Detection of moving charge by position dependent qubits

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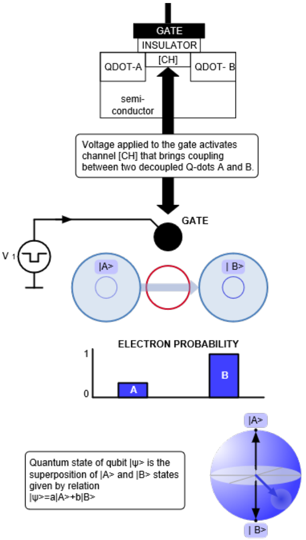
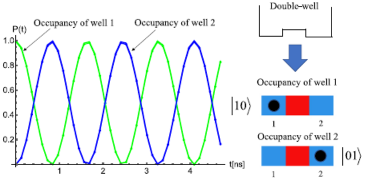
Overview

1. Desired features for programmable quantum electronics
2. Anticorrelation principle in semiconductor and in superconducting electronics
3. Quantum gates
4. Two types of position dependent qubits
5. Physical properties of coupled Single Electron Lines
6. Interface between semiconductor and superconducting quantum computer
7. Hybrid q-semiconductor and q-superconducting computer
    - Analogies between Cooper pair box and CMOS qbit
8. Quantum logic
    - Q-Chemistry
    - Q-Communication
    - Q-Artificial Neural Network

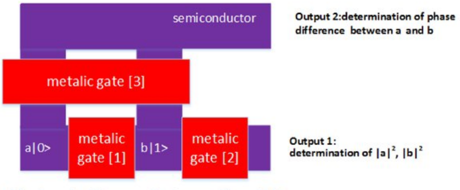
Main desired features of quantum programmable electronics

- Smooth interface between classical and quantum circuits
- High integration and high logical density
- Desired operational temperature above 1K
- Electrical writting up the qubits states
- Electrical reading up of qubits states
- Electrical way of entangling two particles
- Smooth transition from classical to quantum regime

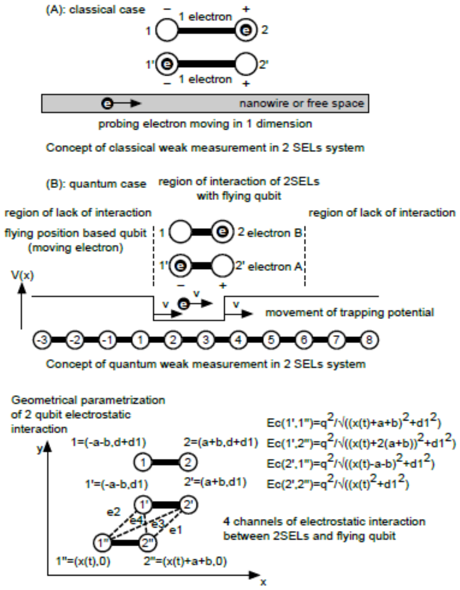




Top view of readout circuit of position dependent qubit

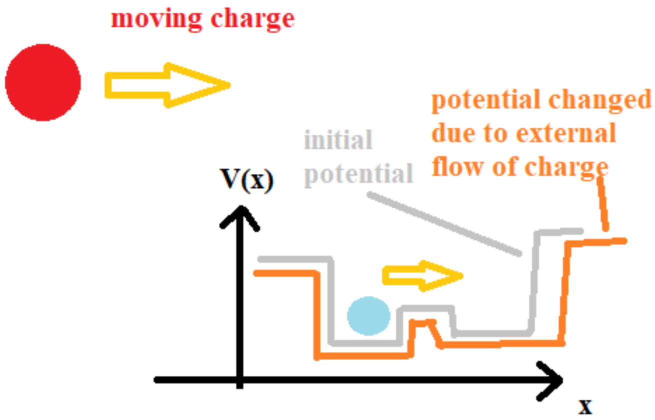


Electrostatic qubit by Panagiotis et al [IEEE Open Access, 2019], Pomorski et al. [Spie 2019], Fujisawa [2004]



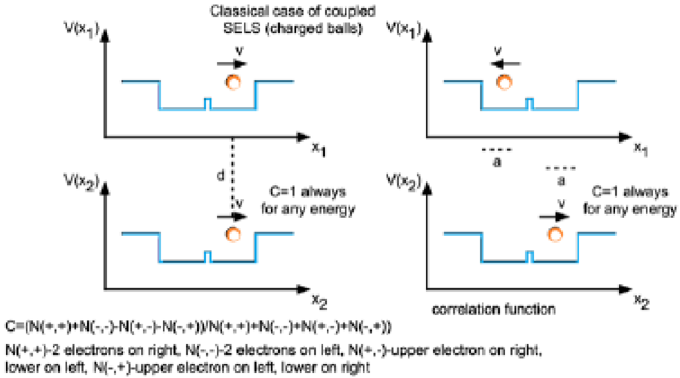
["Analytical view on coupled single electron lines" by K.Pomorski et al. ,2019]

Central idea



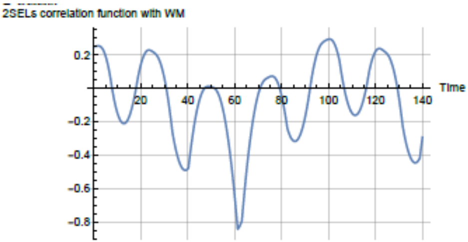
Moving charge brings the phase imprint and reconfiguration of the effective charged confined by local potential.

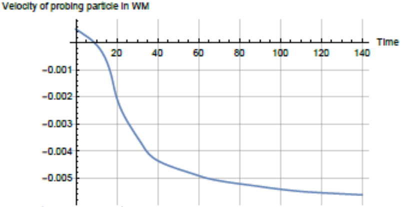
Definition of correlation function

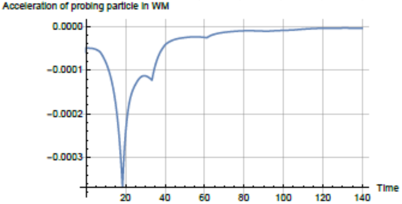


["Analytical view on coupled single electron lines" by K.Pomorski et al. ,2019]

Classical correlation function with time



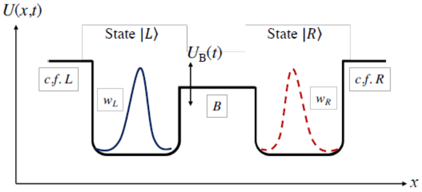




Position based qubit in tight binding model

The Hamiltonian of this system is given as

$$\hat{H}(t) = \begin{pmatrix} E_{p1}(t) & t_{s12}(t) \\ t_{s12}^{\dagger}(t) & E_{p2}(t) \end{pmatrix}_{[x=(x_1,x_2)]} =$$
$$= (E_1(t) |E_1\rangle_t \langle E_1|_t + E_2(t) |E_2\rangle \langle E_2|)_{[E=(E_1,E_2)]}. \quad (1)$$



$$i\hbar\frac{d}{dt}\begin{pmatrix}\alpha(t)\\ \beta(t)\end{pmatrix}=E(t)\begin{pmatrix}\alpha(t)\\ \beta(t)\end{pmatrix}=$$
$$=\begin{pmatrix}E_{p1}+V_1\delta(t-t_1) & t_{s12}+(V_3+iV_4)\delta(t-t_1)\\ t_{s12}^{*}+(V_3-iV_4)\delta(t-t_1) & E_{p2}+V_2\delta(t-t_1)\end{pmatrix}\begin{pmatrix}\alpha(t)\\ \beta(t)\end{pmatrix} \tag{2}$$

with $E_{p1}=\int_{-\infty}^{+\infty}dxw_L(x)(-\frac{1}{2m}\frac{d^2}{dx^2}+V_{eff}(x))w_L(x)$,
$E_{p2}=\int_{-\infty}^{+\infty}dxw_R(x)(-\frac{1}{2m}\frac{d^2}{dx^2}+V_{eff}(x))w_r(x)$,
$t_{s12}=\int_{-\infty}^{+\infty}dxw_R(x)(-\frac{1}{2m}\frac{d^2}{dx^2}+V_{eff}(x))w_L(x)$,
$t_{s21}=\int_{-\infty}^{+\infty}dxw_L(x)(-\frac{1}{2m}\frac{d^2}{dx^2}+V_{eff}(x))w_R(x)$, where $w_L(x)$ and $w_R(x)$ are maximum localized wavefunctions of electron in system of 2 coupled quantum dots. $w_R(x)$ and $w_L(x)$ Wannier wavefunctions are linear combination of system energy eigenstates.

$$\begin{pmatrix}\alpha(t_1^+)\\ \beta(t_1^+)\end{pmatrix} =$$

$$= \frac{\hbar}{(\hbar + iV_1)(\hbar + iV_2) + V_3^2 + V_4^2}\begin{pmatrix}(\hbar + iV_2) & (-iV_3 + V_4)\\ (-iV_3 - V_4) & (\hbar + iV_1)\end{pmatrix}\begin{pmatrix}\alpha(t_1^-)\\ \beta(t_1^-)\end{pmatrix}$$

$$\begin{pmatrix}\alpha(t_1^+)\\ \beta(t_1^+)\end{pmatrix} = \begin{pmatrix}M_{1,1} & M_{1,2}\\ M_{2,1} & M_{2,2}\end{pmatrix}\begin{pmatrix}\alpha(t_1^-)\\ \beta(t_1^-)\end{pmatrix} =$$

$$\frac{1}{(\hbar^4 + (-V_1V_2 + V_3^2 + V_4^2)^2 + \hbar^2(V_1^2 + V_2^2 + 2(V_3^2 + V_4^2)))} \times$$

$$\times \begin{pmatrix}M_{r(1,1)} + iM_{i(1,1)} & M_{r(1,2)} + iM_{i(1,2)}\\ M_{r(2,1)} + iM_{i(2,1)} & M_{r(2,2)} + iM_{i(2,2)}\end{pmatrix} \qquad (3)$$

$$|\psi >_m = e^{i\phi_{E1m}} c_{E1m} e^{\frac{E_1}{i\hbar} t_1} |E_1 > + e^{i\phi_{E2m}} c_{E2m} e^{\frac{E_2}{i\hbar} t_2} |E_2 > =$$

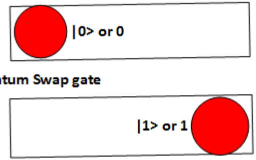
$$= \begin{pmatrix} +e^{i\phi_{E1m}} c_{E1m} e^{\frac{E_1}{i\hbar} t_1} + e^{i\phi_{E2m}} c_{E2m} e^{\frac{E_2}{i\hbar} t_1} \\ -e^{i\phi_{E1m}} c_{E1m} e^{\frac{E_1}{i\hbar} t_1} + e^{i\phi_{E2m}} c_{E2m} e^{\frac{E_2}{i\hbar} t_1} \end{pmatrix} =$$

$$\begin{pmatrix} M_{1,1} & M_{1,2} \\ M_{2,1} & M_{2,2} \end{pmatrix} \begin{pmatrix} +e^{i\phi_{E1}} c_{E1} e^{\frac{E_1}{i\hbar} t_1} + e^{i\phi_{E2}} c_{E2} e^{\frac{E_2}{i\hbar} t_1} \\ -e^{i\phi_{E1}} c_{E1} e^{\frac{E_1}{i\hbar} t_1} + e^{i\phi_{E2}} c_{E2} e^{\frac{E_2}{i\hbar} t_1} \end{pmatrix} \quad (4)$$

$$
\begin{aligned}
&e^{i\phi_{E1m}}c_{E1m} = \\
&(\hbar(c_{E1}|\hbar(2\hbar^2 + V_1^2 + V_2^2 + 2V_1V_3 + 2V_3(V_2 + V_3) + 2V_4^2)Cos[\phi_{E1}] + \\
&c_{E2}(\hbar(-V_1^2 + V_2^2) + 2(\hbar^2 - V_1V_2 + V_3^2)V_4 + 2V_4^3)Cos[\phi_{E2} + (E_1 - \\
&E_2)t_1] + c_{E1}(\hbar^2(V_1 + V_2 - 2V_3) + (V_1 + V_2 + 2V_3)(V_1V_2 - V_3^2 - \\
&V_4^2))Sin[\phi_{E1}] + c_{E2}((V_1 - V_2)(\hbar^2 - V_1V_2 + V_3^2) + 2\hbar(V_1 + V_2)V_4 + (V_1 - \\
&V_2)V_4^2)Sin[\phi_{E2} + (E_1 - E_2)t_1]))/(2(\hbar^4 + (-V_1V_2 + V_3^2 + V_4^2)^2 + \\
&\hbar^2(V_1^2 + V_2^2 + 2(V_3^2 + V_4^2)))) + (i\hbar(c_{E1}(-\hbar^2(V_1 + V_2 - 2V_3) - (V_1 + \\
&V_2 + 2V_3)(V_1V_2 - V_3^2 - V_4^2))Cos[\phi_{E1}] - c_{E2}((V_1 - V_2)(\hbar^2 - V_1V_2 + \\
&V_3^2) + 2\hbar(V1 + V2)V4 + (V1 - V2)V_4^2)Cos[\phi_{E2} + (E_1 - E_2)t_1] + \\
&c_{E1}\hbar(2\hbar^2 + V1^2 + V2^2 + 2V_1V_3 + 2V_3(V_2 + V_3) + 2V_4^2)Sin[\phi_{E1}] + \\
&c_{E2}(\hbar(-V_1^2 + V_2^2) + 2(\hbar^2 - V_1V_2 + V_3^2)V_4 + 2V_4^3)Sin[\phi_{E2} + (E_1 - \\
&E_2)t_1]))/(2(\hbar^4 + (-V_1V_2 + V_3^2 + V_4^2)^2 + \hbar^2(V_1^2 + V_2^2 + 2(V_3^2 + V_4^2))))
\end{aligned}
$$

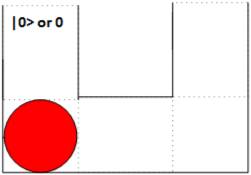
$$e^{i\phi_{E2m}}c_{E2m} = (i\hbar(-c_{E2}(\hbar^2(V_1+V_2+2V_3)+(V_1+V_2-2V_3)(V_1V_2-V_3^2-V_4^2))Cos[\phi_{E2}]+ c_{E1}(-(V_1-V_2)(\hbar^2-V_1V_2+V_3^2)+2\hbar(V_1+V_2)V_4+(-V_1+V_2)V_4^2)Cos[\phi_{E1}- E_1t_1+E_2t_1]+c_{E2}\hbar(2\hbar^2+V_1^2+V_2^2-2(V_1+V_2)V_3+2V_3^2+2V_4^2)Sin[\phi_{E2}]- c_{E1}(\hbar(V_1-V_2)(V_1+V_2)+2(\hbar^2-V_1V_2+V_3^2)V_4+2V_4^3)Sin[\phi_{E1}-E_1t1+ E_2t_1]))/(2(\hbar^4+(-V_1V_2+V_3^2+V_4^2)^2+\hbar^2(V_1^2+V_2^2+2(V_3^2+V_4^2))))+ +(\hbar(c_{E2}\hbar(2\hbar^2+V_1^2+V_2^2-2(V_1+V_2)V_3+2V_3^2+2V_4^2)Cos[\phi_{E2}]-c_{E1}(\hbar(V_1- V_2)(V_1+V_2)+2(\hbar^2-V_1V_2+V_3^2)V_4+2V_4^3)Cos[\phi_E1+(-E_1+E_2)t_1]+ c_{E2}(\hbar^2(V1+V2+2V3)+(V_1+V_2-2V_3)(V_1V_2-V_3^2-V_4^2))Sin[\phi_{E2}]+ c_{E1}((V_1-V_2)(\hbar^2-V_1V_2+V_3^2)-2\hbar(V_1+V_2)V_4+(V_1-V_2)V_4^2)Sin[\phi_{E1}+ (-E_1+E_2)t_1]))/(2(\hbar^4+(-V_1V_2+V_3^2+V_4^2)^2+\hbar^2(V_1^2+V_2^2+2(V_3^2+V_4^2))))$$

Classical/Logic circuits from electron-electron anticorrelation

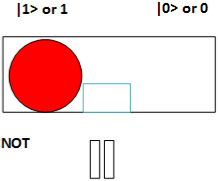


Classical / Quantum Swap gate

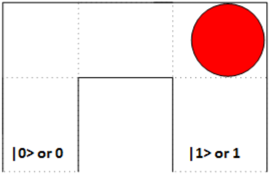
Input of CNOT gate



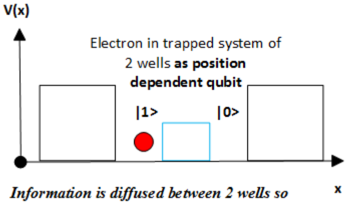
Control bit or qubit for CNOT gate



Quantum Swap Gate or CNOT



Output of Swap Gate/ CNOT gate



Information is diffused between 2 wells so
$|\psi\rangle = a|0\rangle + b|1\rangle$

Occupancy ocillations in position based qubit at nodes 1 and 2

$$
\begin{aligned}
P_1(t) = |\alpha(t)|^2 = \frac{1}{2}((|\alpha(0)|^2 + |\beta(0)|^2) + \frac{1}{2}(|\alpha(0)|^2 \\
-|\beta(0)|^2)\cos((\frac{E_2 - E_1)t}{\hbar})) = \cos(\Theta(t))^2, \\
P_2(t) = |\alpha(t)|^2 = \frac{1}{2}((|\alpha(0)|^2 + |\beta(0)|^2) - \frac{1}{2}(|\alpha(0)|^2 \\
-|\beta(0)|^2)\cos((\frac{E_2 - E_1)t}{\hbar})) = \sin(\Theta(t))^2,
\end{aligned} \tag{5}
$$

and it oscillates periodically with frequency proportional to distance between energetic levels E_2 and E_1 and is given as $\omega_0 = \frac{E_2 - E_1}{\hbar}$.

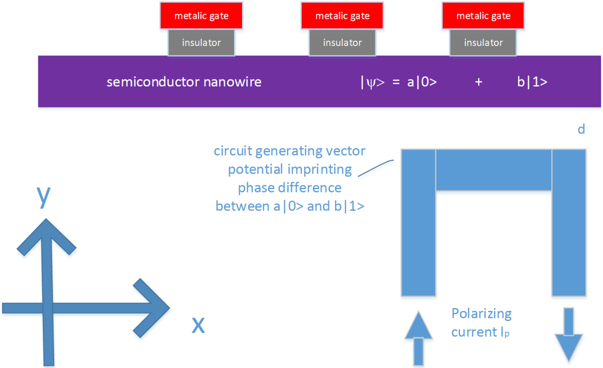
Bloch sphere dynamics for position based qubit

$$-\sin(\phi(t)) = \left[\frac{\sin(\frac{E_1 t}{\hbar})(|\alpha(0)|^2 - |\beta(0)|^2) + \sin(\frac{E_2 t}{\hbar})(|\alpha(0)|^2 + |\beta(0)|^2)}{\cos(\frac{E_1 t}{\hbar})(|\alpha(0)|^2 - |\beta(0)|^2) + \cos(\frac{E_2 t}{\hbar})(|\alpha(0)|^2 + |\beta(0)|^2)}\right] =$$

$$\frac{(1-e^{-i\frac{2E_1 t}{\hbar}})(|\alpha(0)|^2 - |\beta(0)|^2) + \left(\frac{\cos(\Theta(t))^2 - \frac{1}{2}}{\frac{1}{2}(|\alpha(0)|^2 - |\beta(0)|^2)} + i|\sqrt{1 - (\frac{\cos(\Theta(t))^2 - \frac{1}{2}}{\frac{1}{2}(|\alpha(0)|^2 - |\beta(0)|^2)})^2}| - e^{-i\frac{(E_2+E_1)t}{\hbar}}\right)}{i(1+e^{-i\frac{2E_1 t}{\hbar}})(|\alpha(0)|^2 - |\beta(0)|^2) + i\left(\frac{\cos(\Theta(t))^2 - \frac{1}{2}}{\frac{1}{2}(|\alpha(0)|^2 - |\beta(0)|^2)} + i|\sqrt{1 - (\frac{\cos(\Theta(t))^2 - \frac{1}{2}}{\frac{1}{2}(|\alpha(0)|^2 - |\beta(0)|^2)})^2}| + e^{-i\frac{(E_1+E_2)t}{\hbar}}\right)}$$

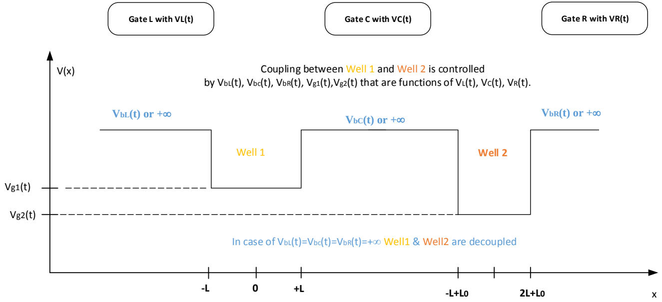
Coevolution of both Θ and ϕ on Bloch sphere.

Phase rotating gate

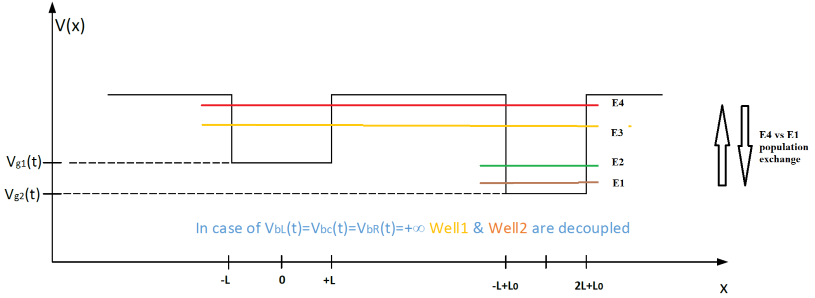


Effective potential in piece-wise approximation and electric Aharonov-Bohm effect (phase rotation gate)

Wavefunction phase difference across 2 deep wells controlled electrostatically is $\propto \frac{-1}{\hbar}\int_{t_0}^{t}(V_{g_1}(t') - V_{g_2}(t')))dt'$.



Localized vs delocalized state in system of coupled q-dots



AC field allows for the transition of the delocalized state into localized state and reversely !!!

Two types of position based qubits

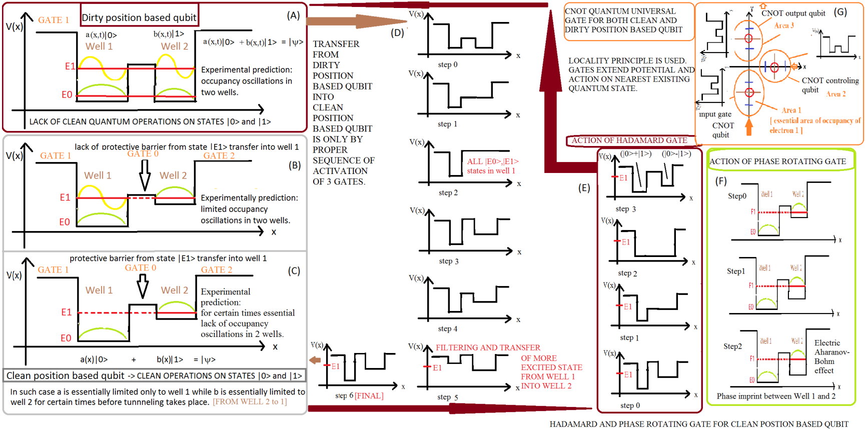
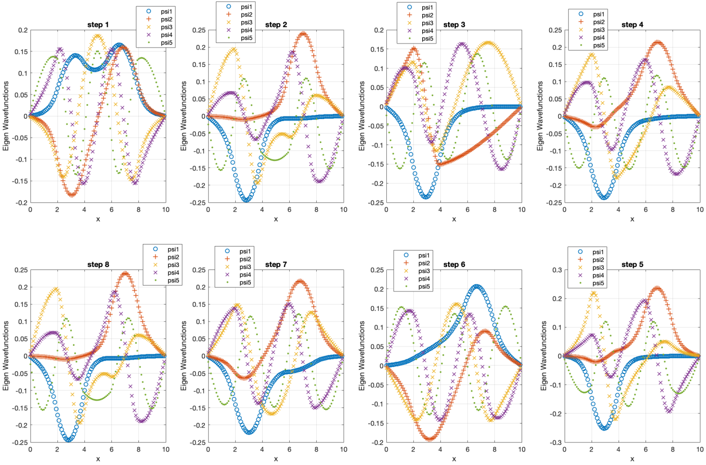


Figure: [Pomorski et al, Spie 2019]

Transition between two types of position based qubits



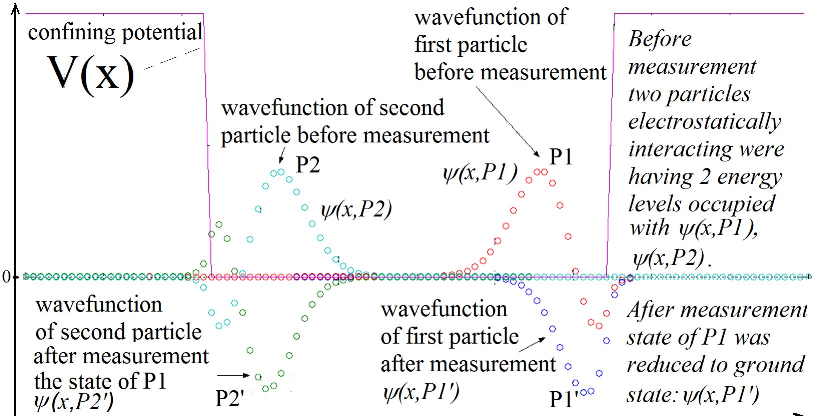
Problem of 2 electrostatically interacting particles in perturbative limit

In the case of 2 weakly interacting particles we have $\psi(x_A, x_B, t) = \psi(x_A, t)\psi(x_B, t)$ what gives

$$[-\frac{\hbar^2}{2m}\frac{d^2}{dx_A^2} + \lambda\frac{\int_{-\infty}^{+\infty} e^2\psi_B(x,t)\psi_B^\dagger(x,t)dx}{4\pi\epsilon_0|x_A - x|} + V_A(x_A)]\psi_A(x_A,t) = \\ = E_A\psi_A(x_A,t) \quad (6)$$

$$[-\frac{\hbar^2}{2m}\frac{d^2}{dx_B^2} + \lambda\frac{\int_{-\infty}^{+\infty} e^2\psi_A(x,t)\psi_A^\dagger(x,t)dx}{4\pi\epsilon_0|x_B - x|} + V_B(x_B)]\psi_B(x_B,t) = \\ = E_B(t)\psi_B(x_B,t). \quad (7)$$

Case of 2 electrons in single quantum well



2 particles in rectangular well with electrostatic interaction

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LETTER TO THE EDITOR

Spontaneous magnetic flux and quantum noise in an annular mesoscopic SND junction

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Received 4 November 1997

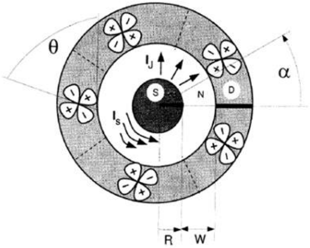


Figure 1. Annular SND junction. The *c*-axis of the *d*-wave superconductor is chosen to be parallel to the SD boundary; θ is the angle between the SD boundary and the nodal plane of the *d*-wave order parameter ($0 \leqslant \theta \leqslant \pi/2$).

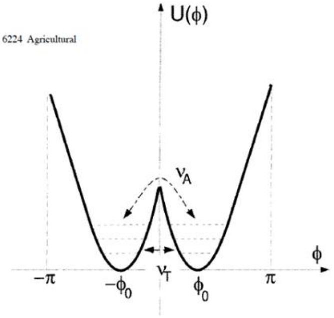
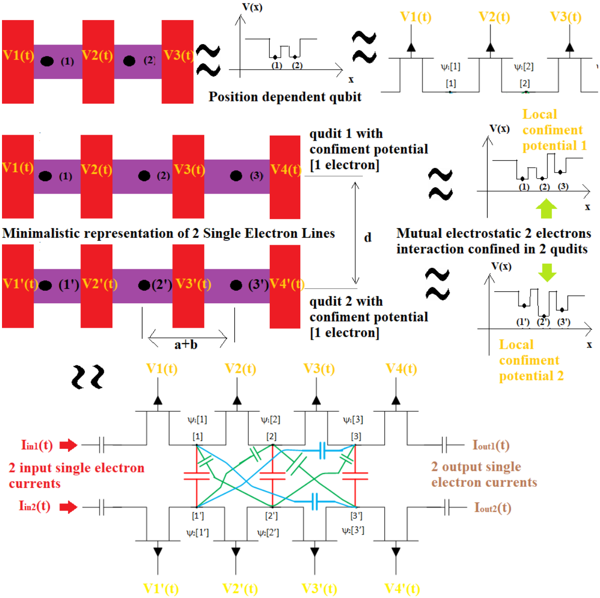


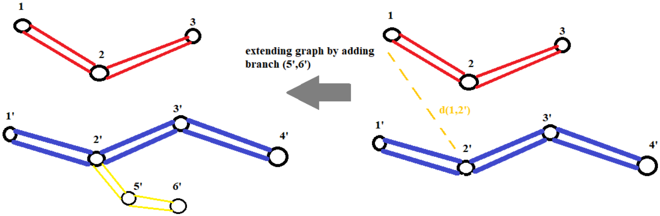
Figure 2. Effective potential and transition rates for the phase v junction.

Most features present in superconducting nanostructures are presented in single electron CMOS technology!!!

Case of 2 electrostatically coupled Single Electron Lines

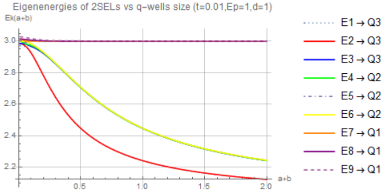


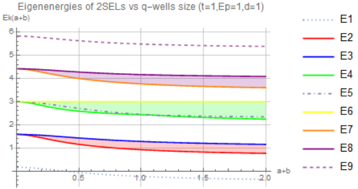
Electrostatically controlled topology of graphs of coupled q-dots in chain of semiconductor q-dots

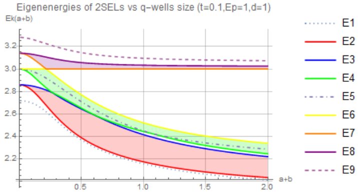


In semiconductor one observes the anticorrelation of electrons positions due to electrostatic repulsion and minimization of electrostatic field energy. In superconductor one observes the anticorrelation of electric non-dissipative currents due to magnetic field shielding. There is charge-phase duality in anticorrelation!!!

Programmable band structure in chain of coupled q-dots







Analytical tight-binding approach for coupled q-dots

$$\hat{H}(t) = \begin{pmatrix} 2E_p(t) + \frac{q^2}{d_1} & t_{sr2}(t) & t_{sr1}(t) & 0 \\ t_{sr2}(t) & 2E_p(t) + \frac{q^2}{\sqrt{(d_1)^2+(b+a)^2}} & 0 & t_{sr1}(t) \\ t_{sr1}(t) & 0 & 2E_p(t) + \frac{q^2}{\sqrt{(d_1)^2+(b+a)^2}} & t_{sr2}(t) \\ 0 & t_{sr1}(t) & t_{sr2}(t) & 2E_p(t) + \frac{q^2}{d1} \end{pmatrix} =$$

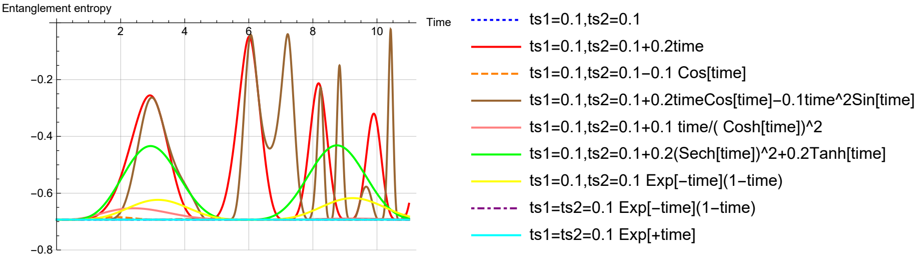
$$= \hat{\sigma}_0 \times \hat{\sigma}_0 q_{11} + \hat{\sigma}_3 \times \hat{\sigma}_3 q_{22} + t_{sr2}(t)\hat{\sigma}_0 \times \hat{\sigma}_3 + t_{sr1}(t)\hat{\sigma}_3 \times \hat{\sigma}_0$$

that has only real value components $H_{k,l}$ with
$q_{11} = E_p(t) + \frac{E_{c1}+E_{c2}}{2} = E_p(t) + \frac{1}{2}(\frac{q^2}{d_1} + \frac{q^2}{\sqrt{(d_1)^2+(b+a)^2}})$,
$q_{22} = \frac{E_{c1}-E_{c2}}{2} = \frac{1}{2}(\frac{q^2}{d_1} - \frac{q^2}{\sqrt{(d_1)^2+(b+a)^2}})$ and $Q_{11}(t) = \int_{t_0}^{t} dt' q_{11}(t')$,
$Q_{22}(t) = \int_{t_0}^{t} dt' q_{22}(t')$, $TR1(t) = \int_{t_0}^{t} dt' t_{sr1}(t')$, $TR2(t) = \int_{t_0}^{t} dt' t_{sr2}(t')$.

$$S_B(t) = Tr[\rho_B(t) Log[\rho_B(t)]] \quad (8)$$

$$|\psi(t)\rangle = U(t, t_0)\,|\psi(t_0)\rangle = e^{\frac{1}{\hbar}\int_{t_0}^{t}\hat{H}dt}\,|\psi(t_0)\rangle.$$

Entanglement entropy of coupled qubits with time



Electrostatic control of entanglement is demonstrated by tight-binding model in symmetric Q-Swap gates when two hopping constants are the same at initial state and when the state is initially in the ground state.

Correlation function

$$C(E_{c1}-E_{c2}=\frac{q^2}{d}-\frac{q^2}{\sqrt{d^2+(a+b)^2}},t_{s1},t_{s2},p_{E1},p_{E2},p_{E3},p_{E4},\phi_{E10},\phi_{E20},\phi_{E30},\phi_{E40},t)=$$

$$=\frac{N_{+,+}+N_{-,-}-N_{-,+}-N_{+,-}}{N_{+,+}+N_{-,-}+N_{-,+}+N_{+,-}}=$$

$$4[\frac{\sqrt{p_{E1}}\sqrt{p_{E2}}(t_{s1}-t_{s2})\cos[-t\sqrt{(E_{c1}-E_{c2})^2+4(t_{s1}-t_{s2})^2}+\phi_{E10}-\phi_{E20}]}{\sqrt{(E_{c1}-E_{c2})^2+4(t_{s1}-t_{s2})^2}}$$

$$+\frac{\sqrt{p_{E3}}\sqrt{p_{E4}}(t_{s1}+t_{s2})\cos[-t\sqrt{(E_{c1}-E_{c2})^2+4(t_{s1}+t_{s2})^2}+\phi_{E30}-\phi_{E40}]}{\sqrt{(E_{c1}-E_{c2})^2+4(t_{s1}+t_{s2})^2}}]$$

$$-(E_{c1}-E_{c2})[\frac{p_{E1}-p_{E2}}{\sqrt{(E_{c1}-E_{c2})^2+4(t_{s1}-t_{s2})^2}}+\frac{p_{E3}-p_{E4}}{\sqrt{(E_{c1}-E_{c2})^2+4(t_{s1}+t_{s2})^2}}] \tag{9}$$

We are going to use Jaynes-Cumming Hamiltonian [?] that describes the interactiton atom with cavity by means of electromagnetic field. In the simplest approach the cavity Hamiltonian describing waveguide without dissipation is represented as

$$H_{cavity} = \hbar\omega_c(\frac{1}{2} + \hat{a}^\dagger \hat{a}), \quad (10)$$

where $\hat{a}^\dagger$ ($\hat{a}$) is the photon creation (annihilation) operator and number of photons in cavity is given as $n = \hat{a}^\dagger \hat{a}$. At the same we can represent the two level qubit system

$$H_{qubit} = E_g \left|g\right\rangle \left\langle g\right| + E_e \left|e\right\rangle \left\langle e\right|. \quad (11)$$

The interaction Hamilonian is of the following form

$$H_{qubit-cavity} = g(\hat{a}^\dagger \sigma_- + \hat{a}\sigma_+), \quad (12)$$

where $\sigma_- = \sigma_1 - i\sigma_2$, $\sigma_+ = \sigma_1 + i\sigma_2$. The qubity-cavity interaction has the electric-dipole nature so quasiclassicaly we can write

$$H_{qubit-cavity} = \hat{d} \cdot \hat{E} = g(\sigma_- + \sigma_+)(\hat{a} + \hat{a}^\dagger) \approx g(\hat{a}^\dagger \sigma_- + \hat{a}\sigma_+). \quad (13)$$

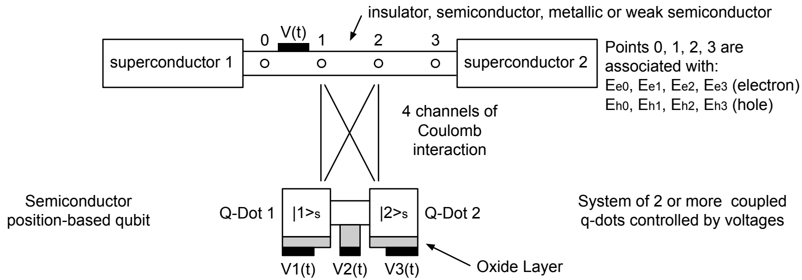
Here we have neglected the terms $g(\sigma_- \hat{a} + \sigma_+ \hat{a}^\dagger)$ and our approach is known as rotating phase

During photon emission from qubit the energy level is lowered and reversely during photon absorption the energy level of qubit is raised what is seen in the term $\hat{a}\sigma_+$. The system Hamiltonian is given as $H = H_{cavity} + H_{qubit} + H_{qubit-cavity}$. It is not hard to construct the Hilbert space for Jaynes-Cumming Hamiltonian. Essentially we are considering the tensor product of qubit space and cavity space.

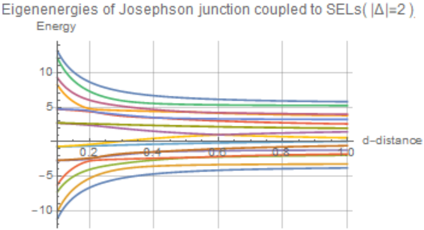
$$|\psi\rangle = \gamma_1 |\phi_1\rangle |0\rangle + \gamma_2 |\phi_1\rangle |1\rangle + \gamma_3 |\phi_2\rangle |0\rangle + \gamma_4 |\phi_2\rangle |1\rangle = \begin{pmatrix} \gamma_1 \\ \gamma_2 \\ \gamma_3 \\ \gamma_4 \end{pmatrix}, 1 = \langle\psi|\psi\rangle = |\gamma_1|^2 + .. + |\gamma_4|^2. \tag{14}$$

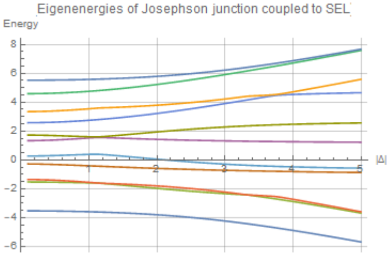
Electrostatic interface between semiconductor and superconducting qubit

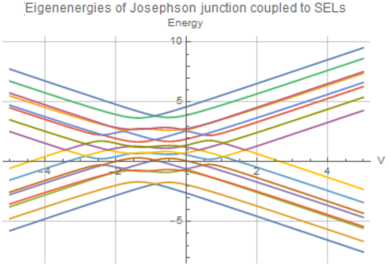
Josephson Junction interacting with two coupled Q-Dots semiconductor qubits



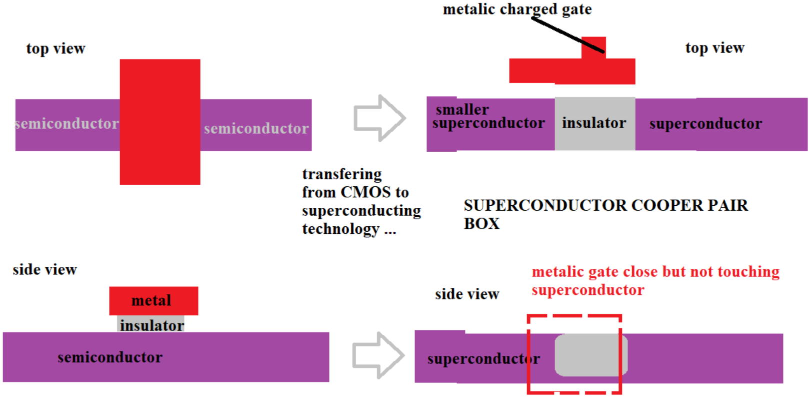
Tight-binding model in description of JJs coupled to semiconductor qubit and modification of ABS in JJ



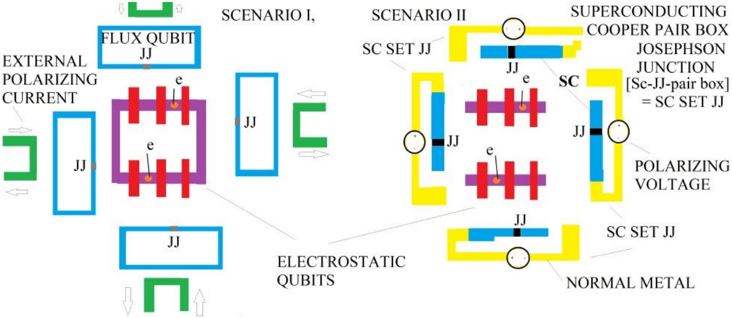




Electrostatically controlled superconducting and semiconducting qubits



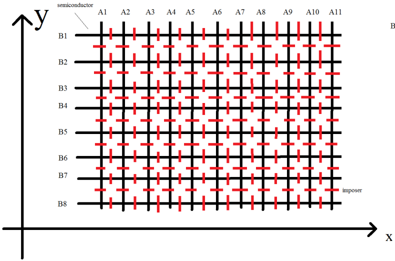
Electromagnetic interface between semiconductor and superconducting circuits

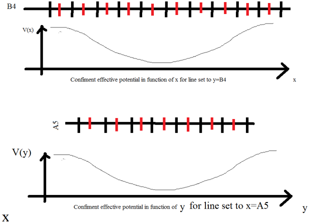


INTERFACE BETWEEN SUPERCONDUCTOR AND SEMICONDUCTOR QUBITS

[K.Pomorski, P.Giounanlis, E.Blokhina, D.Leipold, P.Peczkowski, Robert Bogdan Staszewski, From two types of electrostatic position-dependent semiconductor qubits to quantum universal gates and hybrid semiconductor-superconducting quantum computer, Proc. SPIE 11054, 2019]

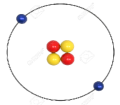
Quantum chemistry in semiconductor lattices





Concept of programmable Quantum Matter:

Having 2 electrons in cofiment
potential created by imposers we
can replicate dynamics of He atom and many
body systems .



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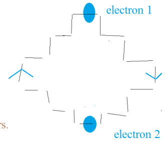
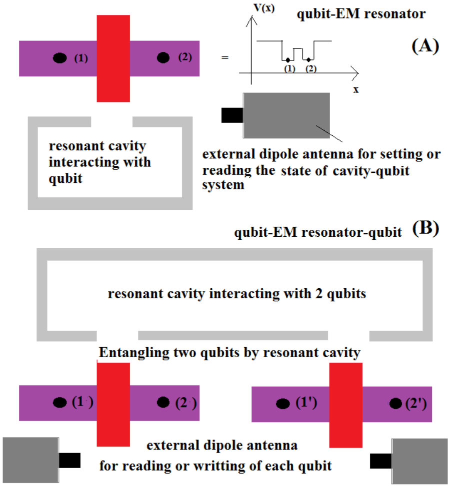


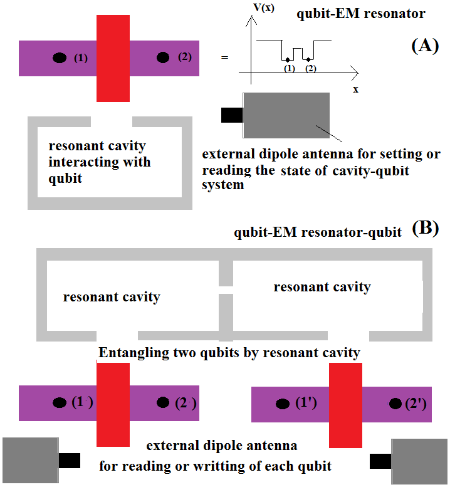
2 Electrons
can move
on 2 dimensional
lattice
simulating
Helium atom
etc , ...

We can replicate N-body dynamics having N electrons in effective potential created by imposers.
In particular we can simulate vortices of magnetic field and many other phenomena

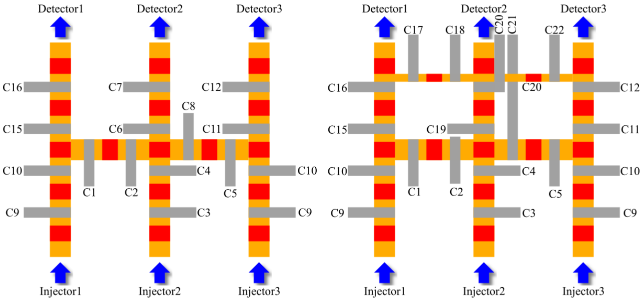
Quantum Communication



Quantum Communication over Long Line



Quantum Neural Network

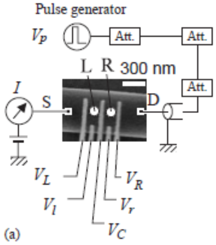


Concept of quantum and classical single electron neural network in CMOS. It can mimic all quantum universal gates. It can be controlled with voltages applied to C1,..,C12, .., C22 gates. Additionally one can use external magnetic field to control its performance.

by Krzysztof Pomorski, 16 Nov 2018

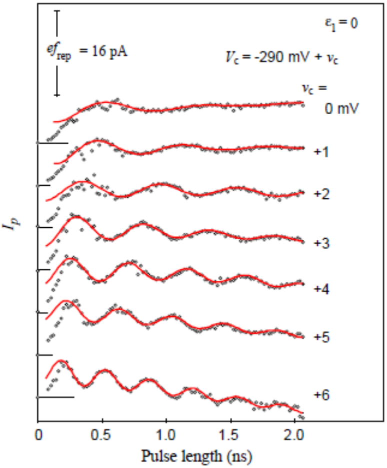
Q-Neural Network can mimic any physical system of N bodies.

Previous experiments



T. Fujisawa et al. / Physica E 21 (2004) 1046–1052

The DQDs used in this work are defined by metal gates on top of a GaAs/AlGaAs heterostructure with a two-dimensional electron gas (2DEG). Each dot contains about 25 electrons with on-site charging energy $E_c \sim 1.3$ meV. The interdot charging energy is $U = 200$ µeV. The qubit parameters, ε and Δ, and tunneling rates, Γ_L and Γ_R, respectively, for left and right



Acknowledgments

All requirements for implementation of large scale Quantum Computer are to be fulfilled.

The project is supported by Science Foundation Ireland under Grant 14/RP/I2921.

New company: Quantum Hardware Systems (QHS)

http : //www.quantumhardwaresystems.com/
Mission: Linking existing quantum and classical old and new technologies in realistic fashion ...

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The End