

QIC Final Project: Anisotropic Transmission of quantum information through quantum fields

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ABSTRACT: In this letter, we briefly review the possible way to transmit the quantum information via quantum fields [1], and then we discuss

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1 Quantum Channel: Via Quantum Mechanics

In quantum information theory, the information is represented by a qubit, and it can be transformed, projected, and transmitted based on basic quantum mechanics posulates. In this letter, we focus on the transmission of a qubit from a spacetime emitter Alice A to a receiver Bob B .

There are various ways to transmit a qubit without contacting, which are based on the *resources* Alice and Bob share. For instance, if an entangled state is shared, they can transmit the qubit by Alice performing the Bell measurement and then send the result (a classical cbit) to Bob, which is the well-known *quantum teleportation*. Here, we simply consider transmission by a third quantum bit C , $\hat{\rho}_{C,0}$. Denote Alice's qubit as $\hat{\rho}_{A,0}$ and Bob's qubit $\hat{\rho}_{B,0}$; the transmission is done by performing SWAP between A and C , and then between C and B . The whole process is unitary and does not violate the non-cloning process because Alice's qubit becomes $\hat{\rho}_{C,0}$.

The SWAP operator can be derived by assuming $\hat{\rho}_{C,0} = |0\rangle\langle 0|$ and $\hat{\rho}_{A,0} = |a\rangle\langle a|$ with $\langle a|0\rangle \neq 0$:

$$U \rho_{A,0} \otimes \rho_{C,0} U^\dagger = \rho_{C,0} \otimes \rho_{A,0} \quad (1.1)$$

Remark: The transmission of qubit described above is rather trivial; however, it is based on an important fact that the dimension of the Hilbert space of C is the same as those of the Hilbert space of A and B , so there is an isomorphism between the Hilbert spaces. As we will see in the next section, the Hilbert space (or more precisely, the Fock space) of quantum fields is infinite-dimensional, and therefore there is no isomorphism like SWAP gate in the quantum mechanic case.

2 Quantum Channel: Via Quantum Fields

2.1 Brief Review on Quantum Field Theory

2.2 Unruh-DeWitt model

Acknowledgments

References

- [1] Petar Simidzija, Aida Ahmadzadegan, Achim Kempf, and Eduardo Martín-Martínez. Transmission of quantum information through quantum fields. *Phys. Rev. D*, 101:036014, Feb 2020.