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Projects history overview

August 2020

Cloning in quantum computation
K.N.T University of Technology, Bachelors

Problem: **cloning an unknown quantum state probabilistically**

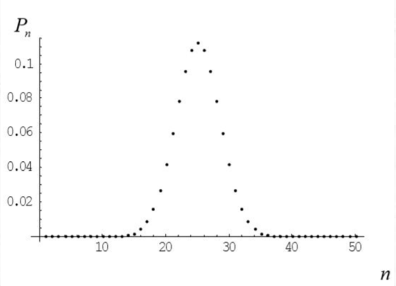
Background: due to the no-cloning theorem, no exact copy of an unknown quantum state is allowed

Results: Theoretical proof of existing a probabilistic cloning machine

$$U\left(|\Psi_i\rangle \overbrace{|0\rangle|0\rangle\cdots|0\rangle}^{M \quad times} |P\rangle\right) = \sum_{m=0}^{2^M-1} \sqrt{p_m^{(i)}}\, |\Psi_i\rangle|a_1\rangle|a_2\rangle\cdots|a_M\rangle |P_m\rangle + \sum_{l=2^M}^{N_c} \sqrt{f_l^{(i)}}\, |\Psi_l\rangle_{AB} |P_l\rangle$$

Reference: Bachelor’s thesis

$$P_n = \frac{\binom{M}{n}}{2^M}$$



Simulation of plasmonic waveguides

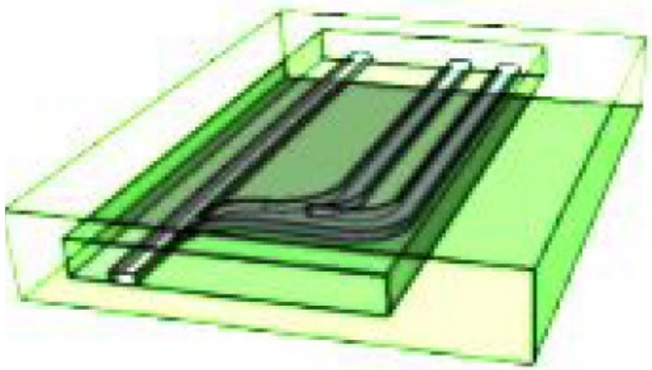
S. B. University, Masters

Problem: **designing nano-metallic waveguides for nano-circuits**

Results: 3D scattering of an incident electric field from a circuit of permittivity ε

$$\vec{E}^{i}(\vec{x}) = \frac{\vec{D}(\vec{x})}{\varepsilon(\vec{x})} - \frac{1}{\varepsilon_0}\int_{\vec{x}'\in D^S} \frac{\exp(ik_0|\vec{x}-\vec{x}'|)}{4\pi|\vec{x}-\vec{x}'|}\,\frac{\varepsilon(\vec{x})-\varepsilon_0}{\varepsilon(\vec{x})}[k_0^2 D(\vec{x}')]d\vec{x}'$$

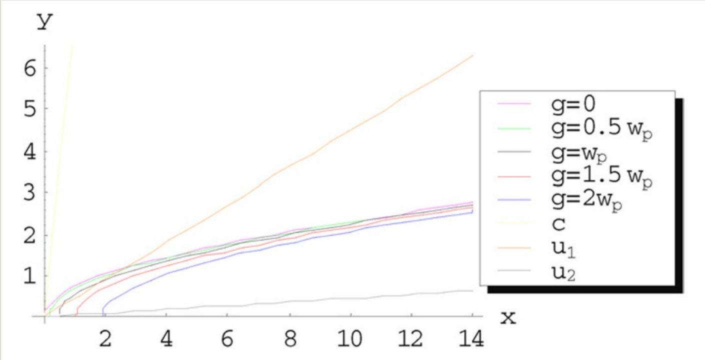
$$-\frac{1}{\varepsilon_0}\int_{\vec{x}'\in D^S} \frac{\exp(ik_0|\vec{x}-\vec{x}'|)}{4\pi|\vec{x}-\vec{x}'|}\,\frac{\varepsilon(\vec{x})-\varepsilon_0}{\varepsilon(\vec{x})}\vec{\nabla}[\vec{\nabla} D(\vec{x}')]d\vec{x}'$$



Nanophotonic carbon nanotube waveguides
S. B. University, Masters

<table>
<tr><td><u>Problems:</u></td><td>Allowed modes on metallic SWCNTs, and
The excitation of surface Plasmon modes</td><td>Allowed modes on double walled metallic DWCNTs</td></tr>
<tr><td><u>Results:</u></td><td>

- Metallic graphite layers with free valence electrons
- Density of electrons, friction due to collision with carbon ions, Maxwell equations
- Surface electronic waves coupled to electromagnetic waves or relativistic electron beams



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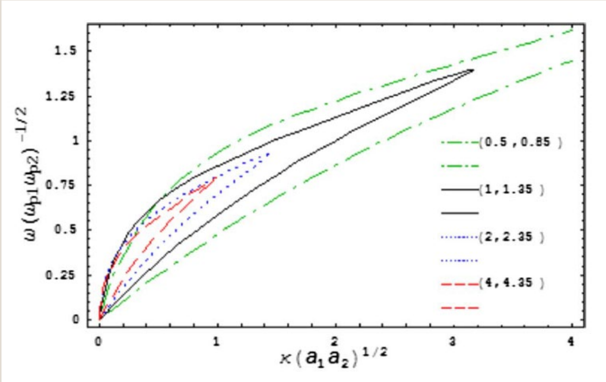
- Derivation of the equation of electronic waves (velocity field and density) out of Schrodinger equation
- Dispersion relations of surface electron waves



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<tr><td><u>References:</u></td><td>J. Phys. D: Appl. Phys. 42 (2009) 055307
PHYSICS OF PLASMAS 16 (2009)022108</td><td>PHYSICS OF PLASMAS 16 (2009) 063501</td></tr>
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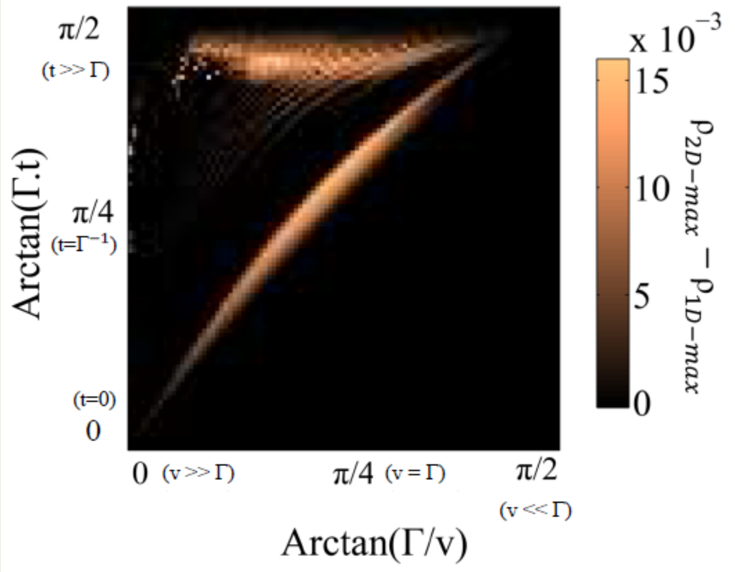
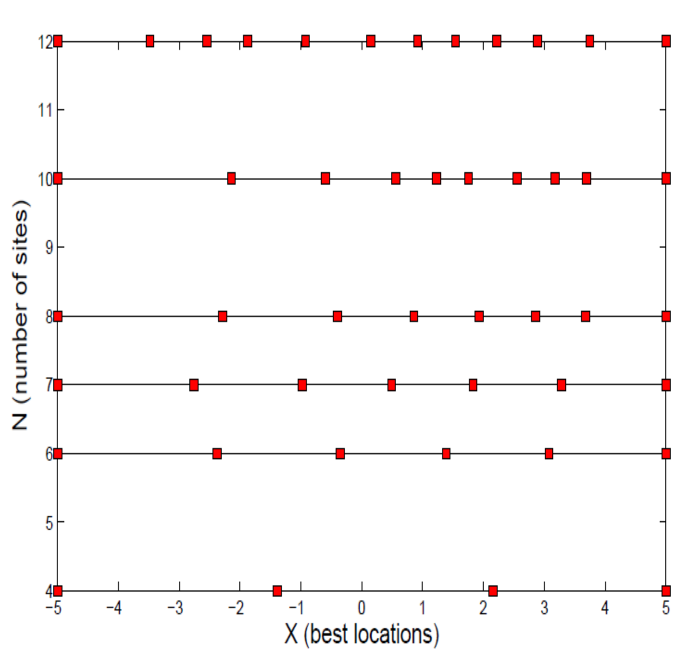
Optimization of qubit networks’ configurations

Ulm University, PhD

Problems:	Searching for better 2D configurations than 1D ones	Searching for best 1D configuration
Results:	▪ Upgrading a random walk algorithm ▪ Using cluster for parallel computing	▪ Writing new random walk algorithms to find optimal networks
References:	Peer reviewed- PhD thesis by publications-chapter 2	PhD report

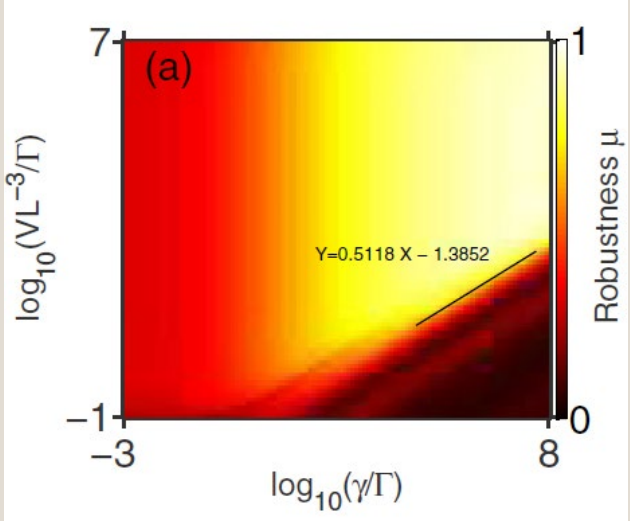
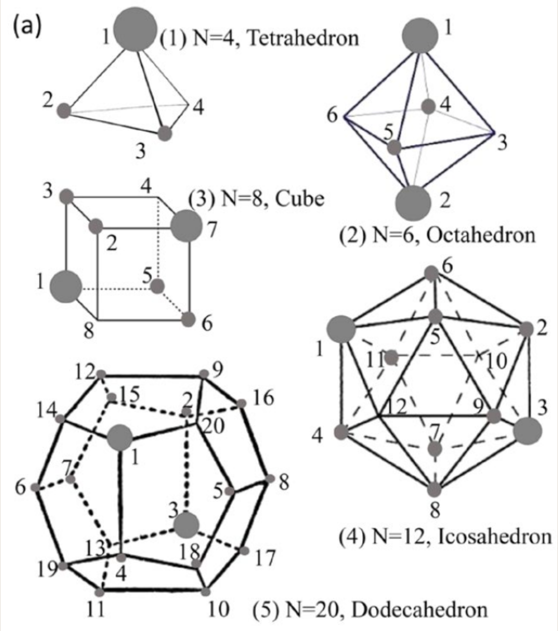
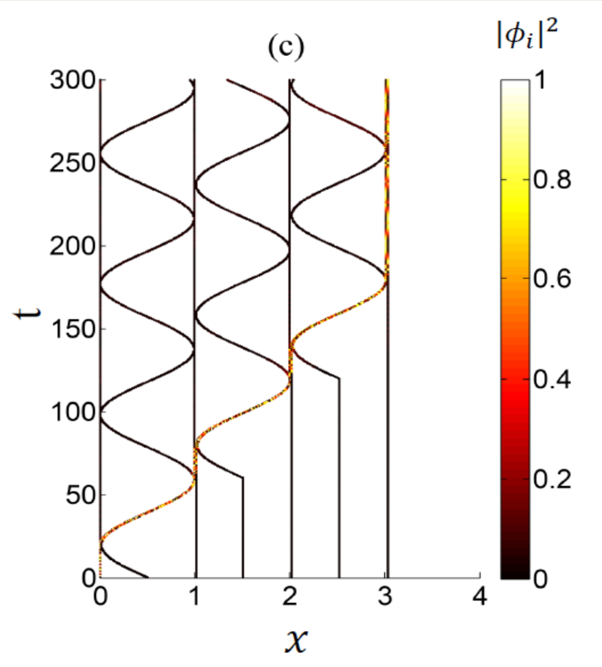


N	$\delta\rho_{21}$
4	0.012083
5	0.004102
6	0.005473
7	0.016030
8	0.014855



Optimal designs of qubit networks

Macquarie University, PhD

Problems:	Optimal design parameters	Proof of trapping energy	Optimal dynamic-networks design
Results:	▪ 1D qubit networks ▪ Optimal parameters for Maximum geometrical robustness 	▪ 3D qubit networks ▪ Switching application 	▪ 1D dynamic qubit networks ▪ Unidirectional quantum transport 
References:	PHYSICAL REVIEW A **90**, 042313 (2014)	J. Phys. D: Appl. Phys. **48** (2015) 235104	OPTICS EXPRESS **25** (2017) 25973

Hamiltonian Learning
Comparison of classical and quantum
(MURI Project, UTS)

Problem: **Finding few qubits Hamiltonian via pulses and measurements**

Assumptions: Hamiltonian is partly known

Tools:

- STEADY (Stochastic Estimation Algorithm for DYnamical variables) , Robust to State Preparation And Measurement (SPAM) errors
- Qiskit software development kit (IBM Q quantum processors), and Pyquil, the Forest SDK (Rigetti quantum processors)

Quantum noise spectroscopy
(MURI Project, UTS)

Problem: **QuDits as noise spectroscopes or sensors**

Assumptions: noise is dephasing, Gaussian, non-stationary

Manuscript results:

Expectation value of a general observable	environmental noise spectrum, pulse sequence characteristics

$$\langle\langle \hat{O}(t)\rangle\rangle_c = R_0 - \frac{1}{2}\int_0^t\int_0^t dt'dt'' \sum_{a,b=0,\ldots,d-1} R_{ab}y_a(t')y_b(t'')\langle\beta_a(t')\beta_b(t'')\rangle_c$$