Building a room temperature quantum computer

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Room temperature quantum computer concept

- Many-device entanglement.
- Room temperature operation.
- Programmable.

**Deterministic Entanglement Sources**

**Quantum Processing Unit**

**Quantum buffer and measurement stations**

- The Dirac equation merges quantum mechanics with special relativity.

\[ i\hbar \frac{\partial \psi}{\partial t} = H_D \psi = (c \hat{p} \sigma_x + mc^2 \sigma_z) \psi \]

- The Jackiw-Rebbi model describes a Dirac field coupled to a soliton field.

\[ i \partial_t \Psi = \left( \alpha cp_z + \frac{\beta mc^2}{\kappa} \phi(z) \right) \Psi \]

- A kink in the soliton yields a topologically protected zero-energy mode.
Dirac dynamics using spinor of light

Spinor of light:

The spinor obeys a Dirac-like equation:

\[
\hat{\Psi}_+ = \cos \theta \hat{\mathcal{E}}_+ - \frac{1}{\sqrt{2}} \sin \theta (\hat{\sigma}_{gs} - i \hat{\sigma}_{gh})
\]

\[
\hat{\Psi}_- = \cos \theta \hat{\mathcal{E}}_- + \frac{1}{\sqrt{2}} \sin \theta (i \hat{\sigma}_{gs} - \hat{\sigma}_{gh})
\]

\[
\hat{\Psi}^* = (\hat{\Psi}_+, \hat{\Psi}_-)^T
\]

\[
i\hbar \frac{\partial}{\partial t} \hat{\Psi} = \left( i\hbar v_g \sigma_z \frac{\partial}{\partial \varphi} + \hbar \delta \sin^2 \theta \sigma_y \right) \hat{\Psi}
\]

\[
- i L_{\text{abs}} v_g \sin^4 \theta \left( \sigma_z \frac{\partial}{\partial z} - \frac{\delta}{c} \sigma_y \right)^2 \hat{\Psi}
\]

\[
c^* = v_g = c \cos^2 \theta
\]

\[
m^* = \hbar \delta \sin^2 \theta / v_g^2
\]
Creating spinors of light experimentally

Realizing topological relativistic dynamics with slow light polaritons at room temperature

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Quantum simulation of Dirac and Jackiw-Rebbi spinor dynamics

\[ i\partial_t \psi = (iv_g \sigma_z \partial_z + m_{eff} v_g^2 \sigma_y - \gamma) \psi \]

“Realizing JR would require beams of relativistic particles interacting with Fermi quantum fields. This realization of the same physics requires only diode lasers and a cell of Rb atoms.”
Quantum processing network in Stony Brook (in collaboration with BNL)

~15 interconnectable quantum devices

Photon Sources

Ancilla qubits

Entangled photons

Quantum processing units

Cavity QED gate

RT phase gate

Network of quantum memories

Two table-top memories

Scalable

Two miniaturized versions ready

Bell measurements

Homodyne detectors

Measurement stations

- Largest quantum processing network of its kind.