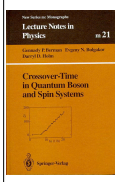
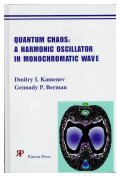
Quantum Institute Workshop

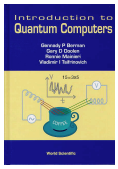
Quantum Institute Briefing Center; December 9–10, 2002

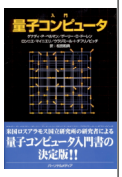




Modeling and simulations of quantum computation and quantum measurement

G.P. Berman (T-13), G.D. Doolen (T-13), D.I. Kamenev (T-13/CNLS), R. Kassman (T-13/CNLS), V.I. Tsifrinovich (Polytech. U., NY)





Our research directions and plans

1. Modeling and simulations the processing of quantum information in scalable solid-state quantum computers with Ising and Heisenberg interactions.

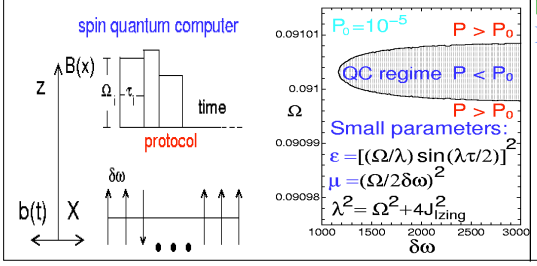
(See review: Contemp. Math. Quant. Comp. and Inf., AMS, 2002)

(a) Utilizing small parameters. Developing perturbation theory for many (>1000) qubits.

(b) Calculating parameters and minimizing errors for stable quantum computation.

(c) Simulations fragments of quantum algorithms (conditional logic, full adder, etc.).

Perturbation theory for QC with 1000 qibits



This research is required for benchmarking quantum computer devices.

Funded by ARDA/NSA/ARO.

Collaborators

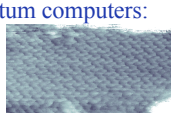
F. Borgonovi & G. Celardo (Brescia, Italy), G.V. Lopez (U. de Guadalajara, Mexico)

On self-assembled quantum computers:

D.L. Allara (Penn. S.U.)

J. Tour (Rice U.)

S. Tretiak (LANL, T-12)



2. Weak chaos in quantum computation. (influence of non-integrability)

Funded by NSA.

Collaborators

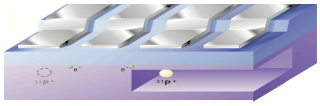
Started with D. James & R. Hughes (LANL), F. Borgonovi & G. Celardo (Brescia, Italy), F.M. Izrailev (Pueblo U., Mexico)

3. Dynamics of qubit measurement in a silicon-based Kane's quantum computer.

(a) Dynamics of swap operation. Optimization of the measurement time.

(b) Simulations of spin decoherence and relaxation.

Funded by LDRD DR.



Collaborators

M.E. Hawley (MST-8), A. Kogan (MST-10), D. Mozyrsky (CNLS), K. Nagaev (Russia).

4. STM based quantum computation (PRL publication. Planned research.)

Collaborators

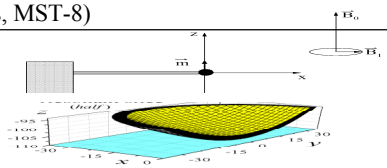
M.E. Hawley, G.W. Brown (LANL, MST-8)

5. MRFM single-spin measurement.

(a) Simulating frequency shift and amplitude of cantilever vibrations.

(b) Modeling and minimizing effects of spin quantum jumps.

Funded by DARPA MOSAIC Program.



Collaborators

P.C. Hammel (Ohio State U.)

F. Borgonovi (Brescia, Italy)

S.A. Gurvitz (Weiz Inst., Israel)

H.S. Goan (U. Queenland, Australia),

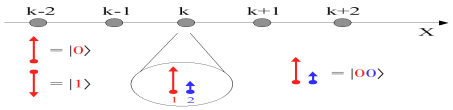
V. Gorshkov (Ukraine)

Presenter: Gennady Berman

6. Type-II quantum computer for simulations of fluid dynamics.

Collaborators

A.A. Ezhov (Fusion Research Inst., Russia)
J. Yepez, (Air Force Research Lab., Hanscom Field, MS)

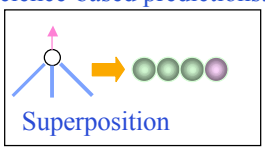


7. Quantum neural technologies — developing new tools for science-based predictions.

• Learning instead of algorithmic approach.

Quantum superpositions will allow to solve exponentially large problems of function approximations, pattern recognition, associations, etc.

Book: http://www.rintonpress.com/books/gberman2.html



Collaborators: A.A. Ezhov (Fusion Research In., Russia), D. Sharp (T-13)

8. Modeling and simulations of STM-based nano-devices
(ac electron transport in QPC, quantum wires, DBRTS, Terahertz detectors)

Was funded by DARPA. Now funded by LDRD ER in collaboration with M.E. Hawley and G.W. Brown (MST-8), V. Mitin (Wayne St. U., Detroit).

9. Dynamics of Bose-Einstein condensates.

(a) Developing asymptotic theory for multi-particle systems.
(b) Quantum instabilities and collapses.
(c) Heisenberg-limit interferometry.

Collaborators

A.R. Bishop (LANL)
A. Smerzi (LANL and Italy)
M. Vishik (U.Texas at Austin)
D. Dalvit (LANL, T-6)