# Quantum Tomography, Teleportation and Distributed Quantum Computing

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# Contents:



# Quantum Possibility Space

The Quantum Possibility space is a set of wavefunctions Ψ,
each represented by (i) **a state vector** and (ii) **a complex magnitude**.

$$QPS = \{ \Psi_0 \dots \Psi_x \dots \Psi_p \}$$

$$\Psi_x = | q_xN\text{-}1 \dots q_xn \dots q_x0 >$$

$$\sum |\Psi_x|^2 = 1$$

QPS = set of wavefunctions, 0 … x … p

$\Psi_x$ = wavefunction of state vector x

$q_xn$ = n'th qubit in state vector x

Sum of squared magnitudes of state vector wavefunctions is unity

## Multi-Qubit State Vector

qn = |0> or |1>

| binary state vector >

$$| qN\text{-}1 \dots qn \dots q0 > \quad = Q = \sum_{q=0}^{q=N-1} 2^q \ |1>$$

State vector equals
Sum two to power q ∀ N
for |1> states
For all N qubits

The Quantum Possibility Space is a new way to compactly and accurately represent quantum tomography i.e. the composite state vectors and complex magnitudes that define wavefunctions of the multi-qubit entangled state.

# Quantum Possibility Space in JSON

RFC 4627 The application/json Media Type for JavaScript Object Notation – D. Crockford


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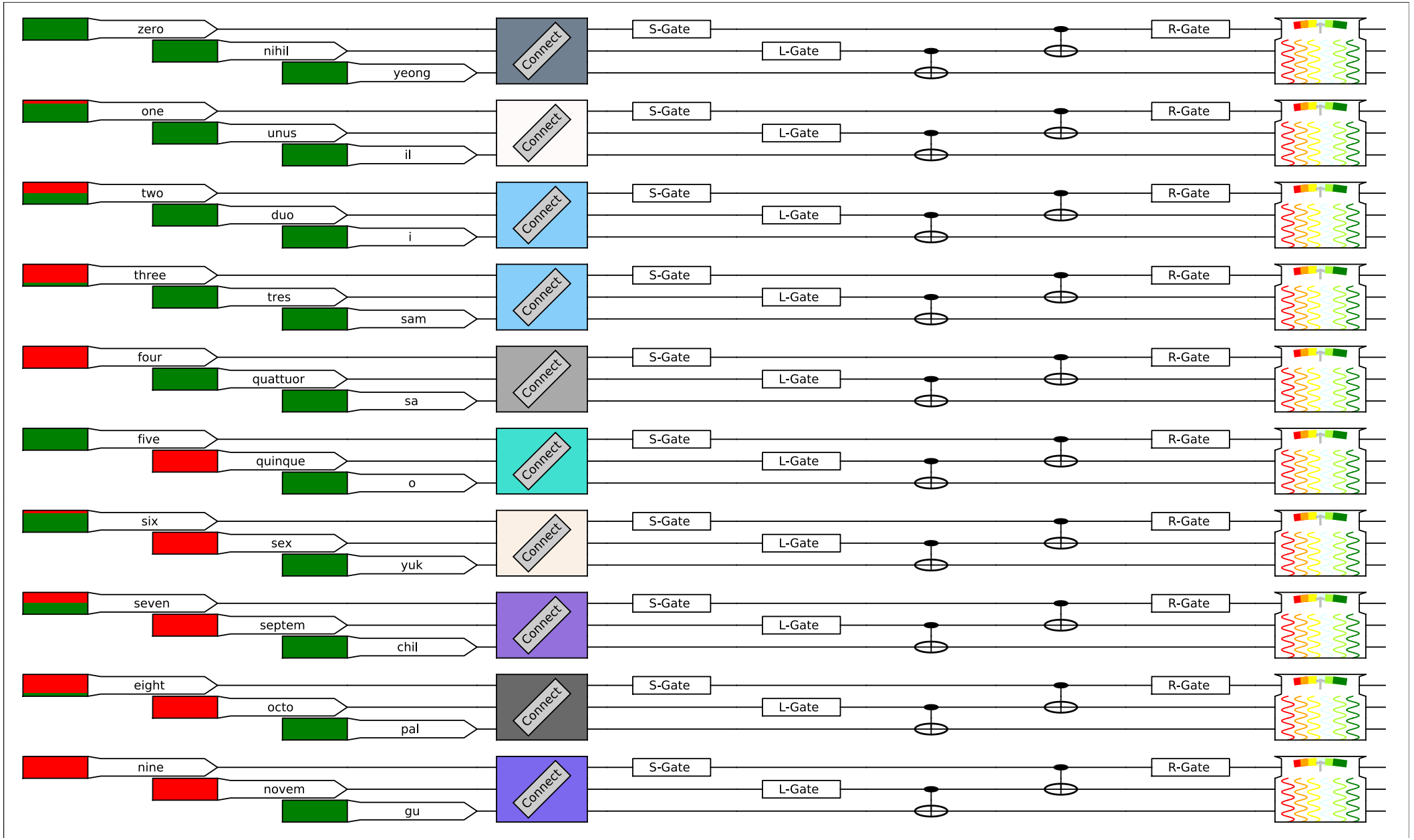
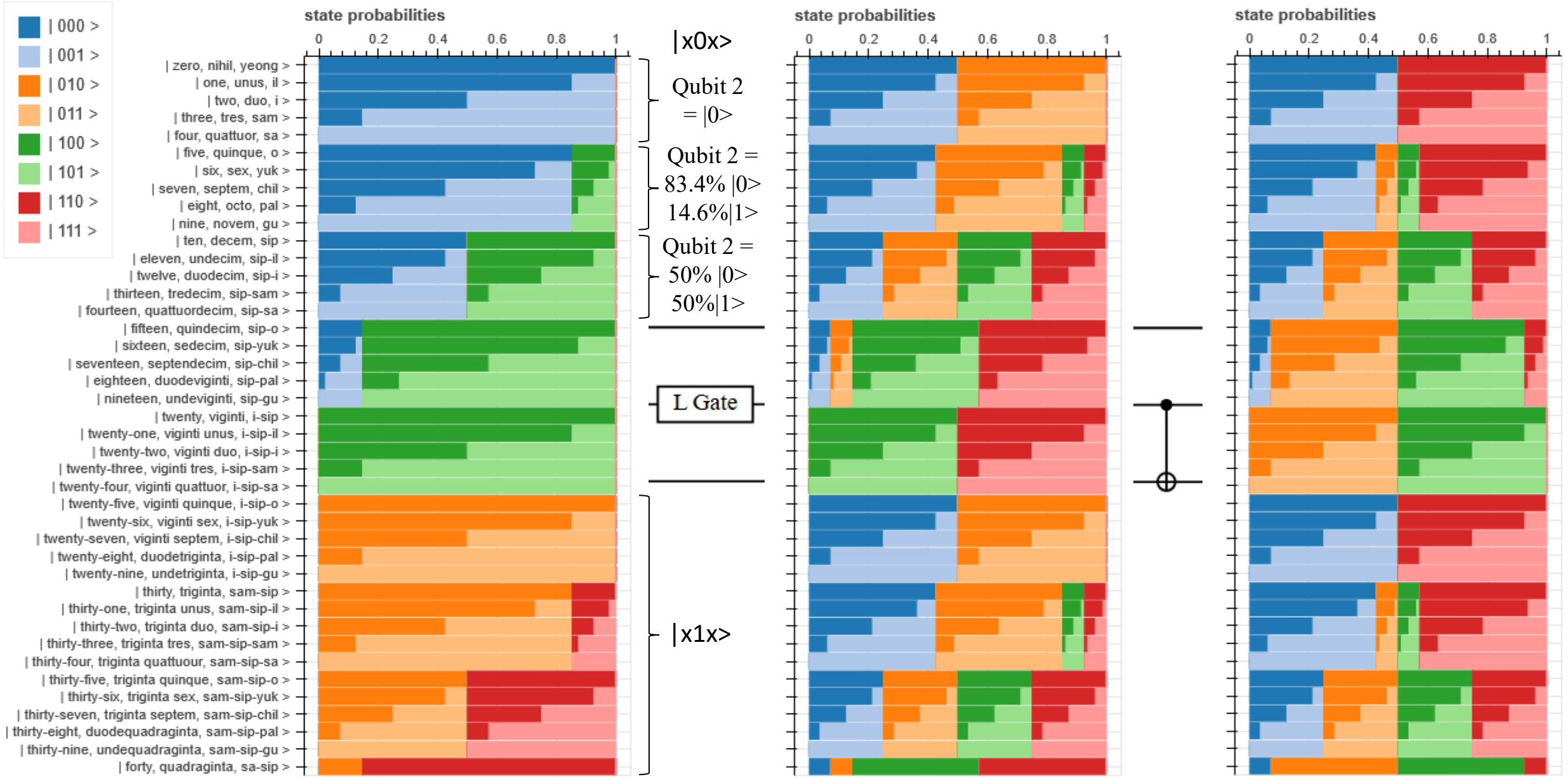
# Alice's quantum gate circuit (Brassard)





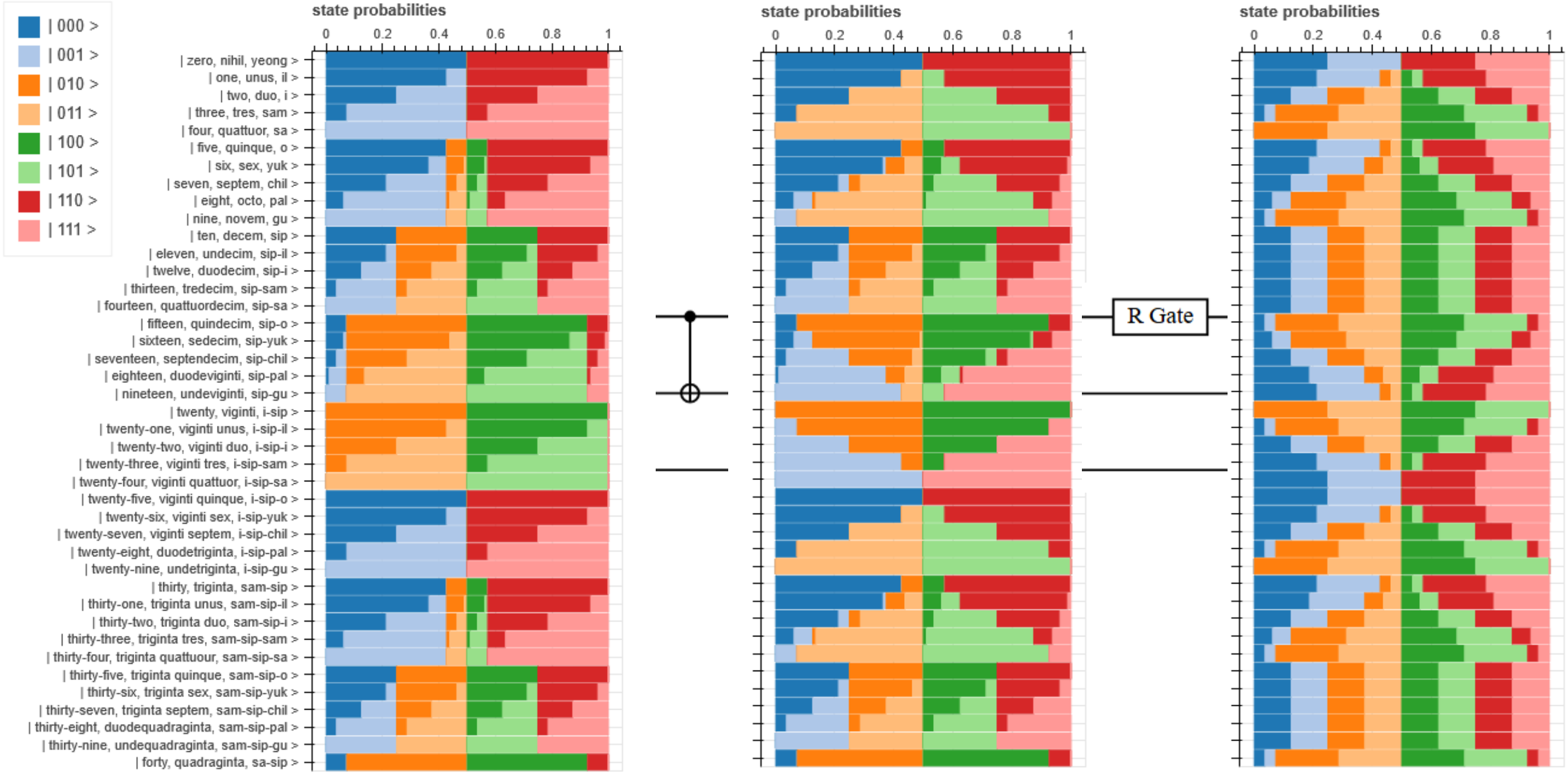
# Evolution of Alice's Quantum State (1)





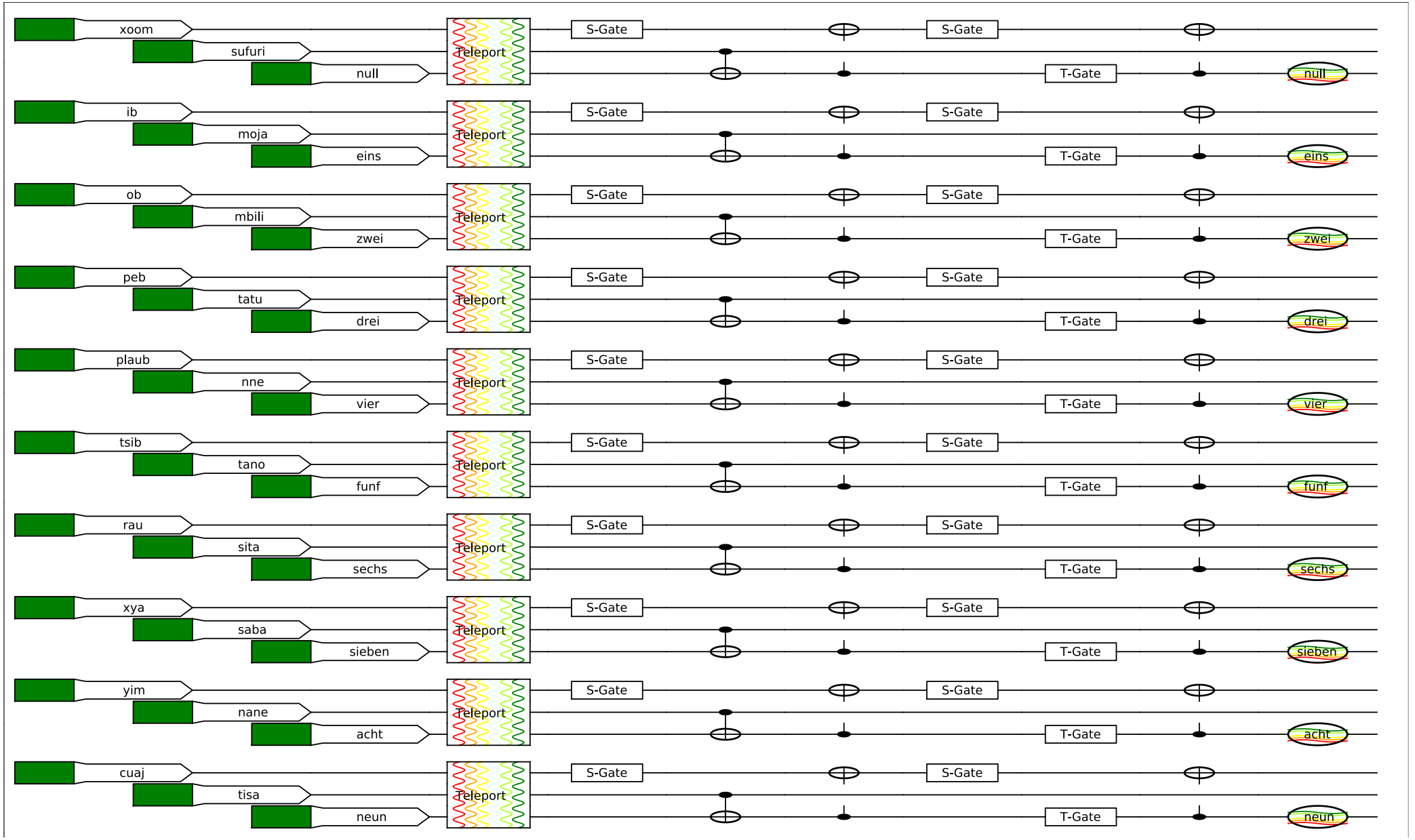
# Evolution of Alice's Quantum State (2)





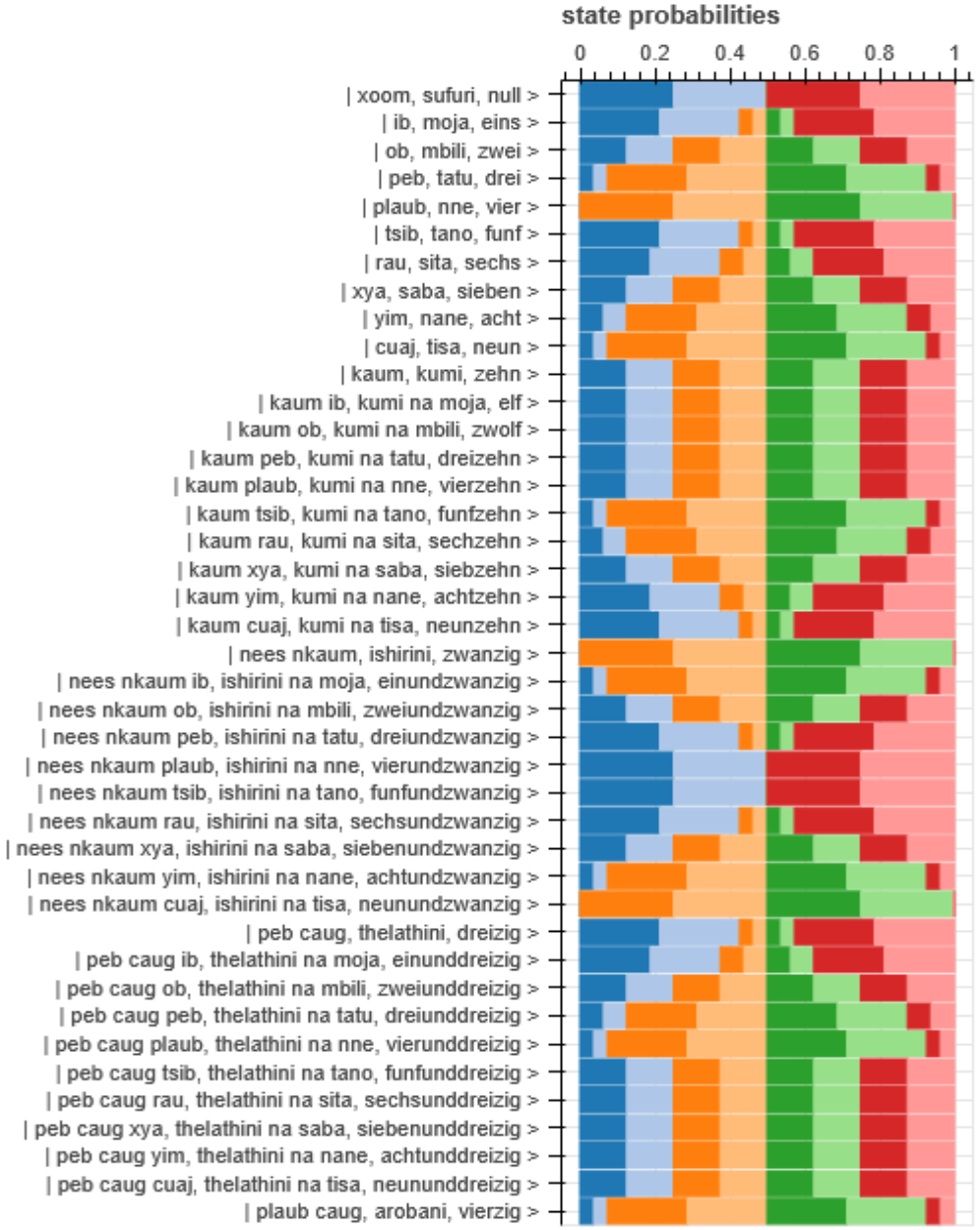
# Bob's quantum gate circuit (Brassard)

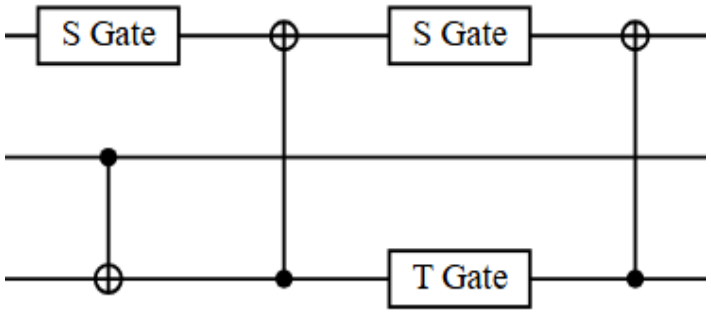


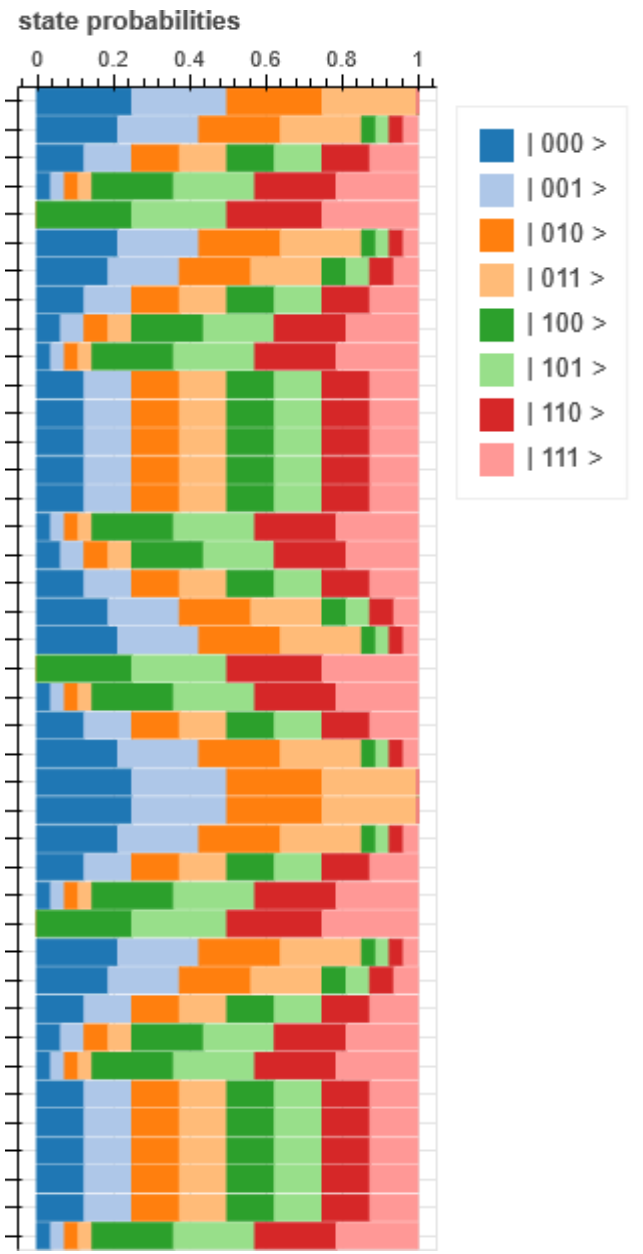


# Evolution of Bob's Quantum State





# Teleportation Formula and Qubit Functionality

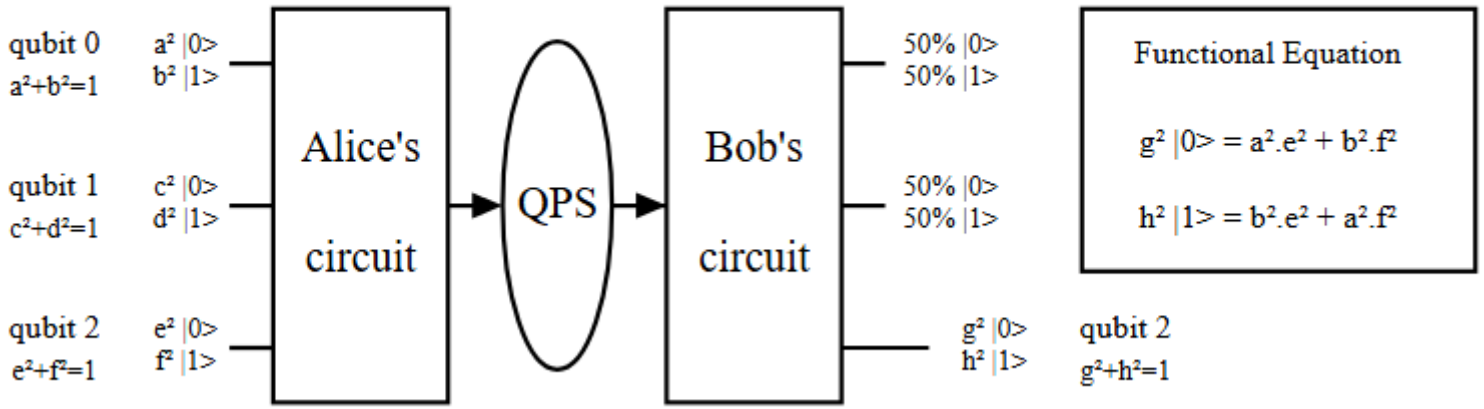
Brassard's 'Teleportation as a quantum computation' was functionally mapped by running multiple circuits with different input states and state superpositions for each of Alice's qubits.

Results confirmed that the state of Alice's qubit 0 is teleported to Bob's qubit 2, however only if Alice's qubit 2 is initially |0>.

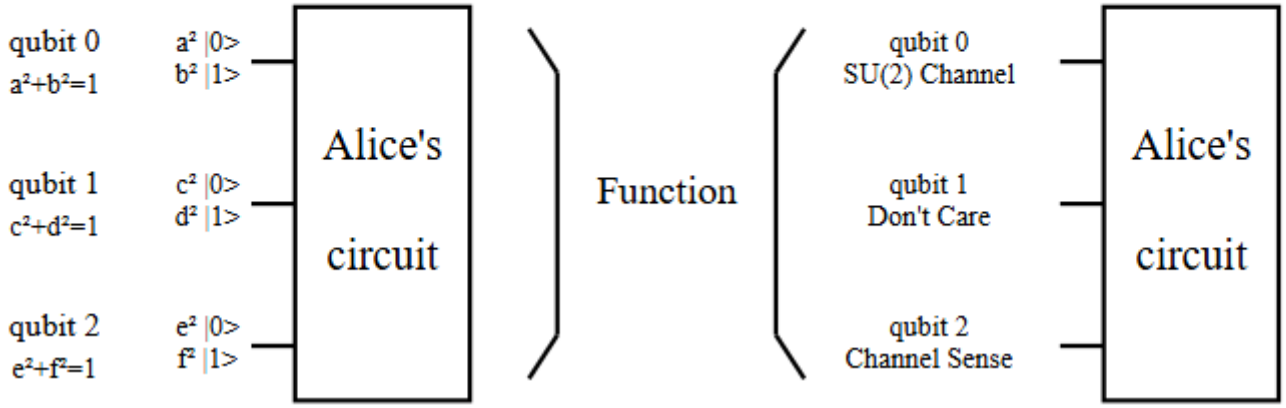
When Alice's qubit 2 starts as |1>, Bob's teleported qubit 2 is 'antisense' with |0> and |1> swapped.

When Alice's qubit 2 input is 50% |0> and 50% |1>, Bob's teleported qubit 2 is 'nonsense' with an equal mixture |0> and |1>.

## Teleportation Formula




## Qubit Functionality

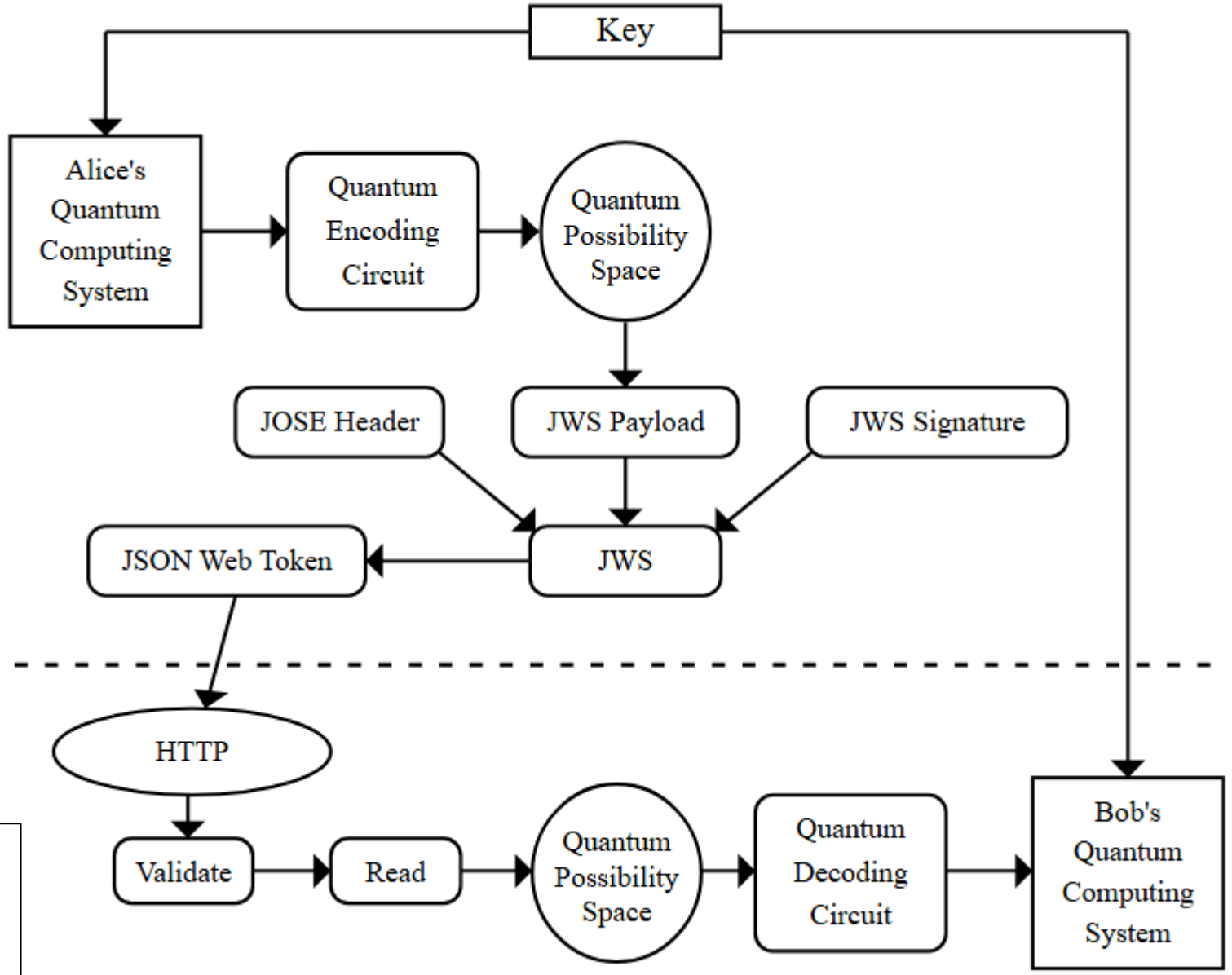


# Web based Quantum Teleportation

Alice's Quantum Computing System sends entangled quantum state to Bob's Quantum Computing System via QPS.

Key is any binary sequence (or seed for a binary sequence generator) used to set Alice's qubit 2 'channel sense' qubit to |0> or |1>.

Key is shared with Bob via a secure side channel and informs if the teleported qubit is equal to Alice's qubit 0 or opposite to it with swapped |0> and |1> states.




RFC 7515 JSON Web Signature – Jones, Bradley, Sakimura.
RFC 7519 JSON Web Token – Jones, Bradley, Sakimura.

# QPS pairs and Quantum Key Distribution



Each QPS has a conjugate QPS* where the imaginary component of each state vector's complex magnitude is negated.
Quantum Key Distribution starts by sending each to a separate system.

$QPS = \{\Psi_0 ... \Psi_x ... \Psi_{p-1}\}$

QPS = set of p wavefunctions, $0 \leq x < p$

$\Psi_x = | q_xN\text{-}1 \ \ldots \ q_xn \ \ldots \ q_x0 >$

$\Psi_x$ = wavefunction of state vector x

$q_xn$ = n'th qubit in state vector x

$QPS^* = \{\Psi^*_0 ... \Psi^*_x ... \Psi^*_{p-1}\}$

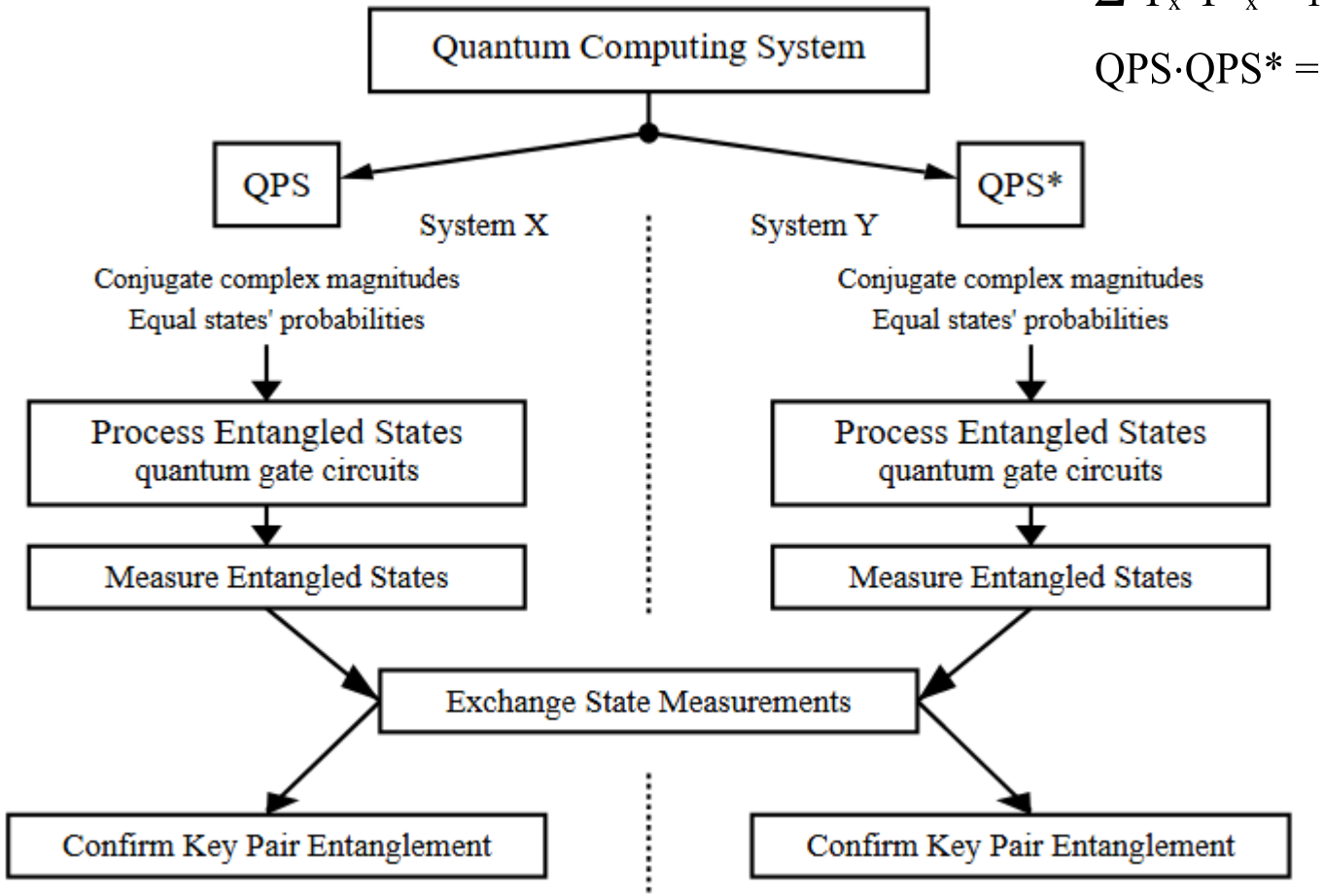
QPS* = set of p conjugate wavefunctions

$\sum \Psi_x \cdot \Psi^*_x = 1$

Sum of products of conjugate state vector wavefunctions is unity

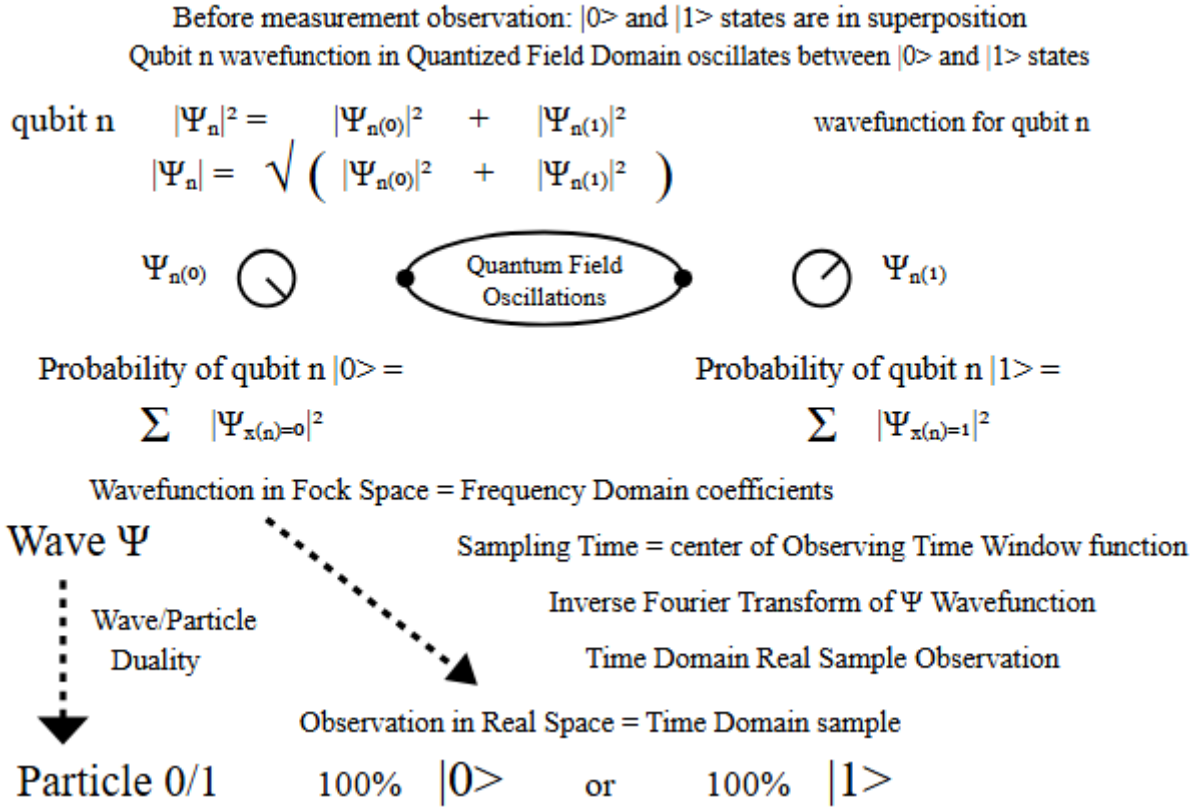
$QPS \cdot QPS^* = 1$

Dot product of QPS and its conjugate QPS* is unity




- Each system processes entangled states using its own quantum gate circuit.
- After quantum gate processing by each system, measurements are made and exchanged. The measurement may be the correlation of qubit states within each system.
- Entanglement of the QPS key pair is confirmed when each system is able to match its internal state measurements with those in its counterpart.

# Measurement and Collapse of QPS




- In the Quantum Field Theory model, energy quanta exist as Fourier coefficient in the frequency domain. Linear combinations are present as superposition mixtures of |0> and |1>.
- Mutually exclusive discrete states |0> and |1> are observed in the time domain.
- Quantum Randomness occurs because Quantum Field Oscillations are asynchronous to the Observer's Sampling Time

The non-observed state vector magnitudes are combined with the observed state vector magnitudes by Root Sum of Squares Addition