Teleporting an Unknown Quantum State
Via Dual Classical and Einstein-Podolsky-Rosen Channels*

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Introduction

Goals/Motivation
- Teleport a quantum particle using quantum entanglement.
- Understand the properties of quantum information.

What does ‘teleporting’ mean?
Alice wants to send Bob a particle. However, she does not know anything about the state of the particle and cannot give it to Bob physically. Let the particle be in the state \(|\psi\rangle\). How does Bob obtain a particle in the exact same state \(|\psi\rangle\) without it?

Alice can use quantum entanglement to teleport a particle

When two particles interact, their wavefunctions become entangled if measurement of one particle determines the state of the other particle. Measuring \(A\) to be \(0\) means \(B\) is \(1\).

The problem of measurement

What happens when I change my basis?

Then my state is \(\frac{1}{\sqrt{2}}(|0\rangle_a + |1\rangle_a)|\psi\rangle + \frac{1}{\sqrt{2}}(|0\rangle_b - |1\rangle_b)|\phi\rangle\). Now measuring in this basis yields different results.

- Bell basis

| 0 1 0 1 0 1 0 1 |
| 0 1 1 0 1 0 1 0 |
| 1 0 0 1 0 1 0 1 |
| 1 0 1 0 1 0 1 0 |

Source of maximally entangled particle pairs

Apply unitary transformation on \((1,A)\) pair

Entangled state

Wait for Alice’s result

Apply unitary transformation (based on message from Alice) on particle \(B\)

Send the result of measurement to Bob with classical channel

Possible Implications

“Pseudo-broadcast” of quantum states

- Broadcasts of states in quantum mechanics are forbidden as they require cloning.
- In this procedure, Alice need no information on the location of Bob, as classical message can be cloned and broadcasted.

Improved Quantum Cryptography

- In this procedure, direct transfer of quantum state was avoided.
- By comparing some part of the message (substring) in public, Alice and Bob could detect eavesdropper easily.

1001100 11101 ...
Without eavesdropper

1001100 11101 ...
With eavesdropper

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