

Analysis of the Development Trend of Frontier Science and Technology in the Field of Quantum Communication Processing

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Abstract: In order to enhance the understanding of the development trend analysis of frontier science and technology. Based on the analysis of the frontier core papers, this paper uses cite space, VOS viewer and other software for visual analysis, and summarizes the current development status of quantum communication processing. In this paper, through visual analysis and research, the countries in the forefront of research, the deepest research fields and the main application technologies are obtained.

Keywords: Quantum Communication Processing; Frontier Technology; Trend of Development Ent Trend; Bibliometrics

1. Introduction

1.1 Research Background

In recent years, with the emphasis on the field of quantum communication, the development of quantum communication technology has received unprecedented support. Quantum information theory is a new interdisciplinary science, which is formed by the application of quantum mechanics to information science and technology. Quantum communication introduces quantum mechanics into traditional communication, which is the first practical research direction in the field of quantum information theory.

With the development of quantum computers, quantum perceptrons and other quantum technologies, as well as the gradual improvement of quantum network theory, quantum communication has become an important part of future communication systems. Moreover, the encryption algorithm in traditional communication faces challenges such as key distribution, algorithm complexity, computing resources, and the risk of cracking with the improvement of computing power. The birth of quantum communication provides

a new way to solve these problems.

1.2 Research Status

China has made remarkable progress in the field of quantum communication and has become one of the world's leading markets. There are many well-known enterprises in the field of quantum communication, which have strong competitiveness in quantum communication technology and products. For example, China successfully launched the world's first quantum science experiment satellite ' Mozi ' and realized quantum communication between satellite and ground. Quantum communication technology has been widely used in finance, military, government affairs and other fields. For example, ICBC, Beijing Rural Commercial Bank and other banks have applied quantum secure communication technology [1].

Quantum information enterprises are highly concentrated in Europe and the United States, accounting for more than 60 % of the world. The United States and Europe are active areas of quantum information industry ecology. In the United States, many technology giants such as IBM, Google, Intel, Microsoft, Amazon and so on have set up quantum computing research and development departments to actively promote the development of quantum communication technology. At the same time, Switzerland, Germany and other European countries are in the first echelon with the United States in the field of quantum precision measurement, and will continue to maintain this advantage in the future [2].

2. Research Design and Method

2.1 Research Level Distribution

The hierarchical distribution of literature research reflects the degree of attention and development trend of different research directions. According to the distribution of the above disciplines, we analyze. At the

theoretical level, there are a large number of journal articles, involving the basic theory of quantum communication, the principle of quantum mechanics, quantum states, quantum entanglement, etc. At the application level, the number of journal articles is gradually increasing, and the application of quantum communication in various fields is explored, such as military defense, e-government, e-commerce, energy and electricity. Papers on the application of quantum communication have been published in journals such as 'Applied Physics Letters' and 'Science China-Physics Mechanics & Astronomy'. These papers show the potential application value and practical benefits of quantum communication technology in various fields [3]. The research levels in the field of quantum communication are widely distributed, involving many aspects such as theory, technology, system and application [4]. Among them, quantum key distribution, quantum teleportation, quantum secure direct communication and the design and construction of quantum communication systems are the key areas of current research [5].

2.2 Data Sources and Preprocessing

This paper mainly uses the journal literature collected by China National Knowledge Infrastructure (CNKI) database and Web of Science data as the retrieval data source, and carries out the retrieval strategy design. The retrieval strategies mainly include: in HowNet retrieval, the subject [6] search term is set to quantum communication, the journal source is set to SCI, CSCD, AMI, Peking University core, SSCI, and the journal publication year range is set to 2014-2024; search in Web of Science. The source of the journal is set to Highly Cited Papers and Hot Papers, and the publication period of the journal is 2014-2024. According to the above retrieval strategy, 500 related papers were retrieved in CNKI, and 2000 papers were retrieved in Web of Science, a total of 2500 related journal articles were retrieved.

2.3 Research Route and Framework

Firstly, the research objectives and scope are determined, including the analysis of the development trend, key technologies, main research institutions and research hotspots in

the field of quantum communication. At the same time, the time range of the study was determined to be from 2014 to 2024. Then, we will use Web of Science, CNKI and other databases to collect relevant literature in the field of quantum communication, and select the papers that meet the requirements according to the research time range. In the data collection stage, ensure that the collected data contains information such as the title, author, keywords, abstracts, and citations of the paper.

In the data preprocessing stage, we mainly use NoteExpress to clean and organize the collected data, remove duplicate and irrelevant information, and convert the data into a format suitable for VOSviewer and CiteSpace. Subsequently, we will use VOSviewer for visual analysis. Then, CiteSpace is used for visual analysis to find out the classic papers and high-impact papers in the field through citation analysis, and to identify the research frontiers and potential development directions in the research field by combining keyword co-occurrence and citation analysis. Finally, the researchers will analyze and interpret the results according to the visual analysis results of VOSviewer and CiteSpace, summarize the development trend, key technologies, main research institutions and research hotspots in the field of quantum communication, and write research reports to show the research results. The overall research idea of this paper is as shown in Figure 1:

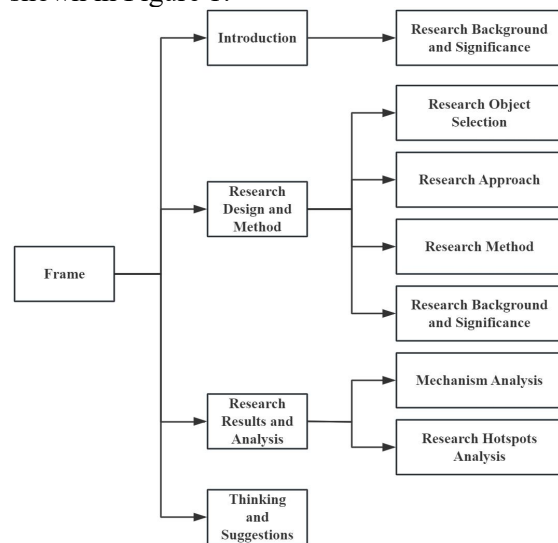


Figure 1. Thesis Framework

3. Research Results and Analysis

3.1 Analysis of Institutional Cooperation

According to the cooperation institutions, we can have a certain understanding of the development of quantum communication in different regions of China. We find that the connection between the core institutions is relatively close, and through the observation of Figure 2, we can see that in addition to the close cooperation and communication between the core institutions, most of the other papers do not cooperate in the field of quantum communication, and a small part of the cooperation has obvious regional characteristics.

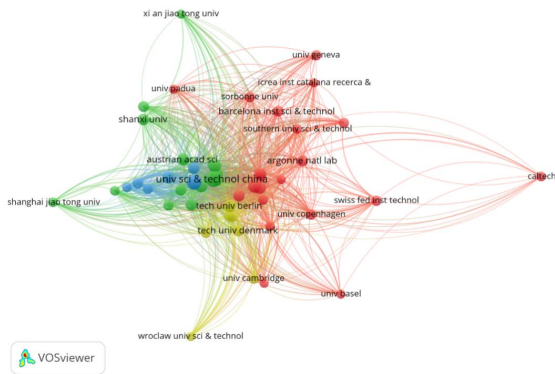


Figure 2. Based on the CNKI Institution Cooperation Status Map

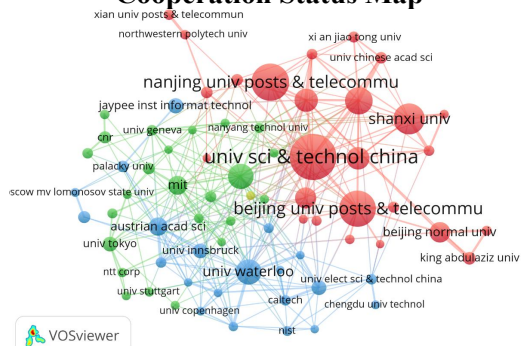


Figure 3. Organization Cooperation Status Diagram Based on WOS

The number of papers published by scientific research institutions can represent the research ability of their field. Using VOSviewer analysis, the threshold is 6, and the institutions with more than 6 papers published in CNKI literature are screened to form a knowledge map. By observing Figure 3, it can be found that there are 367 institutions exceeding the threshold, among which the top three are univ sci & technol China, austrian acad sci, argonne natl lab; the threshold is 11, and the institutions with more than 11 publications in the Web literature are screened to form a knowledge map. By observing Figure 3, 79 institutions can be found to exceed the threshold, of which

the top three are univ sci & technol China, Beijing univ posts & telecommu, nanjing univ posts & telecommu. By comparison, it can be seen that China's development in the field of quantum communication is OK, and it can also be found that China plays an active role in the field of quantum communication.

3.2 Literature Author Country Analysis

The author's country situation was analyzed. From Figure 4, we can clearly see that China, Italy and the United Kingdom have the largest number of literature authors, followed by the United Kingdom, Japan, France, Canada and other countries.



Figure 4. Literature Author Country Display

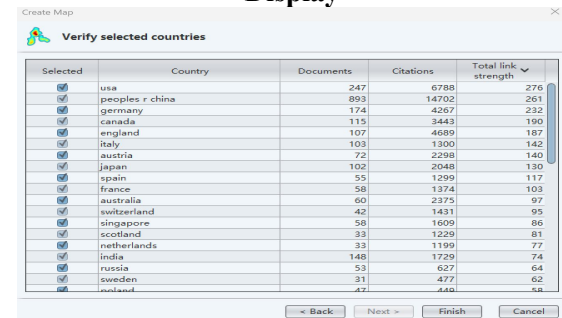


Figure 5. Literature Author Country Analysis

In order to more accurately see the amount of papers and references in the field of quantum communication, VOSviewer is used for extraction, as shown in Figure 5. The third column in the table is the number of published documents, and the fourth column is the number of cited documents. We can find that the more the number of publications, the more the number of documents he cited. Of course, it is not absolute. For example, russia, sweden, etc., the number of documents he published and the number of documents he cited do not conform to this law, and the following research needs to be continued.

3.3 Keyword Co-Occurrence Analysis

Keyword clustering analysis is a commonly used text mining method, which is used to classify and organize keywords in a large number of text data to reveal their associations and patterns.

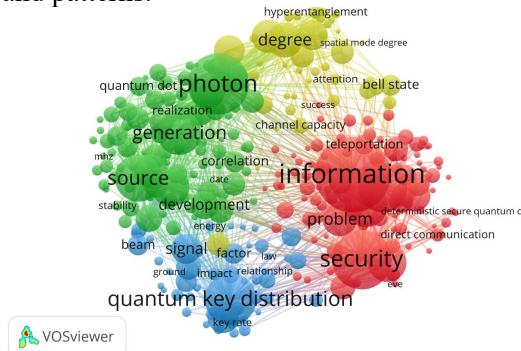


Figure 6. Analysis of WOS Keyword Clustering Results

From Figure 6, we can see that with four colors as the theme clustering, green represents the field of optoelectronic technology research, yellow model degree space model field, blue is the research field of quantum entanglement and quantum key, and red is about information and security research field.

Through the keyword clustering analysis of VOSviewer, researchers can more intuitively understand the research hotspots, main research directions and the correlation between keywords in the field, and provide strong support for the writing of papers and literature review.

3.4 Authors Analysis

The visualization of VOSviewer is used to analyze the authors of academic journals in the field of quantum communication, forming Figure 7. Each node represents an author, the size of the node is proportional to the number of articles published by the author, and each edge represents the connection between the authors.

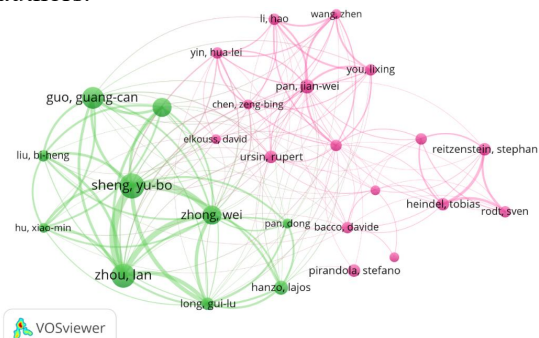


Figure 7. Author Clustering Analysis Based on WOS Citations

The VOSviewer software was also used to analyze the keywords. The threshold was set to 16, and there were 83 results. The more the number of items near a point, the higher the weight of adjacent items, and the closer the color of the point to red. On the contrary, the fewer the number of items near a point, the lower the weight of adjacent items, and the closer the color of the point to blue.

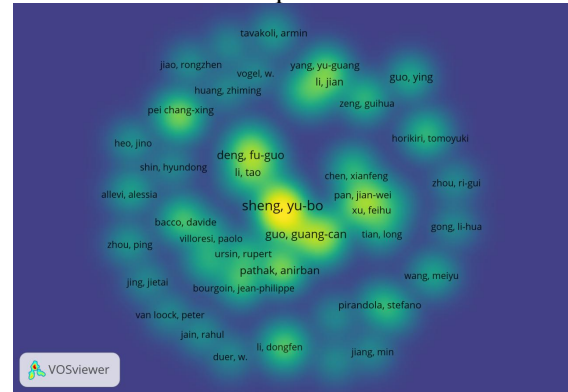


Figure 8. Author Co-Occurrence Diagram

In Figure 8, the author 's lowest published project is set to 7, of which 103 authors are in line. In the figure, shengyubo and guoguangcan have the highest cooperation, indicating that dengfuguo, Zhang Yu, Li Sheng and Lu Zhimao have a close cooperation. It shows that in the field of quantum communication, there are many articles published, but the cooperation between the author and the author is mainly based on the Chinese people, while the individual research of foreigners is more. Among them, the 24 authors are probably divided into four parts. The group of projects led by shengyubo is the most, and the cooperation between Sun Maosheng and other authors is relatively small.

3.5 Case Analysis of Highly Cited Scientists

The development of a discipline depends on the joint efforts of its scholars, and the academic influence of highly cited scientists can be measured by the number of ESI highly cited papers. Through Figure 9 and Figure 10, it can be found that China is the highest cited country, followed by Japen, USA and so on. It can be clearly seen from Figure 11 that' bennett, ch' is the central node and is closely linked to many other authors, indicating that he occupies a central position in the highly cited author network. The colors of nodes in the graph represent different research fields or institutions. By observing these colors, we can

discover the distribution of cooperation and influence between different fields or institutions. Highly cited author network is an important part of academic research, which reflects the cooperation and influence distribution between different authors. By analyzing the highly cited author network, we can identify core authors and active authors, and understand their influence and status in their respective fields. In addition, by observing the cooperation network, we can find the cooperation and interaction between different fields or institutions, and provide useful reference for the cooperation and exchange of academic research.

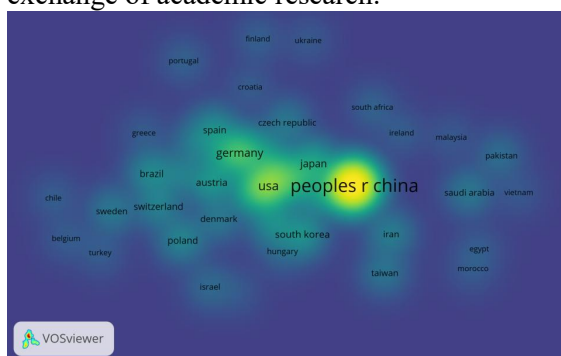


Figure 9. Highly Cited Countries

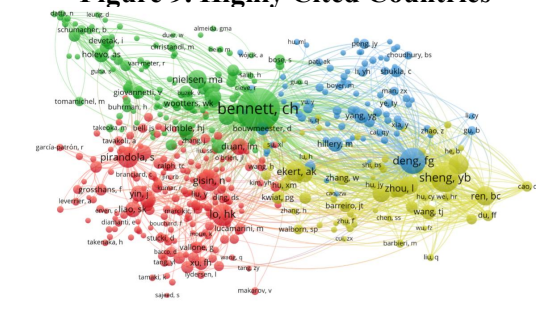


Figure 10. Highly Cited Researchers

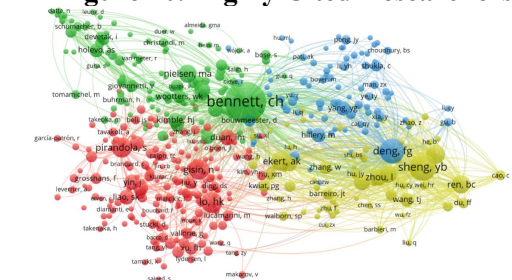


Figure 11. Analysis of Highly Cited Authors

4. Considerations and Suggestions

4.1 The Strengthening of Multilingual Literature Processing

In today's increasingly close global scientific

research cooperation, the research literature in the field of quantum communication also presents diverse language characteristics. In order to have a more comprehensive and in-depth understanding of the global development trend in this field, it is recommended to strengthen the processing capacity of multilingual literature. Through the development of multilingual NLP tools suitable for the field of quantum communication, the effective mining and analysis of low-resource language literature is realized by using transfer learning and other technologies [7].

4.2 The Standardization and Resolution of Ambiguous Terms

The field of quantum communication involves a large number of professional terms, which may be ambiguous in different contexts. In order to improve the accuracy and reliability of literature analysis, it is suggested to strengthen the standardization and resolution of ambiguous terms. By combining deep learning and knowledge graph, context information and prior knowledge are used to eliminate term ambiguity [8].

4.3 The Establishment of Information Security and Ethical Norms

With the continuous maturity of quantum communication technology and the expansion of application fields, the problems of information security and ethical norms have become increasingly prominent. It is recommended to develop comprehensive information security and ethical standards, including but not limited to data privacy protection in quantum key distribution, algorithm transparency and fairness of quantum communication systems, and prevention of misuse and manipulation of quantum communication technologies [9].

4.4 Deepening and Cooperation of Interdisciplinary Research

The development of quantum communication requires the joint efforts of computer science, physics, mathematics and other disciplines. It is suggested to strengthen the construction of interdisciplinary research centers and promote cooperation and exchanges among experts in different fields. This will help to form a more comprehensive and in-depth quantum

communication research system [10].

4.5 Construction of Open Resources and Data Sharing Platform

Open resource and data sharing is an important driving force to promote the development of quantum communication. It is recommended to build a global open resource and data sharing platform to collect and organize valuable resources such as experimental data, theoretical models, and algorithm codes in the field of quantum communication. This will help to reduce research costs, accelerate technological innovation and knowledge dissemination, and promote the rapid development and wide application of quantum communication technology [11].

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