Teleportation of Multiparticle Entangled States

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ABSTRACT

This paper investigates the theoretical basis and actual methods for teleporting entangled states using multiple particles. Beginning with Bennett et al.'s pioneering work in 1993, which established the notion of quantum teleportation. In this paper, I will discuss the quantum teleportation, quantum entanglement, Entanglement schemes such as Entanglement swapping scheme and will find out the rate of successful teleportation in terms of fidelity. Additionally discussed is minimal assured fidelity, which is the lowest level of fidelity for any unknown quantum information about the states[1]. Additionally, the success rate of teleporting a superposition of odd and even coherent states is demonstrated to be able to be raised from 50% to almost 99%[2]. We discover that by just isolating the vacuum state from the even state, it can virtually transport, divert, and exchange.

Key Words: Entanglement, Quantum teleportation, Entanglement swapping scheme, Bell state measurement (BSM), Quantum information.

I.Introduction

The ability of instantly transferring a living being or thing from one place to another is known as teleportation, and it is purely imaginary. It frequently involves the living being or object breaking down at a specific location and then reforming at a different location. Although it is currently impossible, teleportation is frequently portrayed in science fiction films and anime. An example of this kind of technology was seen in the Doraemon anime series "Anywhere Door" (Japanese: Dokodemo Doa). One of Doraemon's devices lets the user to travel any area instantaneously by only opening the door and saying where they would like to go. Entangled particles are subatomic particles, such as electrons or photons, whose characteristics are correlated enough that, regardless of their distance from one another, the state of a specific particle instantaneously affects the state of another particle. In simple terms, this method works by arranging the sharing of an ERR pair of particles as electrons or protons prior to each time. Our approach is the result of expanding Bennett et al.'s (1993) quantum teleportation scheme to the multiparticle event. It is of the utmost importance to have an idea about how to execute a multiparticle quantum teleportation since it may be very helpful in quantum computation and quantum communication[3].

II.Quantum Entanglement

The entanglement widely discussed in the Einstein-Podolsky-Rosen (EPR) paradox proposed by Albert Einstein, Boris Podolsky, and Nathan Rosen in 1935, is a phenomenon in which the quantum states of two or more particles become connected to the point where the state of one particle is unable to be described separately of the state of the other, regardless of the distance between them[4].

Einstein, Podolsky, and Rosen claimed that if two particles A and B are entangled, measuring a characteristic of particle A (such as its location, velocity, or polarisation) will immediately change the associated characteristic of particle B, regardless of their distance in space. This revealed what Einstein memorably described as "spooky action at a distance," implying a non-local link between the entangled particles. However, quantum physics accepts non-local coherence as a basic property of nature. When a pair of particles become entangled, their distinct quantum states become inseparably connected, even when they are separated by a large distance. This means that measuring the condition of one particle instantaneously determines the state of the other, regardless of their distance, which violates the concept of locality.

III.Quantum Teleportation

In 1993, Charles Bennett published the seminal article "Teleporting an Unknown Quantum State via Dual Classical and Einstein-Podolsky-Rosen Channels" with collaborators Gilles Brassard, Claude Crépeau, Richard Jozsa, Asher Peres, and William K. Wootters. This study developed the notion of quantum teleportation, which revolutionised quantum information theory and was a crucial step towards figuring out quantum mechanical concepts. Quantum teleportation is the method of transmitting the exact state of a quantum system (such as a particle's quantum state) from a single place to a different one without having to physically transport the particle[5-7]. The basic concept underlying quantum teleportation is to use the phenomena of quantum entanglement to transfer the present state of a single particle to a different distance particle.

IV.Entanglement Swapping

Entanglement swapping is an outstanding phenomenon in quantum physics that enables entanglement among faraway photons to be transferred or "swapped" onto other particles without involving direct interaction. This idea holds significance for multiple quantum networking and communication protocols. The method consists of four subatomic particles, which are commonly referred to as A, B, C, and D. Initially, particles A and B form an entangled pair. In a similar way particles C and D are entangled with other particles[8].
The important feature of entanglement swapping is that the interaction between particles A and D is formed using the connection between particles B and C, even though particles A and D had previously remained unentangled[9]. This procedure illustrates the non-local characteristics of entanglement, highlighting the possibilities for quantum communication as well as data processing. Entanglement swapping helps to construct realistic quantum communication networks and secure quantum information processing systems by allowing entanglement to be distributed over vast distances without the need for direct particle transmission.

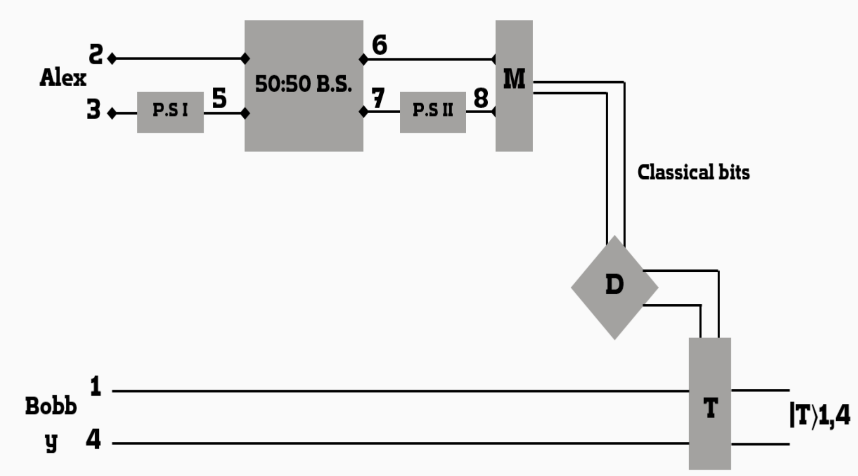
V.Entanglement Swapping Scheme

I have taken the scheme from the paper by Shivani A. Kumar, for Swapping scheme a beam splitter, two phase shifters, and photon counting measurements to shift between two pairs of NECS with the same intensities were used. Evaluate Eve, Bobby and Alex as three parties. Two pairs of NECS are prepared by Eve using states with varying photon densities in mode 1-4. The state of mode 2 is replaced by that of mode 4, resulting in an entangled pair of modes 1 and 4. To do this, Eve assigns Alex and Bobby one state from each of the entangled combinations. In this arrangement, Alex obtains states 2 and 3, and Bobby gets states 1 and 4. Alex will next combine her previously distinct states to entangle them, take a measurement on her now entangled pair, and receive two classical bits, which she will send to Bobby over a classical channel. Bobby selects a unitary transformation based on the information he obtains to apply to his states in modes 1 and 4[10-11].

The numbers 1, 2, 3, 4, 5, 6, 7, 8 represent modes. The straight line of time moves from left to right. Single lines indicate quantum bits(0 or 1), whereas double lines represent classical bits(0 and 1).

(a)Alex converts state 3 to state 5 using phase shifter I.
(b) He then combines states 2 and 5 with a 50:50 beam splitter to create entangled states 6 and 7,
(c) make use of phase shifter II to transform state 7 to state 8, and
(d) measure photons in states 6 and 8 and communicate results to Bobby.
(e)Bobby takes the decision based on the information he gets, and then uses a unitary transformation to transmit the initial entanglement to his quantum states of existence.

FIGURE: Entanglement Swapping scheme



Alex and Bobby now have one entangled pair of photons. By possessing half of each entangled pair, they dissolve the common quantum channel. Alex's photon counting results in one of 17 possibilities cases. Bobby will receive photon counting results over a classical channel. Based on this information, he will perform a unitary transformation to states 1 and 4 to create an exact copy of entangled states[12].
In this we used the swapping scheme which involves two states that are generated and distributed among two particles. We have shown that by altering the teleportation scheme slight, an almost perfect teleportation is achieved with minimum assured fidelity almost equal to 1. Also, by changing the mean number of particles, the fidelity and probability of the particles is almost perfect.

VI.Results and Discussion

We used the swapping technique in this, which includes the generation and distribution of two states among two particles. We have demonstrated that a minimal guaranteed fidelity of almost equal to one may reached with an almost flawless teleportation by slightly changing the teleportation strategy. Additionally, the fidelity and probability of the particles are nearly perfect by varying the mean number of particles. The findings suggest that measurement results break into branches with different fidelities due to differences in the intensities of initially quantum states. Certain branches may revamp and share the same fidelities, depending on the system's initial condition. But the most recent distribution is different from what we would expect for beginning states with the same photon density. By dividing the even state into zero and non-zero-even categories and isolating the zero state from the even state. Therefore, when it discovered that there are zero photons in both output modes, just the vacuum state remains. In this instance, there is no evidence of measurement result swapping.

VII.Conclusion

In this we used the swapping scheme which involves two states that are generated and distributed among two particles. By changing the mean number of particles, the fidelity and probability of the particles is almost perfect. In conclusion, successful teleportation depends on the probability of photons. We achieved fidelity equals to 0.98 for some appreciable photons, i.e. an almost perfect teleportation for multiparticle entangled states system.

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