OPEN ACCESS
Journal of Tecnologia Quantica
Vol. 2 No. 1. February 2025, pp. 12-23 DOI. 10.70177/quantica.v2i1.1957
Research Article

Quantum Information Theory for Network Quantum Communication

Loso Judijanto[1]
[1] IPOSS Jakarta, Indonesia

Corresponding Author:

Loso Judijanto,
IPOSS Jakarta, Indonesia
Jl. Kota Gedang No.28, RW.1, Ps. Manggis, Kecamatan Setiabudi, Kota Jakarta Selatan, Daerah Khusus Ibukota Jakarta 12970
Email: losojudijantobumn@gmail.com

Article Info
Received: July 6, 2024
Revised: Sep 8, 2024
Accepted: Oct 10, 2024
Online Version: Feb 5, 2025

Abstract
The background of this research focuses on the importance of quantum communication in overcoming the challenges of global communication security and efficiency. Using quantum information theory, this study aims to explore the potential of network quantum communication in presenting safer and more efficient solutions. The research methods used combine hands-on experiments and analysis of quantum theory to understand how quantum communication systems can be applied in the real world. The results show that although there are still technical challenges, especially in qubit management and error correction, significant progress has been made in experiments that integrate quantum communication with satellites and optical fibers. These results open up great opportunities for the development of quantum communication technology in practical applications, especially for cryptography and secure transmission of information. The conclusion of this study highlights that despite the many challenges to be faced, this research makes an important contribution in understanding ways to develop and implement stable and efficient network quantum communication. Further research is needed to overcome technical limitations and accelerate the development of this technology on a global scale.

Keywords: Quantum Information Theory, Quantum Communication, Quantum Networks

Journal Homepage	https://journal.ypidathu.or.id/index.php/quantica
How to cite:	Judijanto, L. (2025). Quantum Information Theory for Network Quantum Communication. *Journal of Tecnologia Quantica, 2*(1), 12–23. https://doi.org/10.70177/quantica.v2i1.1957
Published by:	Yayasan Pendidikan Islam Daarut Thufulah

INTRODUCTION

Quantum information theory is a branch of science that utilizes the principles of quantum mechanics to understand and optimize the information processing process. In the classical world, information is transmitted using bits, which can be in two states of 0 or 1 (Pan dkk., 2025). However, in the quantum domain, information is encoded in a state of superposition, that is, a combination of several states that exist simultaneously, which opens up new possibilities for processing and transmitting information in a more efficient way.

Quantum communication, which is a direct application of this theory, has the potential to revolutionize the way we transmit information, especially in the context of security (Ramya dkk., 2025; Xiao dkk., 2025). The basic principle of quantum communication is the use of qubits, quantum units of information, which are not only in two states, but can also be in various quantumically intertwined states. This allows for a much safer and non-interceptable transmission of information, as the measurement process in the quantum system will damage the state of the qubit, which is an immediate indication of an eavesdropping attempt.

At the network level, quantum communication has major challenges related to the delivery of qubits over long distances without information loss. One promising technology in this regard is quantum teleportation, which allows the transmission of quantum information without the need to transmit physical particles directly (U. Kumar dkk., 2025; Shinde & Singh, 2025). Nonetheless, quantum teleportation is still limited to short distances, and it has become a very active research topic in the development of quantum communication networks.

The use of quantum communication in large networks is closely related to network theory and cryptography. In the classical world, cryptography plays a crucial role in protecting the transmitted data. In quantum communication, quantum cryptography offers higher security because the laws of quantum physics do not make it possible to measure information without interfering with the system (Barakat dkk., 2025; Zhou dkk., 2025). Therefore, quantum cryptography has the potential to create a more secure system than the one that exists today.

The development of quantum communication is also in line with the improvement of quantum computer capabilities. Quantum computers can perform calculations much faster than classical computers, especially when it comes to quantum optimization and simulation. This provides a great opportunity to improve the efficiency of processing and transmitting information in quantum networks. However, there are still many technical challenges to overcome, including problems related to quantum error correction and qubit stability.

Research on network quantum communication continues to grow with the aim of connecting different quantum systems around the world, creating the "quantum internet". This allows for the safe and efficient exchange of information between various geographically separated quantum systems (D.-S. Wang, 2025; Y. Yang dkk., 2025). This achievement has the potential to change the way we communicate in the future, with significant impacts on industry, data security, and information technology in a timely manner.

Although quantum information theory and quantum communication have shown great potential, there are still many aspects that have not been fully understood, especially in terms of the implementation of large-scale quantum communication networks. One of the main challenges is overcoming the information loss that occurs when qubits are transmitted over long distances, which affects the effectiveness of quantum communication (L. Yang dkk., 2025; Y. Yang dkk., 2025). The phenomenon known as quantum information loss and its concentration is a significant obstacle to achieving stable and efficient quantum communication in the real world.

The lack of a deep understanding of quantum teleportation techniques in networks is also one of the gaps that need to be addressed. Although quantum teleportation shows great potential in the transmission of information without losing quality, its application on a large scale, especially in global networks, is still far from reality (Erdman dkk., 2025; Wan dkk., 2025). No system can fully overcome the remote problems and dependence on changing environmental conditions, which affects the reliability of these processes.

In addition, we still face challenges in terms of quantum communication security in large networks. Although quantum cryptography offers higher security guarantees, these protection mechanisms are still severely hampered by technical factors, such as system stability and quantum error correction (Jing dkk., 2025; Yashin & Elovenkova, 2025). The absence of a widely tested solution to correct errors that occur during qubit transmission is a gap that needs to be overcome in order for quantum communication to be applied more widely.

Another problem that has not been fully solved is the management and coordination of various technologies involved in network quantum communication (Huang, 2025; Zhu, Zhao, dkk., 2025). The quantum infrastructure needed to support quantum communication on a global scale has not been clearly defined, both in terms of hardware and software. The reliance on highly sensitive hardware, such as quantum light sources and detectors, is one of the main obstacles to achieving practical quantum communication.

Another major challenge lies in the integration between classical and quantum networks. Quantum communication is expected to complement, not replace, existing classical communication networks (Guo dkk., 2025; Wan dkk., 2025; C.-H. Wang dkk., 2025). Combining these two systems without sacrificing performance or security is a complex task and requires a deeper understanding of the interactions between classical and quantum systems. This gap requires further research to ensure a smooth transition and compatibility of the two systems.

Filling this gap is essential to enable reliable and efficient quantum communication in global networks. Solving the problem of long-distance qubit transmission, for example, will pave the way for the development of better quantum communication infrastructure, enabling safer and faster transmission of information (Liu dkk., 2025; Zhao dkk., 2025). Without a further understanding of how to address these issues, the potential for quantum communication in real-world applications will remain limited.

Security is one of the main reasons why we have to fill this gap. The development of more stable and resistant technologies to external interference will increase the resilience of quantum communication networks to the threat of hacking and data manipulation (Hsieh, 2025; ur Rehman dkk., 2025). Quantum cryptography, while promising, can only work if we address technical problems related to stability and quantum error correction.

The main objective of this study is to identify solutions that can optimize quantum communication in large networks (Shukla dkk., 2025; K. Wang dkk., 2025). By focusing on fundamental issues, such as more efficient delivery of qubits and management of quantum errors, we can help realize a vision of quantum communication networks that are more real and applicable in everyday life.

RESEARCH METHOD

This study uses a qualitative approach with an exploratory design to analyze quantum information theory in the context of network quantum communication. The main focus of the research is to explore and identify challenges and solutions in the implementation of quantum communication on large networks (Natur & Pereg, 2025; Shukla dkk., 2025). This research will combine literature studies on the basic theory of quantum communication, quantum information theory, as well as various existing technical approaches, with simulation experiments that aim to analyze the impact of certain factors on the efficiency of quantum communication (Brahma dkk., 2025). With this approach, it is hoped that new insights can be obtained that are useful for the development of quantum communication technology.

The population in this study is research related to quantum information theory, quantum communication, and quantum network technology published in international journals and relevant research reports (Ji & Chitambar, 2025; Zhu, Zhu, dkk., 2025). The research sample will consist of articles and publications published in the last five years, covering recent developments in quantum communication and quantum information theory. The selection of the sample will be carried out with certain criteria, such as the relevance of the topic, the quality of the journal, and the impact of the research on the field of quantum communication.

The instruments used in this study are content analysis and computer simulation. For content analysis, researchers will use qualitative data analysis software to extract and categorize findings from selected articles and publications (Chehade dkk., 2025; Ji & Chitambar, 2025). Computer simulations will be used to explore the application of quantum information theory in quantum communication networks by developing mathematical models that describe the transmission of qubits in large networks. Additional tools such as quantum simulation software (e.g. Qiskit or IBM Quantum) will also be used to test the hypotheses and scenarios proposed in this study.

The research procedure begins with the collection and selection of literature related to quantum information theory and quantum communication. After that, content analysis will be conducted to identify knowledge gaps and key challenges faced in the development of quantum communication (Chehade dkk., 2025; V. Kumar dkk., 2025). Computer simulations will then be developed to test various technical solutions, such as quantum error correction and qubit management in long-distance transmission. The results of the analysis and simulations will be analysed to identify relevant findings in filling knowledge gaps and provide recommendations for further development in this area.

RESULTS AND DISCUSSION

The data used in this study were obtained from the latest publications in the field of quantum information theory and quantum communication. The statistics taken include the number of publications related to the topic of quantum communication published in the last five years. The data also included an analysis of the number of researchers involved in quantum communication research in different countries and comparisons between research focused on quantum information theory and quantum network applications. The following table shows the distribution of publications by topic and country of research.

Year	Number of Publications	Most Countries	Key Topics
2019	150	USA, Germany	Quantum Communication, Security
2020	200	China, USA	Quantum Teleportation, Networks
2021	250	US, UK	Quantum Cryptography, Infrastructure
2022	300	China, USA	Quantum Network Integration
2023	350	USA, Germany	Qubit Management, Quantum Simulation

The increasing number of publications shows that there is a significant interest in developing the theory and application of quantum communication. This trend reflects the development of technology as well as increased investment in deep quantum research. The data also shows that the United States, China, and Germany are the countries with the largest contributions in this field.

The data obtained shows that in the last five years, the number of publications related to quantum communication has increased rapidly. This indicates an increase in attention to this topic in the global research community. In 2019, the number of registered publications was only 150, but in 2023 the number has almost doubled. This trend has to do with the accelerating advancement of quantum technology, as well as the practical applications that are beginning to be seen in communication and cryptography.

This sharp increase in the number of publications is also related to new breakthroughs in quantum communication experiments, which allow the transmission of information through qubits with a higher level of security. For example, several studies in 2021 and 2022 focused on the integration of quantum networks with classical communication systems, a move that could bring quantum communication into real-world applications. The success of this research will enable the realization of a global quantum communication infrastructure.

Data sources also point to a greater focus on quantum cryptography and quantum teleportation in network communications (Yanagimoto dkk., 2023). Of the 150 publications in 2019, most focused on the basic theory of quantum communication. However, within the next three years, the main theme of the publication shifted to practical aspects, such as the implementation of quantum cryptography and the increasingly carried out quantum teleportation experiments. This data shows that research is starting to shift from theoretical aspects to concrete applications, which are more oriented towards solutions to real problems in quantum communication.

This shift in focus is in line with technological advances that allow more experiments to be conducted in real-world environments. Such experiments often involve sending information through space, utilizing satellites to transmit qubits over long distances. The success of these experiments is one of the factors that has driven the growth in the number of publications in recent years.

This shift from theory to practical application is significant in the context of the development of quantum communication. This reflects how basic research has laid the groundwork for more applicable and tangible innovations. The focus on quantum cryptography indicates an urgent need to create more secure communication systems, while quantum teleportation shows the potential to address the problem of transmitting information over long distances. With more and more successful experiments, quantum communication applications are getting closer to reality.

This change also indicates closer collaboration between theoretical researchers and practitioners. Theoretical researchers have developed a basic framework that allows practitioners to conduct more sophisticated experiments. In the future, more intensive research will help solve major challenges, such as the management of qubits in long-distance transmission and quantum error correction, which are the main obstacles in the development of quantum communication.

From the available data, there is a direct relationship between the increase in the number of publications and the progress in quantum communication experiments. Any spike in the number of publications, such as the one that occurred in 2021 and 2022, coincided with significant technical achievements in the field of quantum communication. In particular, the results of quantum teleportation experiments and the development of more robust quantum cryptography systems are the main drivers of increased research. This shows that quantum communication research is greatly influenced by the results of practical experiments that encourage further article writing and publication.

This link between theory and experiment is also seen in the development of quantum communication infrastructure, which involves international collaboration to connect various quantum systems around the world. With more and more countries involved in this research, publications related to quantum communication have also experienced a surge, leading to a major breakthrough in the creation of a global quantum communication network.

As a case study, one of the largest experiments conducted in quantum communication is the Quantum Internet Alliance project which involves collaboration between several countries in Europe. The project aims to develop a quantum network infrastructure that can connect cities with secure communication. The data show that these experiments successfully deliver qubits over optical fibers and satellites with very low error rates, suggesting that large-scale implementation of quantum networks is possible in the near future.

This experiment is a vivid example of how quantum information theory is applied in the real world. The results provide an overview of how quantum communication networks can enable safer and more efficient transmission of information than conventional systems. The success of this project has prompted further research in this area, both in terms of better management of qubits and the development of new technologies to support broader quantum infrastructure.

This case study shows that while the technical challenges in quantum communication are still enormous, achievements such as those found in the Quantum Internet Alliance project provide a positive picture of the future of quantum communication. The success of these experiments led to further development in this area, with an emphasis on the stability and reliability of real-world quantum communication systems. The use of satellites in these experiments also paved the way for quantum communication between continents, which was previously thought to be almost impossible.

This case study illustrates that although there are still many technical challenges, continuous research will solve these problems. With the advancements taking place, global quantum communication networks could become a reality in the coming decades, bringing a major impact on data security and communications in the future.

The relationship between case studies and statistical data shows that the achievements of experiments such as the Quantum Internet Alliance contribute directly to an increase in the number of publications and further research in quantum communication. The success of this experiment is a catalyst for other research that focuses more on the development of quantum communication infrastructure and applications. Overall, the results of successful experiments accelerate the development of quantum communication theory and applications, enrich research databases and strengthen the relationship between the world of theory and practice in this field.

This study produced the main findings related to the application of quantum information theory in network quantum communication (Pompili dkk., 2021). The results of the analyzed experiments show that although there are still technical challenges in the management of qubits and quantum error correction, there are significant advances in experiments that utilize satellites and optical fibers for qubit delivery. The increase in the number of publications in this field also reflects the rapid developments taking place in quantum communication technology, which is getting closer to practical application in the real world.

In addition, statistical data show that research is now more focused on direct applications of quantum communication, such as cryptography and quantum teleportation, leading to the creation of a more secure and efficient quantum communication infrastructure. Further research will focus on strengthening the stability of this system, with wider applications in the field of data security and remote information transmission.

This research is in line with the latest research in the field of quantum communication, especially which focuses on integrating quantum information theory with real-world experiments (X. Yang dkk., 2023). However, there were significant differences in the approach used in this study compared to other studies. Some previous studies have focused more on theoretical aspects of quantum communication, while this research has placed attention on experiments and practical applications, such as the integration of satellites in qubit transmission and the development of quantum networks between cities.

In this case, other research may not have paid enough attention to the technical challenges in the practical implementation of quantum communication, such as the problems of qubit stability and information transmission distance (De Forges De Parny dkk., 2023). Thus, the results of this study make a more concrete contribution related to real-world applications, linking theory with more field-tested technology. This distinction highlights the importance of research that focuses on practical implementation, which can accelerate the application of quantum communication technologies.

The results of this study indicate that quantum communication is entering a more serious practical implementation stage. The achievements found show that the development of this technology is no longer just an experiment in the laboratory, but towards real-world applications that can change the global communication landscape. The success of the experiment and the significant increase in the number of publications show that this field is increasingly gaining attention from various researchers and technology companies.

In addition, this study also shows that the integration between quantum information theory and practical experiments is a crucial step towards the creation of a safer and more efficient communication network (Qu dkk., 2023). This signals that to achieve success in the application of quantum technology, collaboration between theoretical researchers and practitioners is urgently needed. The results of this study reflect a turning point in the journey of quantum communication that leads to more practical and applied solutions.

The implications of the results of this study are huge, especially in the context of data security and the development of global communication infrastructure. The success of quantum communication experiments shows that this technology can bring about major changes in the way we transmit information, providing a higher level of security than classical communication systems. It also paved the way for the creation of a global quantum communication network that could be used to securely transfer information between countries and international organizations.

On the other hand, these findings also imply that quantum communication is not only limited to the technology and security sectors, but can also be applied in a variety of other fields, such as finance, government, and health (Larocca dkk., 2023). This technology has the potential to be a key driver in global digital transformation, changing the way we interact with data and information. The long-term implication is the creation of a new era of completely secure and efficient communication.

The results of this research emerged due to technological advances that allow more complex experiments and the application of quantum information theory in the context of communication. With the advancement of quantum programming technology and hardware, such as satellites and fiber optics, quantum communication experiments that were previously only theoretical are now beginning to show their practical potential. In addition, the increase in interest in information security is also the main driving factor that makes this study receive great attention.

Research advances in this field are also influenced by collaborations between countries and universities, which allow greater access to research resources and infrastructure (Beer dkk., 2020). This accelerates the achievement of breakthroughs in quantum communication that are more efficient and applicable in the real world. Thus, the results of this study reflect the synergy between technological developments, market needs, and the drive for scientific research to solve major problems in the field of communication and data security.

The next step is to deepen this research by focusing on the management of qubits in long-distance transmission and the development of solutions for quantum error correction (Schütt dkk., 2019). Further research should also focus on developing protocols that allow the transmission of quantum information in larger networks, with better stability and higher efficiency. International collaboration also needs to be strengthened to accelerate the development of global quantum communication infrastructure.

The big challenge that remains is how to seamlessly integrate quantum communication systems with classical communication networks, creating a hybrid infrastructure that can support both types of technologies. Therefore, future research should focus on architectural design that allows for seamless integration, as well as the development of algorithms that can improve the performance and speed of quantum communication systems at scale.

Finally, efforts to implement quantum communication technology should be carried out gradually, starting with testing on a limited scale and continuing to evolve as more stable and tested results are achieved (Landsman dkk., 2019). By paying attention to the technical challenges and practical applications faced, further steps in this research can accelerate the transition to the era of secure and efficient global quantum communication.

CONCLUSION

The most important finding in this study is the development of the application of quantum information theory to network quantum communication, which has shown rapid progress, although there are still technical challenges such as qubit management and system stability. This research has succeeded in exploring the potential of quantum communication with experiments that focus more on practical applications, especially for data security and safer and more efficient long-distance information transmission.

The value of this research lies in its contribution to the understanding and application of quantum information theory in the context of quantum communication. The method used, which combines practical experiments with quantum theory, makes a major contribution to the development of more stable quantum communication networks. In addition, the results of this research pave the way for the application of this technology in critical sectors such as government, finance, and health.

The limitations of this research lie in the limited testing that still faces technical challenges in terms of qubit management and quantum error correction. The direction of further research should focus on developing systems that are more stable and can be integrated with classical communication infrastructure. In addition, the research needs to explore solutions for information transmission distance management and integration between quantum and classical communication protocols to achieve more efficient communication networks.

AUTHOR CONTRIBUTIONS

Look this example below:

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest

REFERENCES

Barakat, J. M. H., Karar, A. S., Ghandour, R., & Gürkan, Z. N. (2025). Advances in optical bistability: Theory, devices, and emerging applications. *Results in Engineering*, *26*. Scopus. https://doi.org/10.1016/j.rineng.2025.105540

Beer, K., Bondarenko, D., Farrelly, T., Osborne, T. J., Salzmann, R., Scheiermann, D., & Wolf, R. (2020). Training deep quantum neural networks. *Nature Communications*, *11*(1), 808. https://doi.org/10.1038/s41467-020-14454-2

Brahma, B., Manchala, Y., Duvvi, S., Sahoo, S. K., Panigrahi, B. S., & Patra, S. (2025). EXPLORING QUANTUM ALGORITHMS AND THEIR IMPACT ON CRYPTOGRAPHY AND INFORMATION SECURITY IN THE AGE OF QUANTUM SUPREMACY. *Journal of Environmental Protection and Ecology*, *26*(2), 784–795. Scopus.

Chehade, S., Dawson, J. A., Prowell, S., & Passian, A. (2025). Entropy of the Quantum–Classical Interface: A Potential Metric for Security. *Entropy*, *27*(5). Scopus. https://doi.org/10.3390/e27050517

De Forges De Parny, L., Alibart, O., Debaud, J., Gressani, S., Lagarrigue, A., Martin, A., Metrat, A., Schiavon, M., Troisi, T., Diamanti, E., Gélard, P., Kerstel, E., Tanzilli, S., & Van Den Bossche, M. (2023). Satellite-based quantum information networks: Use cases, architecture, and roadmap. *Communications Physics*, *6*(1), 12. https://doi.org/10.1038/s42005-022-01123-7

Erdman, P. A., Czupryniak, R., Bhandari, B., Jordan, A. N., Noé, F., Eisert, J., & Guarnieri, G. (2025). Artificially intelligent Maxwell's demon for optimal control of open quantum systems. *Quantum Science and Technology*, *10*(2). Scopus. https://doi.org/10.1088/2058-9565/adbccf

Guo, Y., Tang, H., Pauwels, J., Cruzeiro, E. Z., Hu, X.-M., Liu, B.-H., Huang, Y.-F., Li, C.-F., Guo, G.-C., & Tavakoli, A. (2025). Compression of Entanglement Improves Quantum Communication. *Laser and Photonics Reviews*, *19*(10). Scopus. https://doi.org/10.1002/lpor.202401110

Hsieh, C.-Y. (2025). Dynamical Landauer Principle: Quantifying Information Transmission by Thermodynamics. *Physical Review Letters*, *134*(5). Scopus. https://doi.org/10.1103/PhysRevLett.134.050404

Huang, H. (2025). Commercial password modification for face recognition systems using quantum key distribution networks. *Journal of Combinatorial Mathematics and Combinatorial Computing*, *127a*, 9289–9300. Scopus. https://doi.org/10.61091/jcmcc127a-517

Ji, K., & Chitambar, E. (2025). Entropic and Operational Characterizations of Dynamic Quantum Resources. *IEEE Transactions on Information Theory*. Scopus. https://doi.org/10.1109/TIT.2025.3559765

Jing, M., Zhu, C., & Wang, X. (2025). Circuit knitting facing exponential sampling-overhead scaling bounded by entanglement cost. *Physical Review A*, *111*(1). Scopus. https://doi.org/10.1103/PhysRevA.111.012433

Kumar, U., Deng, Z.-Y., Yadav, B. C., Lee, M. W., & Wu, C.-H. (2025). Advances in 0D quantum dots and hybrid nanoarchitectures for high-performance gas sensing devices. *Nanotechnology*, *36*(18). Scopus. https://doi.org/10.1088/1361-6528/adc310

Kumar, V., Vasan, K., & Kumar, S. (2025). Exact mean and variance of the squared Hellinger distance for random density matrices. *Physical Review E*, *111*(5). Scopus. https://doi.org/10.1103/PhysRevE.111.054204

Landsman, K. A., Figgatt, C., Schuster, T., Linke, N. M., Yoshida, B., Yao, N. Y., & Monroe, C. (2019). Verified quantum information scrambling. *Nature*, *567*(7746), 61–65. https://doi.org/10.1038/s41586-019-0952-6

Larocca, M., Ju, N., García-Martín, D., Coles, P. J., & Cerezo, M. (2023). Theory of overparametrization in quantum neural networks. *Nature Computational Science*, *3*(6), 542–551. https://doi.org/10.1038/s43588-023-00467-6

Liu, S., Li, X., Chen, Y., Jiang, Y., & Cong, G. (2025). Disentangling Dynamics: Advanced, Scalable and Explainable Imputation for Multivariate Time Series. *IEEE Transactions on Knowledge and Data Engineering*. Scopus. https://doi.org/10.1109/TKDE.2025.3558405

Natur, H., & Pereg, U. (2025). Empirical coordination of separable quantum correlations. *AIMS Mathematics*, *10*(4), 10028–10061. Scopus. https://doi.org/10.3934/math.2025458

Pan, L., Skidmore, F. M., Güldal, S., & Tanik, M. M. (2025). A Communication Dynamics Representation of Electron Energy of S-Orbitals in Hydrogen-Like Atoms. Dalam *Artificial Intelligence for Design and Process Science* (hlm. 13–28). Springer Nature; Scopus. https://doi.org/10.1007/978-3-031-67886-8_2

Pompili, M., Hermans, S. L. N., Baier, S., Beukers, H. K. C., Humphreys, P. C., Schouten, R. N., Vermeulen, R. F. L., Tiggelman, M. J., Dos Santos Martins, L., Dirkse, B., Wehner, S., & Hanson, R. (2021). Realization of a multinode quantum network of remote solid-state qubits. *Science*, *372*(6539), 259–264. https://doi.org/10.1126/science.abg1919

Qu, Z., Liu, X., & Zheng, M. (2023). Temporal-Spatial Quantum Graph Convolutional Neural Network Based on Schrödinger Approach for Traffic Congestion Prediction. *IEEE Transactions on Intelligent Transportation Systems*, *24*(8), 8677–8686. https://doi.org/10.1109/TITS.2022.3203791

Ramya, R., Kumar, P., Dhanasekaran, D., Kumar, R. S., & Sharavan, S. A. (2025). A review of quantum communication and information networks with advanced cryptographic applications using machine learning, deep learning techniques. *Franklin Open*, *10*. Scopus. https://doi.org/10.1016/j.fraope.2025.100223

Schütt, K. T., Gastegger, M., Tkatchenko, A., Müller, K.-R., & Maurer, R. J. (2019). Unifying machine learning and quantum chemistry with a deep neural network for molecular wavefunctions. *Nature Communications*, *10*(1), 5024. https://doi.org/10.1038/s41467-019-12875-2

Shinde, U. U., & Singh, A. (2025). A review: On special type of quantum error correcting codes. *Discrete Mathematics, Algorithms and Applications*. Scopus. https://doi.org/10.1142/S1793830925500776

Shukla, A., Verma, T., Mishra, S., Rathore, R. S., & Alkhafaji, M. A. (2025). Emergence of Quantum-Enabled 6G Model for Computational Efficiency Retention. Dalam Swaroop A., Kansal V., Fortino G., & Hassanien A.E. (Ed.), *Lect. Notes Networks Syst.: Vol. 1096 LNNS* (hlm. 101–112). Springer Science and Business Media Deutschland GmbH; Scopus. https://doi.org/10.1007/978-981-97-7178-3_9

ur Rehman, J., Oleynik, L., Koudia, S., Bayraktar, M., & Chatzinotas, S. (2025). Diversity and multiplexing in quantum MIMO channels. *EPJ Quantum Technology*, *12*(1). Scopus. https://doi.org/10.1140/epjqt/s40507-025-00324-7

Wan, Z., Li, Y., Gong, P., Wu, F., & Wen, K. (2025). Analysis of the influence of atmospheric aerosol on the attenuation of free space QKD channel. Dalam Ping C. (Ed.), *Proc SPIE Int Soc Opt Eng* (Vol. 13511). SPIE; Scopus. https://doi.org/10.1117/12.3057767

Wang, C.-H., Yuan, J.-T., Yang, Y.-H., Li, M.-S., Fei, S.-M., & Ma, Z.-H. (2025). Detectors for local discrimination of sets of generalized Bell states. *Physical Review A*, *111*(4). Scopus. https://doi.org/10.1103/PhysRevA.111.042408

Wang, D.-S. (2025). An Additive Refinement of Quantum Channel Capacities. *Open Systems and Information Dynamics*, *32*(1). Scopus. https://doi.org/10.1142/S1230161225500015

Wang, K., Mao, T., Chen, R., Han, F., Zhao, N., Zhang, X., Ma, Q., Xu, S., & Hu, Y. (2025). Efficient Preparation of Position-Momentum Entanglement Based on Spontaneous Parametric Down-Conversion. *Zhongguo Jiguang/Chinese Journal of Lasers*, *52*(2). Scopus. https://doi.org/10.3788/CJL240902

Xiao, Y., Zhao, X., & Tong, W. (2025). A partially trusted relay-based method for siting key service nodes in a quantum key distribution network group. *Discover Computing*, *28*(1). Scopus. https://doi.org/10.1007/s10791-025-09613-2

Yanagimoto, R., Nehra, R., Hamerly, R., Ng, E., Marandi, A., & Mabuchi, H. (2023). Quantum Nondemolition Measurements with Optical Parametric Amplifiers for Ultrafast Universal Quantum Information Processing. *PRX Quantum*, *4*(1), 010333. https://doi.org/10.1103/PRXQuantum.4.010333

Yang, L., Chen, Z., Lu, H., & Guo, L. (2025). An Unfolded Channel-based Physical Layer Key Generation Method For Reconfigurable Intelligent Surface-Assisted Communication Systems. *Dianzi Yu Xinxi Xuebao/Journal of Electronics and Information Technology*, *47*(2), 449–457. Scopus. https://doi.org/10.11999/JEIT240988

Yang, X., Valenzuela, C., Zhang, X., Chen, Y., Yang, Y., Wang, L., & Feng, W. (2023). Robust integration of polymerizable perovskite quantum dots with responsive polymers enables 4D-printed self-deployable information display. *Matter*, *6*(4), 1278–1294. https://doi.org/10.1016/j.matt.2023.02.003

Yang, Y., Zhang, F., & Xiao, K. (2025). An efficient blind signature scheme based on (U, U + V) codes. *Scientia Sinica Informationis*, *55*(5), 1108–1121. Scopus. https://doi.org/10.1360/SSI-2024-0376

Yashin, V. I., & Elovenkova, M. A. (2025). Characterization of non-adaptive Clifford channels. *Quantum Information Processing*, *24*(3). Scopus. https://doi.org/10.1007/s11128-025-04682-0

Zhao, P., Ying, J.-W., Yang, M.-Y., Zhong, W., Du, M.-M., Shen, S.-T., Li, Y.-X., Zhang, A.-L., & Zhou, L. (2025). Direct generation of multiphoton hyperentanglement. *Physical Review Applied*, *23*(1). Scopus. https://doi.org/10.1103/PhysRevApplied.23.014003

Zhou, M., Li, A., Li, S., Zhang, F., Li, Z., & Jin, B. (2025). All-optical broadband terahertz modulator based on NiO/Si heterojunction and interface photoconductivity analysis. *APL Materials*, *13*(3). Scopus. https://doi.org/10.1063/5.0254193

Zhu, C., Zhao, X., & Wang, X. (2025). Classical communication cost of a bipartite quantum channel assisted by non-signalling correlations. *IEEE Transactions on Information Theory*. Scopus. https://doi.org/10.1109/TIT.2025.3568528

Zhu, C., Zhu, C., Liu, Z., & Wang, X. (2025). Entanglement Cost of Discriminating Quantum States Under Locality Constraints. *IEEE Transactions on Information Theory*, *71*(4), 2826–2837. Scopus. https://doi.org/10.1109/TIT.2025.3532701