

EXOTIC ORDER AND CRITICALITY IN QUANTUM MATTER June 7-11

22 Talks: 40+20 minutes with active discussion

7 Experimental talks; 15 Theoretical talks (Not necessarily connected)

WHAT IS 'EXOTIC' (AND WHY)?

“...organization of strongly interacting quantum condensed matter which do not fit the standard paradigms of solid state and statistical physics ...rather than attacking “from the bottom up” this program will take the “top down” approach of focusing on qualitatively new concepts”

VERY AMBITIOUS GOAL

“EXOTIC ORDER....”

L. exoticus; G. exotikos

- Introduced from another country
- Not native to the place where found
- OUTLANDISH, ALIEN (arch.)
- Strikingly, excitingly different or unusual
- Relating to striptease ???

**IN THIS CASE 'EXOTIC' MEANS UNUSUAL:
PERHAPS BEYOND CURRENT PARADIGMS
IF ONE IS LUCKY**

PARADIGMS!

(Paradigm shifts are, fortunately, rare)

Superconductivity, Superfluidity, QHE, FQHE
Anderson localization, Mott transition, Josephson
effect, Abrikosov vortex lattice (matter), Kondo
problem, Luttinger liquid, Topological(KT) order

BAND THEORY

FERMI LIQUID THEORY

PERTURBATION THEORY

MEAN FIELD THEORY

LGW THEORY

**WARNING: EFFECTIVE FIELD
THEORY OFTEN PREDICTS
POSSIBILITIES OR SCENARIOS FOR
EXOTIC ORDER AND CRITICALITY,
WHICH DO NOT ALWAYS OCCUR
IN NATURE**

(e.g. PRB66,195334(2002);B68,165303(2003): 27+47pp.)

**ISOSPIN SKYRMION STRIPES
NATURE MAY SOMETIMES BE
BORING (SUCH IS LIFE)
NEED NUMERICAL WORK &
EVENTUALLY EXPERIMENTS**

‘PARADIGMS’ (buzzwords in this conference)

JUST THE TITLES e.g. New States of Matter (Wen)

Quantum Loop Gas, Topological Matter (Nayak)

Topological QC (Preskill)

Emergent Photons (Motrunich)

Landau Forbidden Transitions (Vishwanath)

Deconfined QC (Vishwanath)

Dissipationless Current (Nagaosa)

Quantum Hall Exciton Condensate (Eisenstein)

Bose glass (Demler; Takagi)

CONTRAST: High-T_c, QH, DMS, QPT

show up only once each in the titles!

NOTE: QC=quantum criticality or quantum computation!

**THEMES EMERGING IN THE
CONFERENCE**

1. Transcending LGW paradigm

String-Net Condensation

Deconfined QC&Fractionalization

First Order Transition? How and where to observe?

2. Topological matter

Topological quantum computation

How does one ‘see’ topological features?

Braiding? Manipulation of quasiparticles?

Connection between ‘loops’ and ‘nets’?

3. Quantum frustration

Competing order, valence bond ordering, dimer liquids

**14 Talks on ‘spin/magnetic’
systems/models/phenomena**

Coldea,Sandvik,Wen,Motrunich,Vishwanath,Senthil
Timm,Rosenbaum,Nagaosa,Eisenstein,Demler,
Tchernyshyov,Takagi,Tanaka

**4 Talks on topological quantum
computation**

Freedman,Nayak,Preskill,Demler

**4 Talks on high-Tc and ‘strong
correlations’**

Georges,Yazdani,Hill,Schrieffer

OTHER TOPICS: WEN, RADZIHOVSKY, DEMLER

EXTREMELY BROAD SCOPE

Abstract mathematical (Freedman, Nayak,
Wen) to QMC (Sandvik), DMFT (Georges)
Very general (Preskill, Wen, Nagaosa,
Freedman) to very specific(Timm,Sandvik)
Quantum to classical (Radzihovsky)
Deconfinement/fractionalization to
technology (QC,spintronics,super-high-Tc)
Cs₂CuCl₄(Coldea) to GaAs bilayers
(Eisenstein)through DMS(Timm),spinels
(Takagi),cuprates(Yazdani,Hill),cold atoms
(Demler),spin liquids(Rosenbaum)....

5 Broad Categories/Topics

1. Quantum spin models(beyond LGW)

Wen, Sandvik, Motrunich, Vishwanath, Senthil,
Tchernyshyov, (Nagaosa)

2. Topological matter and QC

Preskill, Nayak, Freedman, (Wen, Nagaosa)

3. Interplay of order

Timm, Georges, Demler, Schrieffer... (Nagaosa)

4. Classical critical without fine-tuning

Radzihovsky

5. Coldea, Rosenbaum, Takagi, Tanaka

Yazdani, Hill

Eisenstein

SOME ISSUES

- WHERE AND HOW TO LOOK FOR DECONFINED CRITICALITY BOTH AS A PHENOMENON OR IN NUMERICS
- WHERE AND HOW TO FIND TOPOLOGICAL MATTER (QC): FQHE, ROTATING BEC, OPTICAL LATTICE, ARTIFICIAL (QUANTUM DOT) KITAEV LATTICE, JOSEPH. JN. ARRAY

5 Questions in Exotica

- How and where to see deconfined criticality
- Deconfined criticality in real hamiltonians
- Continuous versus first order transitions
- How generic is topological matter(TM)
- How do you 'braid' real nonabelions(QHE)

5 More Questions

- Nontrivial observable features of TM
- Do I need to learn about loops/webs/strings
- Will there ever be a REAL QC (topological or otherwise)
- Does 'exotica' solve any existing problems
- How exotic is the pseudogap

Still more questions

- Is AHE all generic Berry phase effect
- Dissipationless spin current?
- DMFT versus LDA (very nonexotic)
- Is there a DC Josephson effect in the bilayer interlayer tunneling experiment
- Excitonic condensate 'versus' neutral superfluid
- T_c (KT) = 0 ?
- Are there quantum realizations of 'generically scale invariant' phases?
- Would BEC/Optical lattices ever teach us about totally new aspects of condensed matter physics
- Magnetism+Frustration+Disorder ? Bose Glass?

And more questions...

- Are there 'exotic' (e.g. VBG) phases in the DMS phase diagram
- Is the bilayer $\nu=1$ ground state a gauge glass
- What concrete work is needed to advance the cause of topological QC
- Where are the phenomena and the experiments and the numerics requiring exotica
- How generic is 'exotica' either in the form of 'Landau forbidden' (remember Wegner and localization transition) or in the form of topological matter (remember the $5/2$ state)

SUMMARY of the Conference on Exotic Order and Criticality in Quantum Matter

