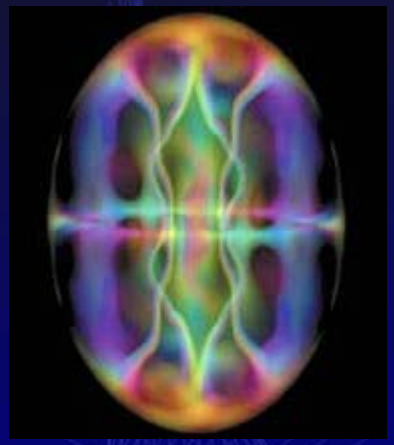
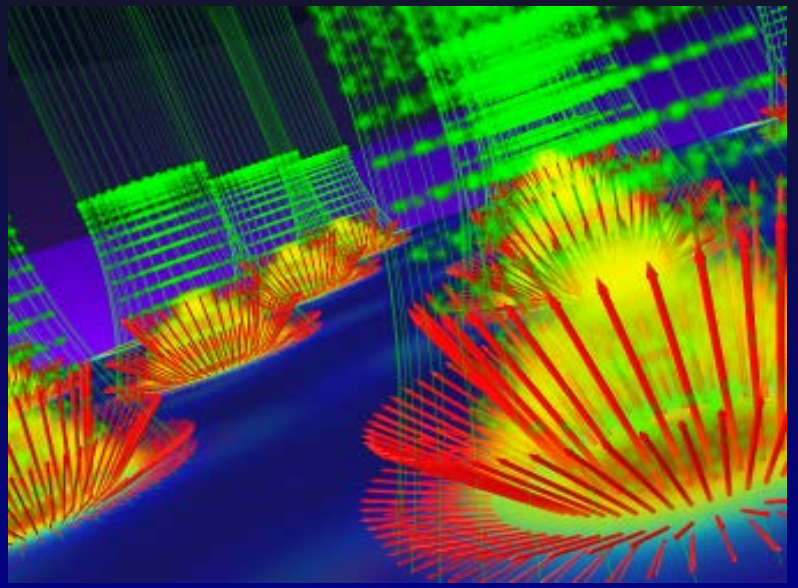
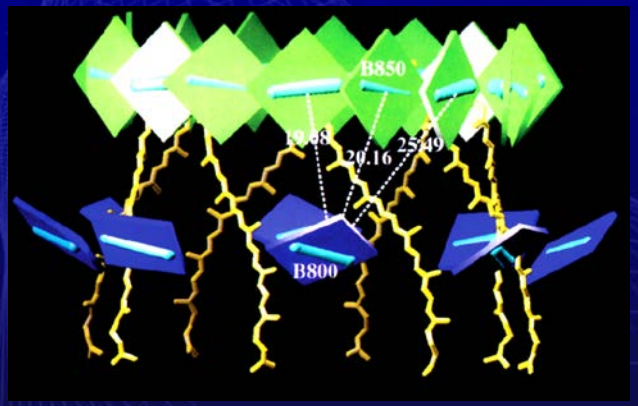
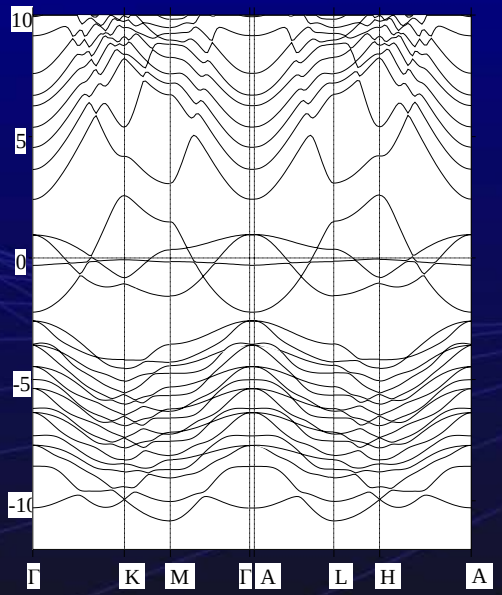
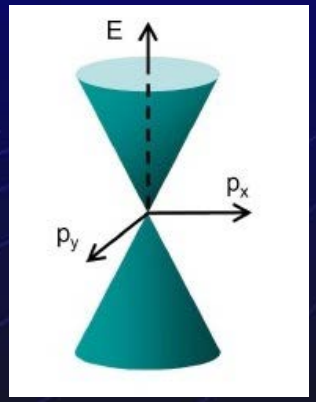
CONDENSED MATTER THEORY at UBC







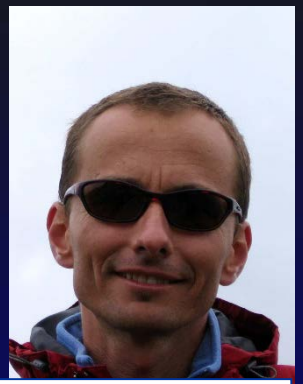




Condensed Matter Theory (more info at www.physics.ubc.ca/cmt)


Ian Affleck


Mona Berciu


Marcel Franz


Steve Plotkin


Joerg Rottler


George Sawatzky


Philip Stamp


Fei Zhou

The CMT GROUP

Others with overlap in CMT

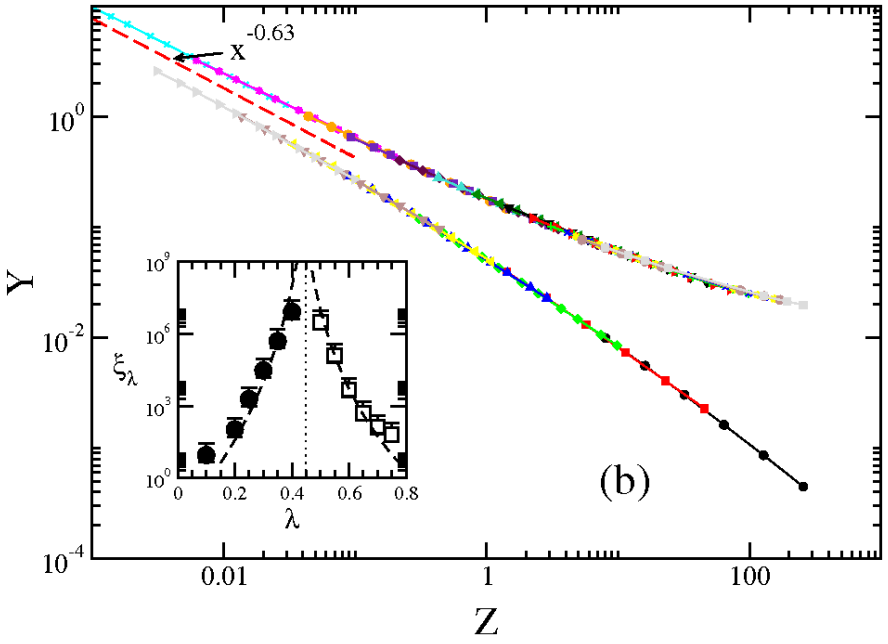

Robert Raussendorf

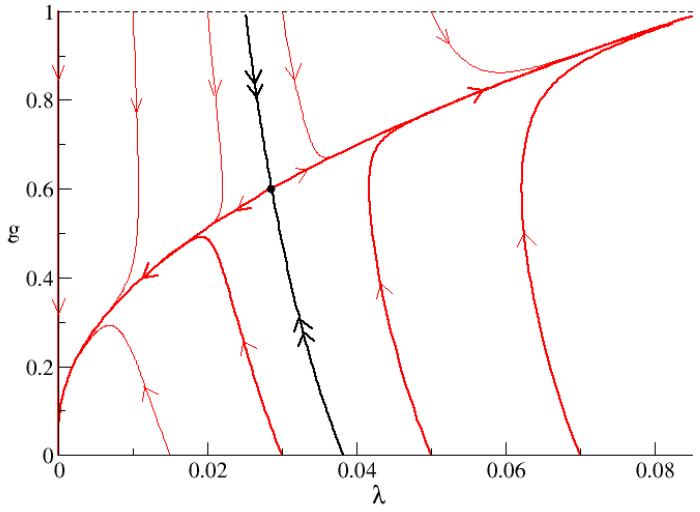

Bill Unruh


Gordon Semenoff

Ian Affleck:

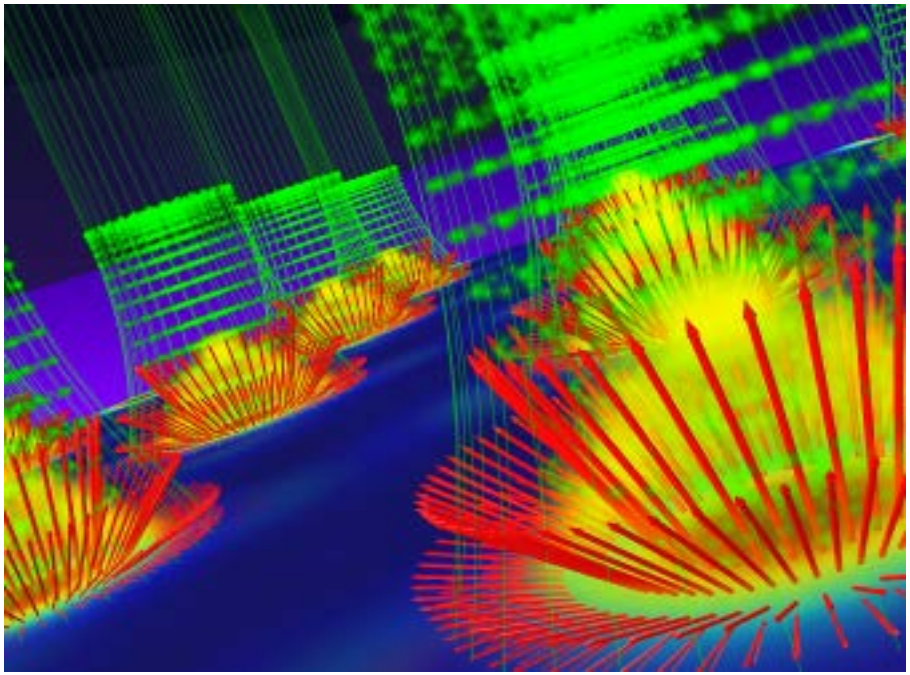
→ I specialize in applying theoretical techniques from high energy theory, including string theory, to experimentally relevant problems in the theory of strongly correlated condensed matter systems.

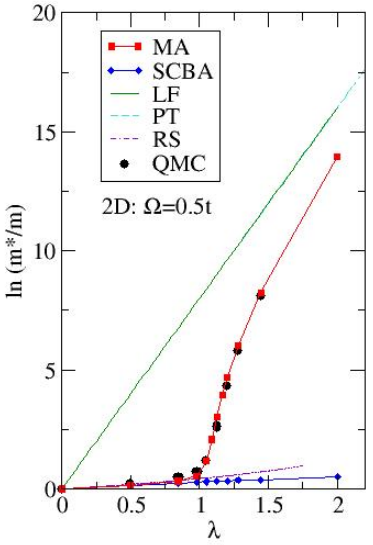


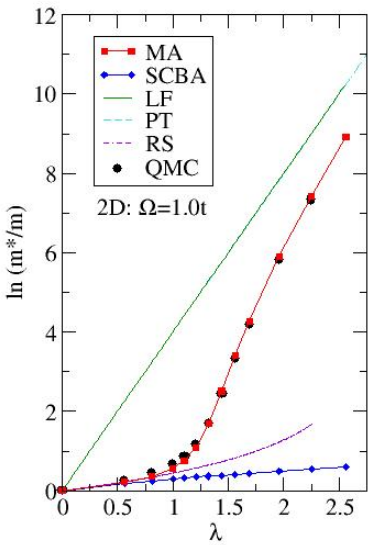


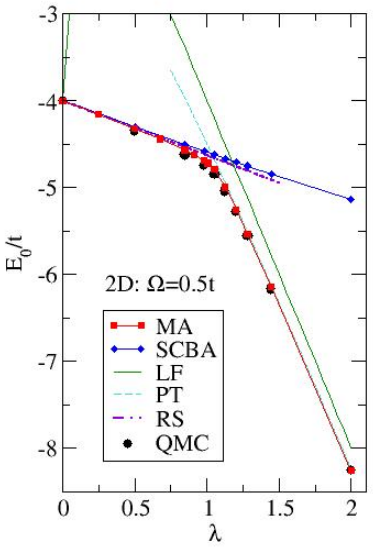
Mona Berciu:

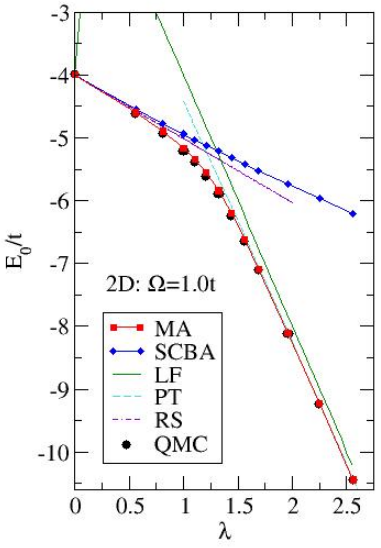
→ Currently I'm most interested in finding good approximations for all coupling strengths for Green's function (especially for polaronic problems); also spintronic devices based on diluted magnetic semiconductors, transport in meso/nanoscopic systems, Integer Quantum Hall Effect, etc.





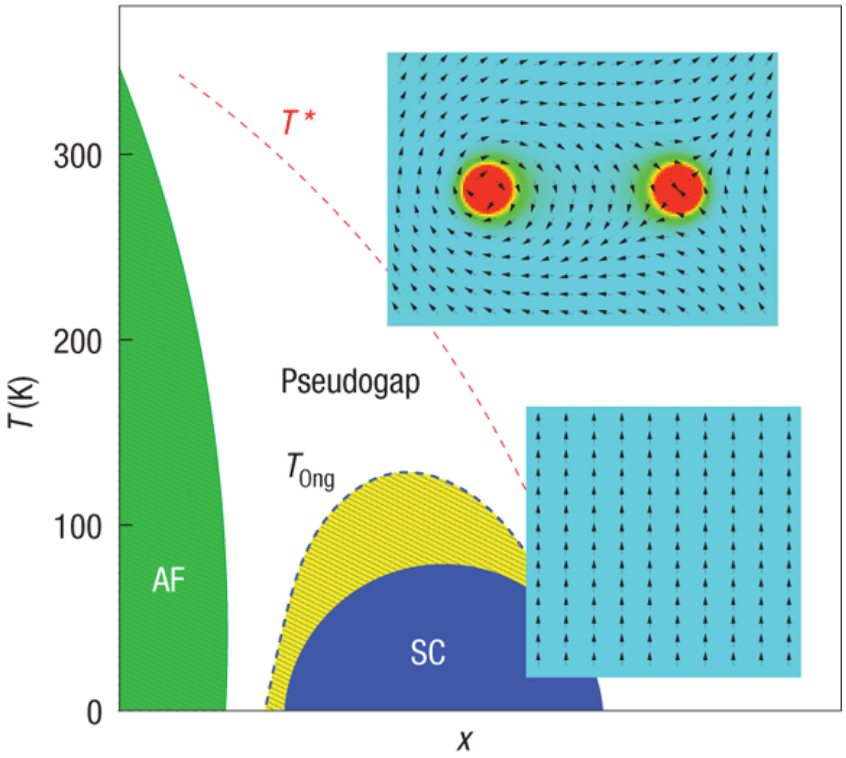


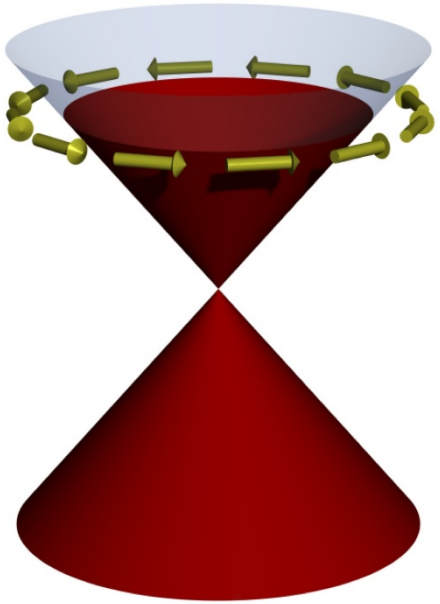




Marcel Franz:

→ I specialize in strongly correlated electron systems, in topological insulators, exotic order in quantum matter, cuprate and other unconventional superconductors and anything else out of the ordinary.

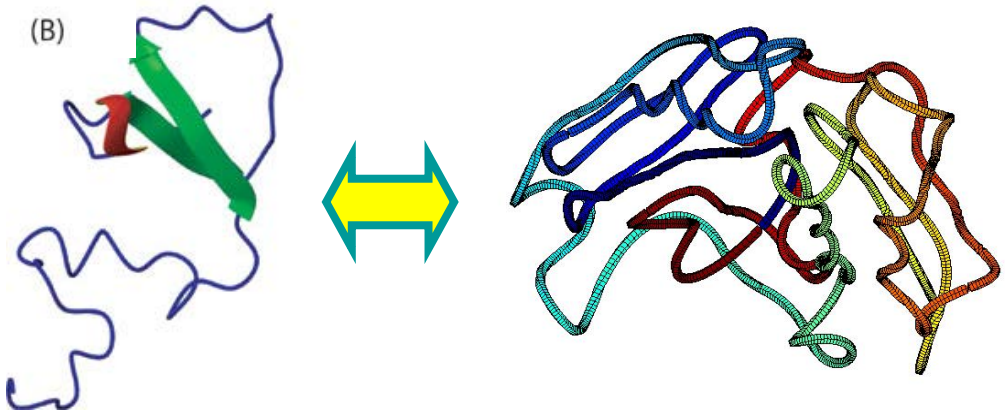


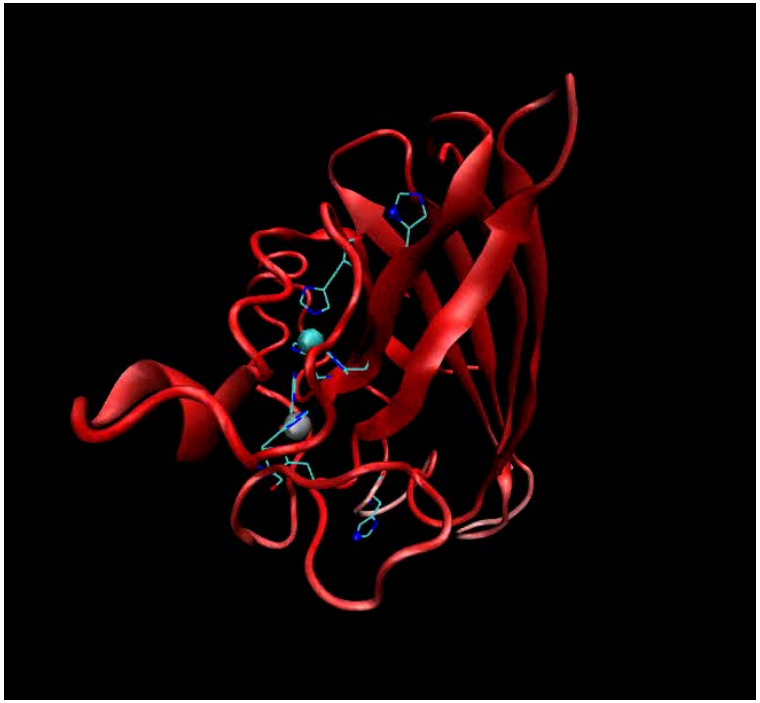


Steve Plotkin:

→ From the theoretical physics of Biopolymer folding:

$$S_{Nambu-Goto}[\mathbf{r}(s,t)] = \int_0^L ds \int_0^T dt \sqrt{\dot{\mathbf{r}}^2 \mathbf{r}'^2 - (\dot{\mathbf{r}} \cdot \mathbf{r}')^2}$$

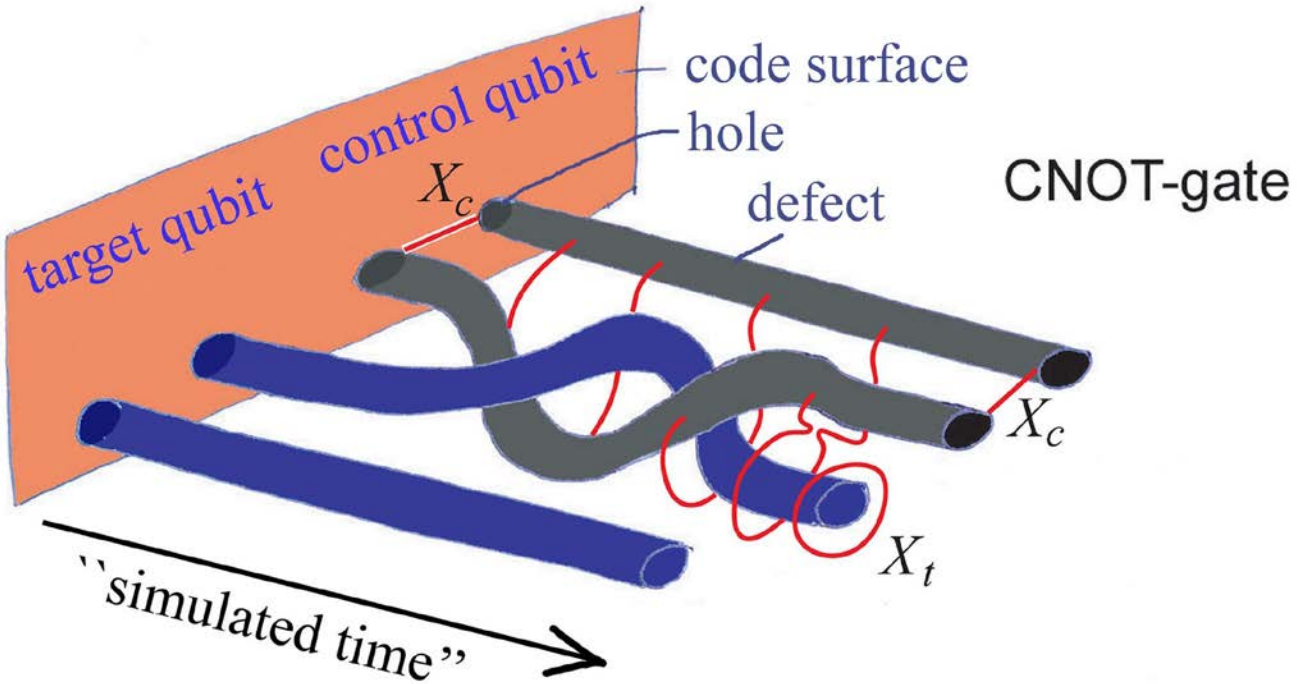




... to the molecular basis (and cures for!) neurodegenerative diseases:

Robert Raussendorf:

→ My research is in quantum computation. I am particularly interested in computational models, such as computation by measurements, and in making quantum computers stable against the effects of noise and decoherence.



Jörg Rottler :

I am interested in:

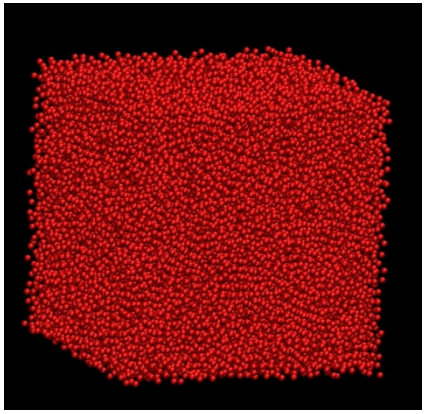
→ Noncrystalline (glassy) solids far from equilibrium

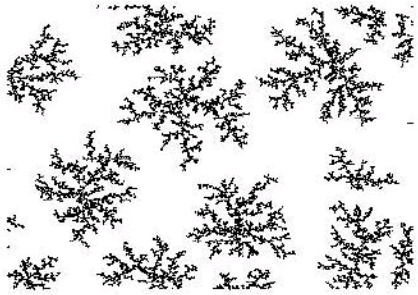
→ Polymer Physics

→ Electrostatic effects in complex fluids and biomolecular systems, development of fast algorithms for Coulombic interactions

→ Stochastic growth phenomena and morphology

→ Computational approaches for modeling materials on different length scales





Goals:

→ understand the molecular origins of macroscopic material properties

→ theory and modeling as a guide for the design of new materials

Facilities:

•180 CPU computer cluster for large scale parallel simulations

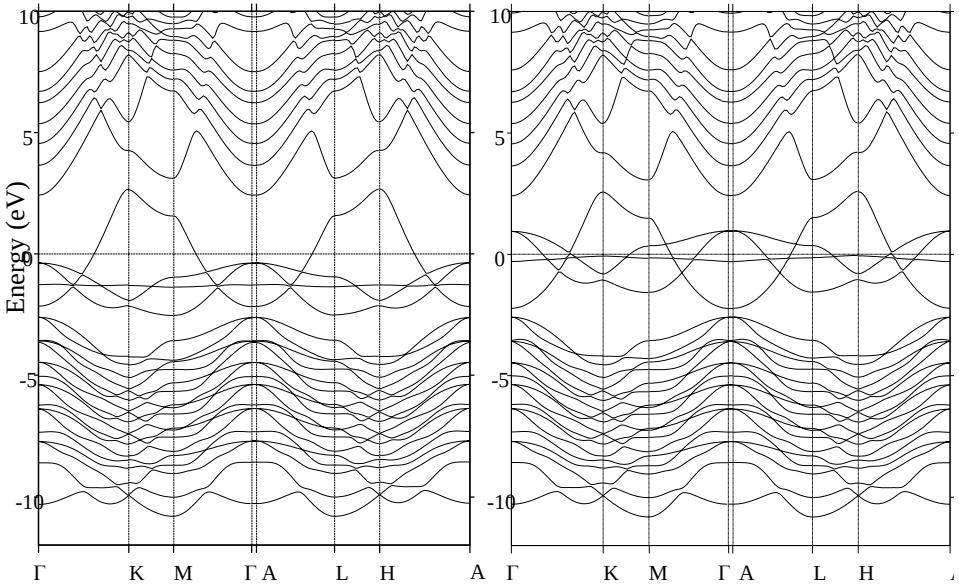
George Sawatzky:

→ Research focuses on quantum materials and devices; heterostructures and correlated systems; electronic structure; theory of synchrotron-resonant x ray scattering

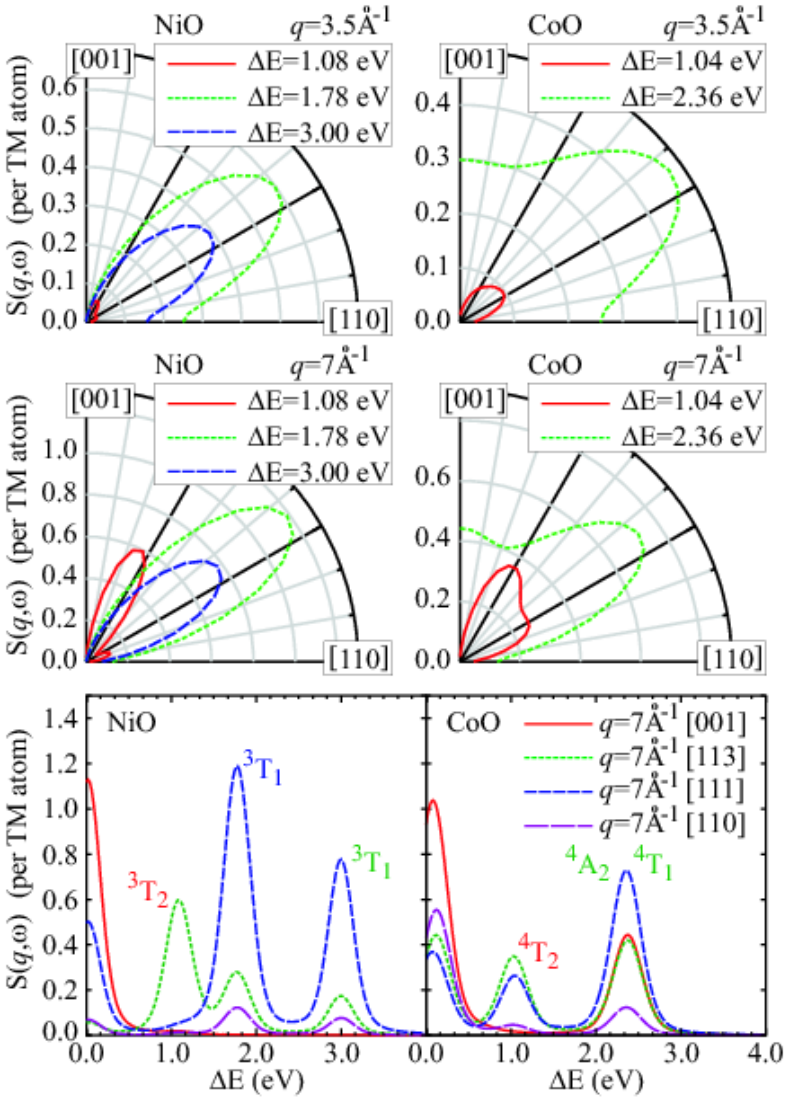
LSDA Band Structure of CaO (111) slab terminated with Ca and O

Spin up

Spin down



Angular distribution of inelastic x ray scattering Intensity at 10KeV



Philip Stamp:

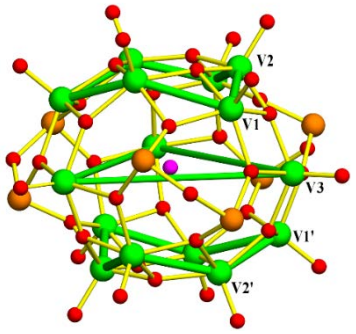
Large-Scale Quantum Phenomena: How Decoherence works in Nature. Using this understanding to build a Quantum Computer. **Large-scale coherence in biological systems.**

Strongly-correlated systems: Large-scale quantum phenomena in spin systems; Quantum spin glasses & quantum glasses; Dynamics of superfluids & vortices

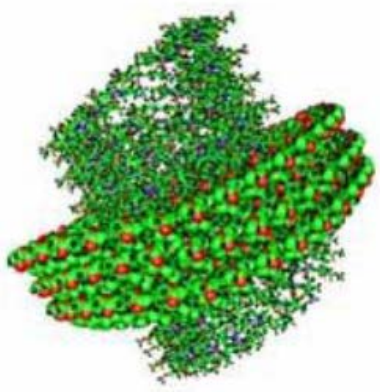
Quantum Mechanics & General Relativity; **Breakdown of QM caused by gravity; Gravitational Decoherence (project with WG Unruh)**

Black Hole: where GR confronts QM

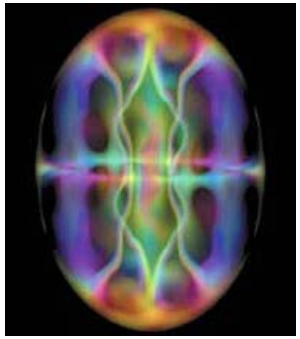
Magnetic molecules: Qubits for a Q computer



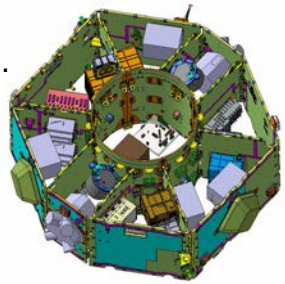
chlorosome (green sulfur bacteria)



Vortices in rotating superfluid

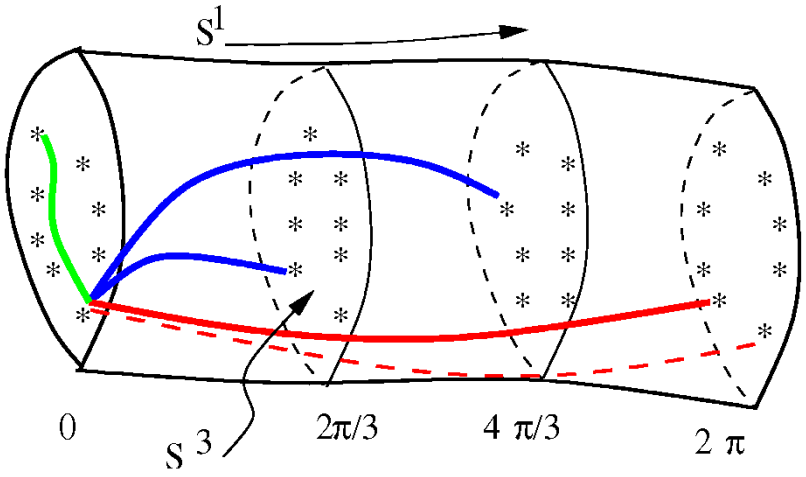


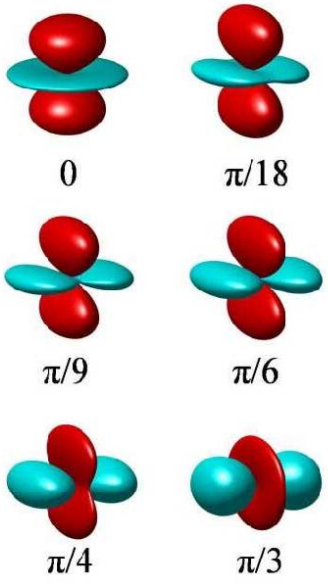
MACRO satellite to look for Grav Deco.



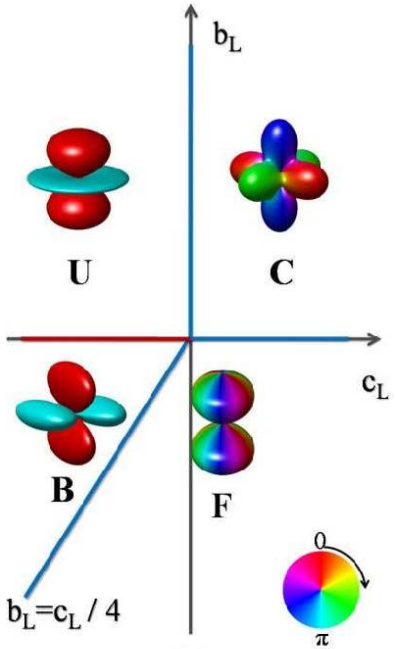
Fei Zhou:

→ My research is focused on understanding cooperative behaviors of ultra cold alkali atoms in extreme quantum limits. Particularly, correlated cold quantum matter in optical lattices, highly-coherent quantum dynamics, quantum number fractionalization and underlying topological order in atomic gases at nano-Kelvin temperatures.





(a)

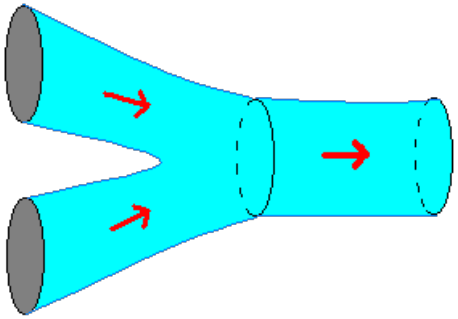


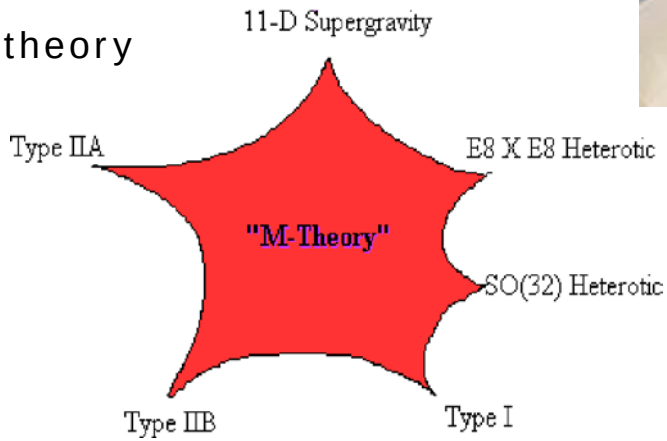
(b)

Gordon Semenoff

(1) Elementary Particle Physics & String Theory

* Duality between gauge field and string theories
• Related issues in quantum field theory, particle physics, quantum gravity
• basic properties and solutions of string theory

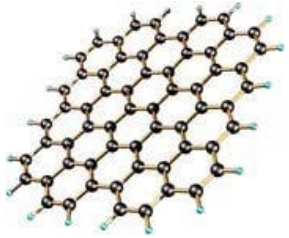


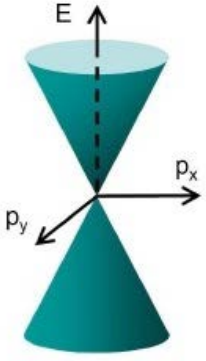


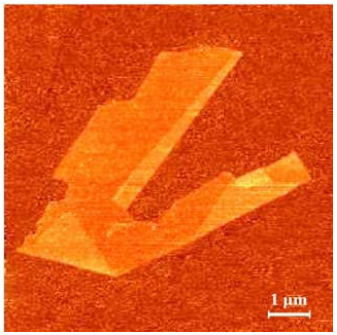
(2) Condensed Matter Analogs of Relativistic Field Systems

• Graphene: theory & application to experiments on graphene sheets; strong correlations in graphene.

• Topological field theories in Condensed Matter (eg., Quantum Hall fluids)





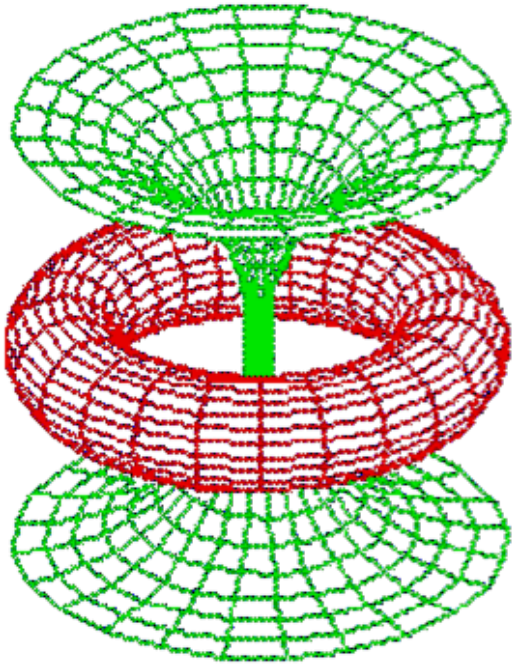


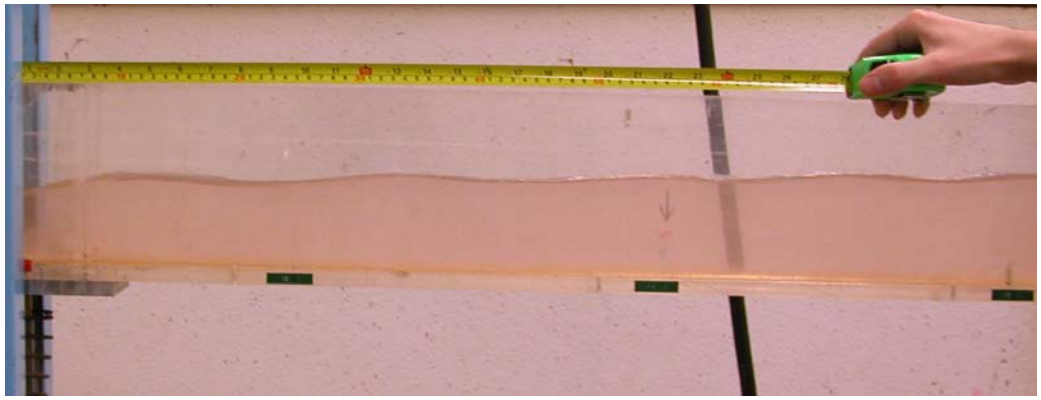
Bill Unruh:

Dumb Holes: The physics around black holes can be modeled by condensed matter systems (sound waves, surfaces in fluids giving clues to where the particles in black hole evaporation come from

Foundations of Quantum Mechanics: What is the best way of interpreting and understanding quantum theory? What makes quantum computers more powerful than classical?

Quantum Mechanics and Gravity: Quantum behavior around black holes, early universe; gravitational decoherence (project with PCE Stamp).





PRELIMINARY SUMMARY

Theorists make up roughly 40% of our faculty

CM Theory is about half of all theory at UBC

Very wide variety of research themes. Main areas of concentration:

- strongly-correlated quantum systems
- exotic quantum phenomena, particularly on large scale
- New ideas in quantum mechanics, & how they apply in condensed matter systems
- Condensed matter realizations of relativistic field theory and quantum gravitational ideas..

INTERNAL LINKS

WEEKLY CMT LUNCH: (each of us -- faculty, grad students, postdocs – talk in turn. Talks are informal blackboard style: find out what others do, start collaborations, get suggestions, be part of the community. Plus, we get cookies!)

SEMINARS: (includes both theory and experimental talks) + cmt part of theory seminar + cmt colloquium talks + …

INTERNAL COLLABORATIONS: between groups – opportunities for students to work with more than one faculty (multiple advisors) and interact with many postdocs and other graduate students.lots of interactions with our oustanding experimental condensed matter groups

NATIONAL/INTERNATIONAL LINKS

PITP = PACIFIC INSTITUTE for THEORETICAL PHYSICS: summer schools, conferences, seminars, long-term visitors, etc → excellent opportunities for all our graduate students in international collaborations (go to pitp.phas.ubc.ca)

CIFAR: Lots of our CMT faculty are members of Canadian Institute for Advanced Research: opportunity for participation in schools, workshops…