EXOTIC ORDER AND CRITICALITY IN QUANTUM MATTER June 7-11

22 Talks: 40+20 minutes with active discussion7 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-Tc, 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

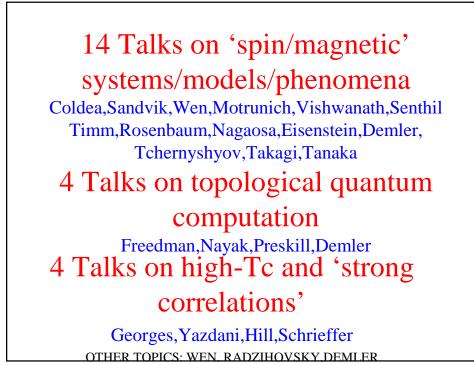
Deconfined QC&Fractionalization First Order Transition? How and where to observe?

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



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. Toplogical 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

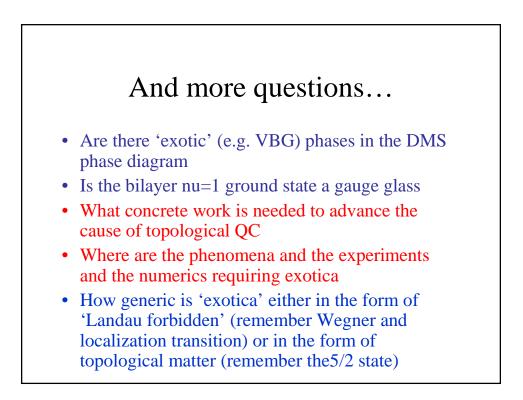
- How and where to see deconfined criticality
- Deconfined criticality in real hamiltonians
- Continuous versus first order transitions
- How generic is topological matter(TM)
- How do you 'braid' real nonabelions(QHE)

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
- Excitionic 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?



N-N₀ "Phase Diagram"

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

