, perfectly conducting state is not.

One of the key signatures of superconductivity is the Meissner Effect in which would lead to the facts that superconductor is also a perfect diamagnetism. For now, Superconductor=Perfect conductor + Perfect diamagnetism.

Experimentally, physicists observed that when the temperature of certain metals were decreased below a critical temperature, they would begin to expel all the applied magnetic field so that there's no magnetic field trapped inside of it. However, for the conducting state of matter the applied magnetic fields would penetrate through it. Fritz and Heinz London are the first ones to use a phenological approach to describe this phenomena. However, it does not take the microscopic behavior of electrons into consideration.

For a more solid derivation, advanced level of quantum mechanics is needed in which the superconducting electron in the superconductor is described as a macroscopic wavefunction. The basic idea is that there are two types of electrons in a conductor. One is the normal electrons that carry the amount of charge q_n and density n_n (particle density per unit volume), the other one is the superconducting electrons that carry the amount of charge q_s and the density n_s. The density of the electrons would change as the matter is transforming from one state to another. In the normal conducting state of matter, the density of electrons inside the conductor $n = n_n$. However, in the superconducting state of matter, $n_s = n$, $n_n \rightarrow 0$.

2.2 BCS theory

Since the superconductivity was discovered in 1911, physicists have always wanted to crack the physical basis behind superconductivity, and many scholars have explained it from multiple levels. In 1957, the BCS theory developed and perfected by John Bardeen, Leon N.Cooper and John R.Schrieffer explained the superconductivity from the microscopic point of view, and won the Nobel Prize in physics in 1972 (Hoddeson, 2002). Since then, the BCS theory has gained great recognition in the study of low-temperature superconductivity. Using this theory, the superconductivity of metals and alloys can be successfully explained. The BCS theory holds that since the electrons with opposite spin and momentum in the metal form a Cooper pair by pairing, this Cooper pair can move losslessly in the lattice, resulting in superconductivity (Bardeen et al., 1957). The superconducting transition temperature Tc formula of BCS theory is as follows:

$$K_B T_C = (2\gamma h W_D / \pi) exp(-1/\lambda)$$

Where λ is the electro-acoustic interaction coefficient and W_D is the Debye frequency of the system.

According to the explanation of superconductivity by BCS theory, thermal motion will destroy the formation of Cooper pair at high temperature, thus hindering the occurrence of superconductivity. On the contrary, under extremely low temperature conditions, the energy of the Cooper pair is relatively stable, and it is easy to form a superconducting state without resistance.

2.3 High temperature superconducting theory

2.3.1 Unconventional superconductors

Since the introduction of superconductivity, it has been found that the transition temperature of superconducting for most materials is very low, always around 20K. In 1968, Mcmillan proposed the Mcmillan limit based on the BCS theory, that is, the superconducting transition temperature caused by electron-phonon interaction cannot exceed 40K (Mcmillan, 1968). However, since then, new materials have been continuously studied to break through the superconducting transition temperature of 40K. In particular, the discovery of copper-based high-temperature superconductors (Zhongxian et al., 1987) in 1986 and the discovery of iron-based high-temperature superconductors in 2008 (Kamihara et al., 2008) have broken people's understanding of traditional superconducting theory and also set off a wave of research on high-temperature superconducting theory.

In the study of these new high-temperature superconductor materials, it has been found that the superconductivity of some of these materials cannot be explained by the BCS theory. Therefore, in the study of superconductors, people generally regard superconductors that conform to the BCS theory as conventional superconductors, while superconductors that does not conform to the BCS theory are classified as unconventional superconductors. The study of the mechanism of such higher transition temperature superconductivity has always been a difficulty that physicists hope to overcome.

2.3.2 Pairing symmetry

Since the discovery of very high temperature superconducting materials in 1986 (Zhongxian et al., 1987), the principle behind high temperature superconductivity is still not very clear. Although the pairing of electrons in unconventional superconductivity has been observed in experiments, this pairing mechanism cannot be explained by the phonon-electron mechanism of BCS theory. Researchers have determined that there is symmetry in superconducting electron pairing in high temperature superconductors through experimental measurements. In quantum mechanics, superconductivity is regarded as a macroscopic quantum state, so the quantum wave functions of superconductors can be divided into s-wave, p-wave and d-wave. These different wave functions have different symmetries. The wave functions of different symmetries reflect the orbital angular momentum of paired electrons, which will ultimately determine the physical properties of superconductors. Early studies have suggested that copper-based oxide superconductors are d-wave pairing symmetry (Hidden order in the cuprates). The symmetry of these different wave functions is different. In the study of the mechanism of high temperature superconductivity, it is a key step to determine the symmetry of the electron pairing wave function of the superconductor. In 2021, Xue's team found the characteristics of s-wave pairing (Zhu et al., 2021) by measuring data on thousands of samples.

We are still not sure what is the interaction mechanism of electron pairing in unconventional superconductors? On the one hand, people hope to find out more new high-temperature superconducting materials by analyzing the principle of high-temperature superconductivity. On the other hand, people study the existing high-temperature superconducting materials by developing new technologies such as angle-resolved photoelectron spectroscopy, hoping to provide new ideas for understanding the mechanism of high-temperature superconductivity.

As shown in Fig.2, the critical temperature and discovery time of various superconducting materials. It can be seen that people are committed to the development of new superconducting materials, hoping to break through the temperature limit, so as to better apply superconducting materials to human production and life.

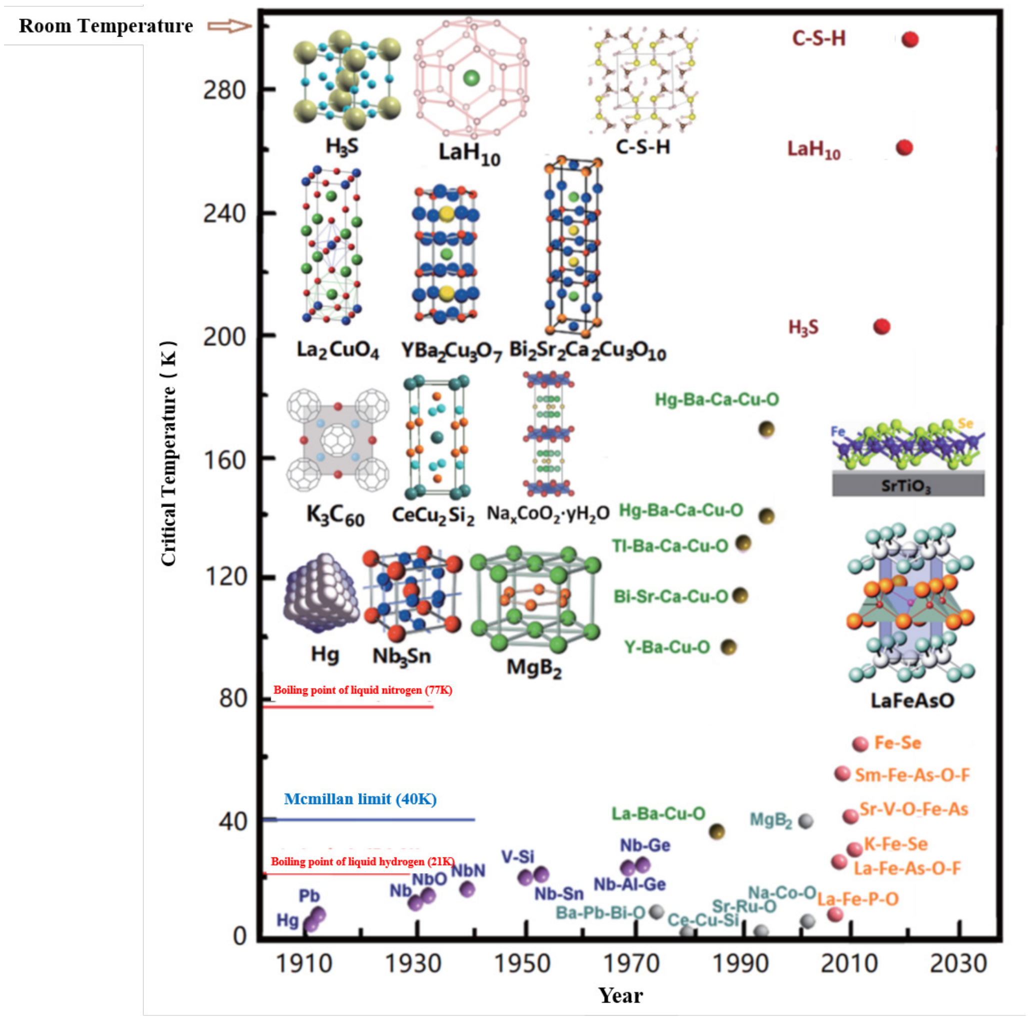

Fig. 2 The discovery age and critical temperature of superconducting materials(Cited from Luo, 2021)

2.4 High temperature superconductors

2.4.1 Copper oxide superconductor

Copper oxide superconductors were first discovered by Johannes Georg Bednorz and Alex Müller in 1986. The critical temperature of superconducting transition is 31K (Bednorz et al., 1986). Then in 1987, Zhao Zhongxian et al.discovered the high temperature superconducting material YBa2Cu3O7, and its superconducting transition temperature was 93K at atmospheric pressure (Zhongxian et al., 1987), which is much higher than the 40K predicted by Mcmillan limit. In 1994, the superconducting critical temperature of the modified superconducting material HgBa2Ca2Cu3O8 + δ under high pressure reached 164K (Gao et al., 1994). The research and development of copper oxide high-temperature superconductors has continuously refreshed the critical temperature of superconducting transition, and has also greatly increased people's confidence in the realization of high-temperature superconductivity. The mechanism of copper oxide superconductors has also been explored. Taking Y-Ba-Cu-O as an example, its crystal structure (Fig. 3) has been analyzed. Its crystal structure shows a clear layered distribution, in which the copper oxide surface is considered to be a key factor in superconductivity. (Tiege, 2019)

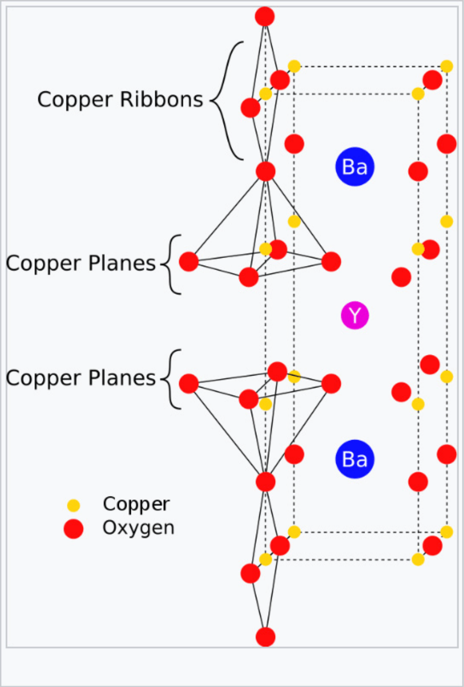

Fig. 3 The crystal structure of Y-Ba-Cu-O superconductor (Cited from Tiege, 2019)

2.4.2 Iron oxide superconductors

Iron oxide high-temperature superconductors were first discovered by Japanese scientist H. Hosono in 2008, when the critical temperature of superconducting materials was 26K (Kamihara et al., 2008). Then, by increasing the pressure, their group raised the critical transition temperature to 43K (Takahashi et al., 2008). Later, a team led by Chinese scientist Zhao Zhongxian achieved a superconducting transition temperature of 55 K by modifying iron-based superconducting materials (Zhi et al., 2008). The latest research shows that China's Xue Qikun team discovered 100 K superconductivity in 100 K in single-layer FeSe films on doped SrTiO3(Ge et al., 2015). The currently discovered iron-based superconductors are structurally similar (Fig.4).

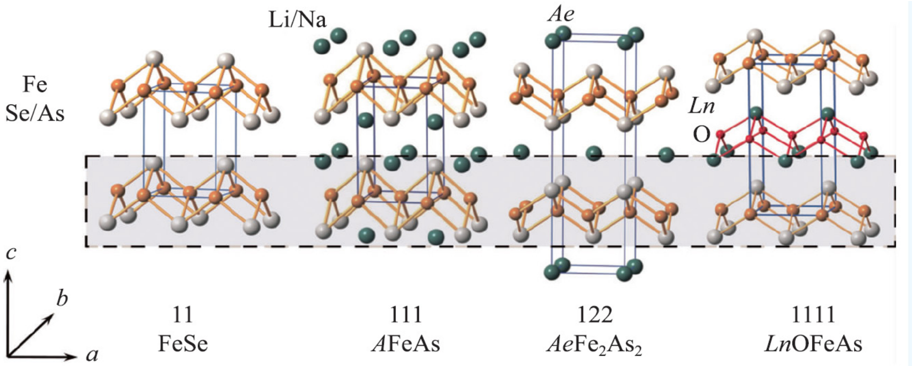

Fig. 4 The main structure of iron-based superconductors (Cited from Chen et al., 2014)

2.4.3 Nickel oxide superconductors

The research on the superconductivity of nickel oxides is an area that researchers have begun to pay attention to in recent decades. The first article officially reporting the superconductivity of nickel oxides came from the Stanford research team in the United States in 2019. The nickelate samples prepared by the researchers can undergo superconductivity in an infinite-layer nickelate at 15K (Li et al., 2019). Subsequently, in 2023, a team from Tsinghua University in China discovered a nickel oxide (Sun et al., 2023).

Subsequently, more researchers have paid attention to the superconductivity of nickel oxides and sorted out the structural characteristics of nickel oxide superconductors. It has been found that the structure of nickel oxides is similar to that of copper oxides, and the electronic configuration of nickel ions is the same as that of copper ions (Fig. 5).

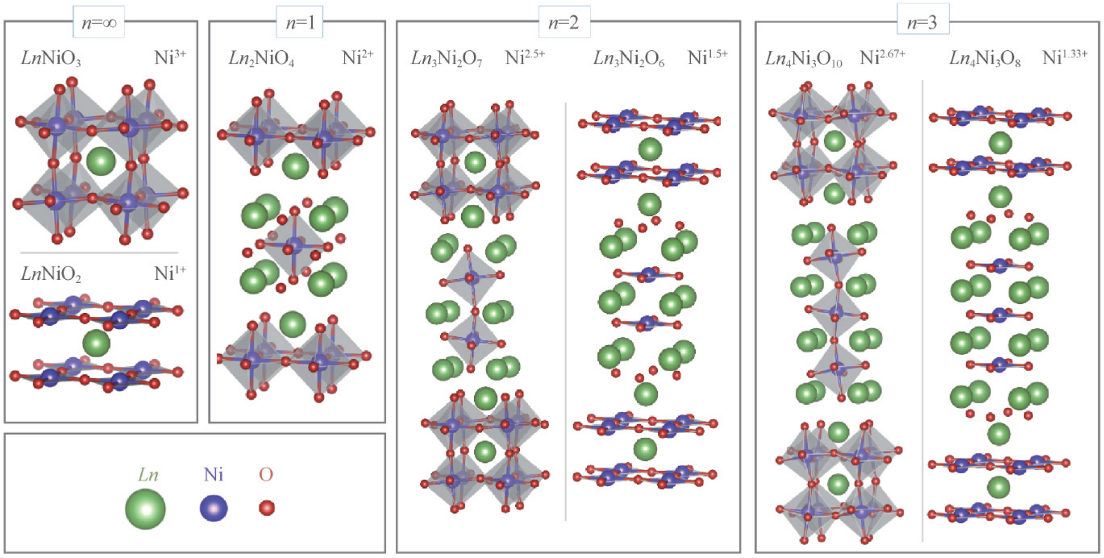

Fig. 5 Material structure of typical nickel oxide superconductors (Cited from Meng, 2023)

2.5 Applications of room temperature superconductors

2.5.1 Lossless energy transfer

With the global capacity transformation and carbon reduction initiatives, improving energy efficiency and reducing transport losses have become one of the issues of concern to countries. Superconducting materials can reduce energy loss to the greatest extent because of their zero resistance characteristics. Especially in traditional power transportation, the way high-voltage power grid transports power often causes a lot of power loss, and because the resistance causes the material to be heated, the cost of transportation is increased. In addition, in the use of new energy sources including wind power and solar power, superconducting materials can also increase the conversion rate of energy by reducing losses.

2.5.2 Quantum computing

With the development of science and technology, people ‘s daily life and scientific research often produce massive amounts of data. People need to analyze these big data in order to achieve precision medicine, drug development, ecological testing and personalized services. The realization of this large-scale operation has high requirements for electronic components, and superconducting materials are perfectly in line with people’s expectations with their advantages of high efficiency and low energy consumption. More importantly, in quantum computing, room temperature superconducting materials help to achieve large-scale quantum operations. For example, the computing power of the quantum chip built by the Google Quantum AI team in 2019 far exceeds that of the current supercomputer. (Boixo et al., 2018)

2.5.3 Strong magnetic field

According to the Meissner effect (Fig. 6), the object in the superconducting state will exhibit a completely repulsive magnetic field. In this case, the magnetic field line will not enter the superconductor, and this property is also completely diamagnetic (Keesom et al., 1934). Based on the complete diamagnetism of superconductors, superconducting maglev trains have been designed. Based on the advantages of superconducting low energy consumption and strong magnetism, the construction of superconducting maglev train can bring the advantages that ordinary

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trains do not have. It includes the advantages of low energy consumption, safety and comfort, high speed, no pollution and durability. Therefore, in the one hundred years since the discovery of superconducting theory, countries around the world have generally paid attention to the research and development of maglev trains. Countries such as Germany, the United States, Japan and China have made some breakthroughs in superconducting maglev trains. It can be seen from Table 2 that all countries in the world are investing in the test and construction of maglev trains. With the breakthrough of room temperature superconductivity, the speed of human travel will be further improved (Deng et al., 2022).

Table 2: Development status of high-speed maglev railway

Country	Magnetically levitated train	Time-to-build	Maximum running speed	Running or not
Japan	L0 series trains	2014	505km/h	It will be put into operation in 2027
Germany	TR 09 new type maglev train	2009	550km/h	No commercial operation
USA	Developed by Space X Company	2016	457km/h	Test pipeline
China	Developed by CRRC Sifang Co., Ltd.	2018	600 km/h	Test pipeline
Switzerland	Developed by Swissmetro	2017	No data	No data
Republic of Korea	‘HTX ‘ super high-speed rail plan	2017	No data	No data
Canada	Developed by TransPod	2016	No data	No data
Netherlands	Developed by Hardt Hyperloop	2019	No data	No data

In addition, the strong magnetic field characteristics of superconductors can also be used in medical testing. Taking magnetic resonance imaging (MRI) as an example, its principle can be simply described as: when a patient in a static magnetic field receives a fixed-frequency pulse signal, the hydrogen nucleus in his body will undergo nuclear magnetic resonance and release radio waves. People receive these signals through instruments and use computers to reconstruct images of the internal structure of the human body (Berger, 2002). According to this principle, the quality of the imaging effect is closely related to the magnetic field strength. If the magnetic field strength of the magnetic resonance system can be improved, higher quality information can be obtained. The superconductor can better provide a stable and uniform strong magnetic field for the magnetic resonance detection system.

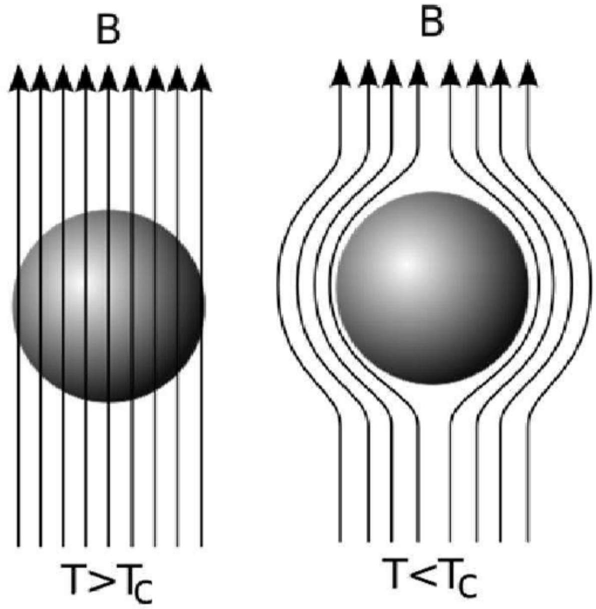

Fig.6 Meissner effect (Cited from Keesom et al., 1934)

3. Discussion

Superconducting theory has been a hot topic for physicists and materials scientists since its discovery, and room temperature superconductivity is a dream of many physicists. According to the latest research results, the US research team has realized a superconducting material with a superconducting critical temperature of 287.7K at 270 GPa, which is very close to the room temperature of 300K (Snider et al., 2020). It can also be seen from Fig. 1 that physicists have discovered various superconducting materials in the past 100 years, and the pressure and temperature conditions for achieving superconductivity vary greatly. In recent decades, more and more superconductors close to room temperature have been discovered, which is a further step for the real large-scale application of superconductors. In recent decades, scientists have made some breakthroughs in the study of the mechanism of room temperature superconductivity. Taking the resonance valence bond theory as an example, the researchers observed much higher energy than phonon or magnetic resonance in the electrons of high-temperature superconducting materials, indicating that the electron pairing mode in high-temperature superconducting materials is different from the BCS theory (Zhang et al., 2008).

Although the scientific community and the industry are generally optimistic about the future prospects of room temperature superconductors, it can be found from the analysis of the current development status of superconductors that the development of room temperature superconductors faces many problems and challenges. The first is the preparation of room temperature superconducting materials with high cost, low yield and instability. For example, according to the BCS theory, it is predicted that metal hydrogen will have superconductivity exceeding the critical temperature of 300 K under high pressure. However, due to technical limitations, it has always been impossible to effectively prepare stable metal hydrogen. In 2017, researchers at Harvard University prepared metallic hydrogen at 495 GPa, but it was damaged due to improper experimental operation (Dias et al., 2017). The preparation of many high-temperature superconductors requires very stringent conditions and limited production. Generally, it is necessary to adjust the structure of the material at the micro level. Its complex preparation process and high-precision instrument technology limit the large-scale production of superconducting materials. In addition, at present, in addition to the frontier fields such as military aerospace, the demand for superconductors in ordinary industrial production is low, which also restricts the large-scale development of superconductors. In addition, compared with traditional materials, the use of high-temperature superconductor materials requires a relatively strict environment. In particular, the interference of pressure, temperature and magnetic field. In practical applications, how to avoid the interference of these factors on the equipment and ensure the normal operation of the superconducting equipment will be one of the focuses of future research.

In recent years, the research on room temperature superconductivity has remained high, but it has also been mixed with some false results. These false data will not only disturb the public ‘s attention, but also mislead the development of the scientific community. From 2017 to 2023, a researcher from the University of Rochester withdrew several articles published in the journal Nature because the results could not be repeated. At the end of 2023, a paper on room temperature superconductivity published by the Korean scientific research team was also withdrawn due to the defects of the results. These results show that on the one hand, people ‘s urgent expectation for room temperature superconductivity, on the other hand, it also reflects that the progress in this field needs to be studied patiently.

At present, the room temperature superconducting materials available for research are still relatively limited, so the development of new room temperature superconducting materials with new technologies may help break through the research bottleneck to a certain extent. With the development of big data and artificial intelligence, researchers may be able to use the super computing power of supercomputers to establish a database for machine learning on the structure and properties of existing superconducting materials, so as to predict possible superconducting materials. On the other hand, it may be an effective way to integrate the currently discovered microscopic mechanisms for the manufacture of new room temperature superconducting materials.

From the current situation that some countries have begun to build superconducting magnetic levitation and some commercial superconducting medical equipment, it can be seen that the advantages of superconductivity are irreplaceable by other materials at present. However, in the study of superconductivity in the last century, more superconductors belong to lower temperature superconductors, and liquid helium is needed to provide ultra-low temperature. However, the cost of liquid helium is too high and vulnerable to market fluctuations, so only a few hospitals can afford the operation cost of superconducting equipment. Although so far, we are still not able to achieve room temperature and atmospheric pressure superconductivity. However, since the discovery of high-temperature superconductors, the transition temperature of superconductors has been greatly improved, and superconductiv-

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ity can be achieved by using liquid nitrogen to provide a low-temperature environment. Compared with liquid helium, liquid nitrogen is easier to produce, so the cost is lower. Therefore, using liquid nitrogen to achieve superconductivity is a more realistic and fast way than blindly waiting for room temperature superconductivity that can be achieved when we don ‘t know when.

4. Conclusion

Superconductivity research has made great breakthroughs in the past 100 years, and scientists have also achieved amazing results in the study of the critical temperature of superconductors. In recent decades, superconducting materials close to room temperature have been found, and the theoretical research of high-temperature superconductivity has also made some breakthroughs. However, from the current situation of room temperature superconductivity research, it is not realistic to achieve large-scale room temperature superconductivity in the near future. On the one hand, there are still many unsolved mysteries in the study of the mechanism of room temperature superconductivity, and little is known about how it undergoes superconducting transition. On the other hand, there are still many limitations in the preparation of room temperature superconductors, including preparation conditions and preparation processes, as well as the high-pressure environment required to achieve room temperature superconductivity, which means that room temperature superconductivity can only be achieved in the laboratory for a long time in the future. Nevertheless, we are still full of expectations for the future of room temperature superconductivity. With the development of quantum mechanics and machine learning, these new technologies can provide new impetus for the development of room temperature superconductors.

5. Review

The purpose of this project is to analyze the possibility of large-scale realization of room temperature superconductivity in the future by investigating the literature on the research progress of room temperature superconductivity. In the implementation of the project, I first combed the research history of superconductivity, and understood the process of putting forward and perfecting the theory of superconductivity. After that, I focused on the analysis of the BCS theory, and thus focused on the Mcmillan limit, and knew why the critical temperature of the superconductor is not too high in theory. After that, the focus of this project was formally entered. Room temperature superconductors require a very low transition temperature compared to conventional superconductors. The transition temperature of unconventional superconductors is generally higher, and superconductors with a transition temperature of about 300 K have been concerned by researchers. I have learned about the development status and critical temperature of several of the most popular high-temperature superconducting materials, including copper-based oxide superconductors, iron-based oxide superconductors and nickel-based oxide superconductors. After that, according to the literature report, I envisioned the field where room temperature superconductivity can bring convenience to human production and life in the future. In the discussion, I evaluated the breakthroughs, challenges, and possible future research directions. Finally, I conclude that room temperature superconductivity has great potential in the future, which has been proved by existing research. However, the limitation of technology means that it will take a long time for room temperature superconductivity to really enter people ‘s lives. From the results of the project, I basically completed the research objectives set at the beginning of the project.

Since I am still a beginner who is very interested in room temperature superconductivity, there may be some deficiencies in the understanding of professional terms in physics. In addition, due to the lack of financial support, I did not have a good opportunity to communicate with scientists who are really engaged in room temperature superconducting research, nor did I have the conditions to visit the relevant laboratories. These shortcomings limit my understanding of this field.

If the university in the future has the opportunity to let me continue to engage in the research of related projects, I will actively contact experts in related fields, and strive to go to their superconducting laboratory for exchange learning. If conditions permit, I hope I can try to prepare some simple superconducting materials and explore the transition temperature and physical properties.

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