

# Entanglement and physical correlations

Joint states, no-cloning, and Bell correlations. Preparation circuits appear in  $M_3$ .

# No-Cloning

## No-Cloning Theorem

It is **not** possible to copy an **arbitrary unknown** quantum state

This contrasts with classical information, which can be duplicated freely

## Implications

Reinforces quantum information's fragility

Enables secure communication (e.g., quantum key distribution)

Forces new strategies:

entanglement, teleportation, error correction

# Meet the Bell States

## Meet the Bell States

The four maximally entangled two-qubit states:

$$\Phi^+ = \frac{1}{\sqrt{2}} (|00\rangle + |11\rangle)$$

$$\Phi^- = \frac{1}{\sqrt{2}} (|00\rangle - |11\rangle)$$

$$\Psi^+ = \frac{1}{\sqrt{2}} (|01\rangle + |10\rangle)$$

$$\Psi^- = \frac{1}{\sqrt{2}} (|01\rangle - |10\rangle)$$

Now we are dealing  
with two qubits

$|10\rangle$

Means one qubit is in  
state  $[0,1]$  and the other  
is in state  $[1,0]$

- Perfect correlation or anti-correlation when measured
- Basis for quantum communication, teleportation, and error correction

# Entanglement and local statistics

Define separability and entanglement with explicit joint states.

Calculate joint probabilities and each subsystem's marginal probabilities. Explain why correlations do not permit faster-than-light messaging.

# Bell assumptions and an experimental test

State the assumptions behind the chosen Bell inequality. Give measurement settings, a classical bound, and a quantum prediction.

Explain experimental limitations without claiming that the result proves faster-than-light communication.

## Q2 synthesis exercise

Combine state preparation, tensor products, measurement bases, and physical evolution in one problem.

Students should explain the predicted evidence before Q3 introduces computational models.