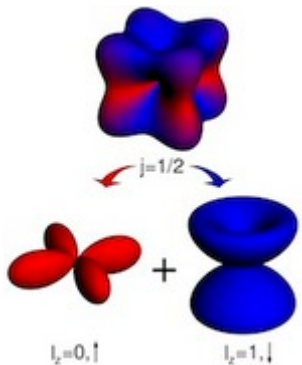


Theory overview

Leon Balents, KITP

KITP conference on Novel States in Spin-Orbit
Coupled Quantum Matter: from Models to Materials

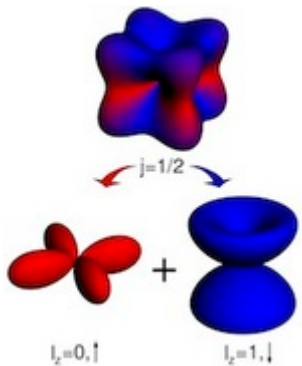
July 2015



Theory overview

Leon Balents, KITP

*or: you should have left while you
had the chance*



Collaborators



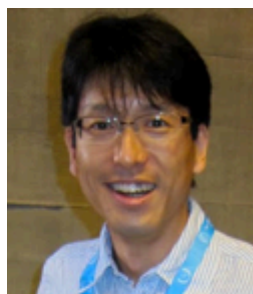
Lucile Savary



Ru Chen



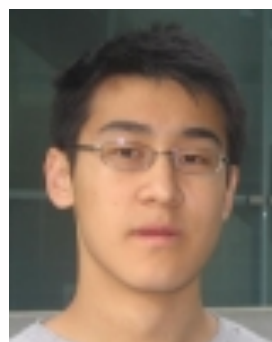
Eun-Gook Moon



S. Nakatsuji



T. Kondo



T. Hsieh



H. Ishizuka

Collaborators



Lucile Savary



Ru Chen



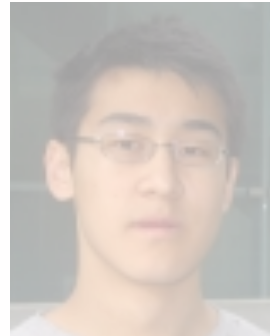
Jun-Gook Moon



S. Nakatsuji



T. Kondo



T. Hsieh



H. Ishizuka

No one to blame but me

LS Matter??

LS Matter??



LS Matter??

```
1. balents@Leons-MacBook-Pro: ~/Dropbox/Documents/temp/LSmatter (zsh)
balents@Leons-MacBook-Pro:~| => cd Dropbox/Documents/temp/LSmatter
balents@Leons-MacBook-Pro:~/Dropbox/Documents/temp/LSmatter |
= ls
Hello George.txt
Is Sr2IrO4 a high Tc superconductor??.txt
Kitaev is everywhere.txt
Kugel-Khomskii.txt
The chiral magnetic effect does not exist.txt
The secret true parameters of Yb2Ti2O7.txt
Undeniable proof of spin liquid in XXXXX.txt
balents@Leons-MacBook-Pro:~/Dropbox/Documents/temp/LSmatter |
=> |
```

LS Matter??

- Topological band structures/Weyl/
Majoranas
- SOC vs. Exchange
- Kitaev++
- Iridates
- Quantum spin ice



All GREAT!!! Maybe just a few comments

Already one unparalleled
achievement

GINIYAT

KHALIULLIN

This summer,
Prince Akeem
discovers
America.



COMING TO AMERICA

PARAMOUNT PICTURES PRESENTS AN EDDIE MURPHY PRODUCTION A LANDIS/FOLSEY FILM
EDDIE MURPHY • COMING TO AMERICA • ARSENIO HALL • JAMES EARL JONES • JOHN AMOS • MADGE SINCLAIR • SHARI HEADLEY
Music Score by NILE RODGERS Production Designer RICHARD McDONALD Executive Producers LESLIE BELZBERG and MARK LIPSKY
Story by EDDIE MURPHY Screenplay by DAVID SHEFFIELD & BARRY W. BLAUSTEIN Produced by ROBERT DAWCHS and GEORGE FOLSEY, JR.
Directed by JOHN LANDIS A PARAMOUNT PICTURE



Original soundtrack album available on CD, cassette and compact disc



LS Matter??

- Topological band structures/Weyl/
Majoranas
- SOC vs. Exchange
- Kitaev++
- Iridates
- Quantum spin ice



All GREAT!!! Maybe just a few comments

Weyl++

- Many talks once again prove that we are really good at theory of free electrons - and there are still some good ideas being explored
- c.f. Potter's quantum oscillations - nice!

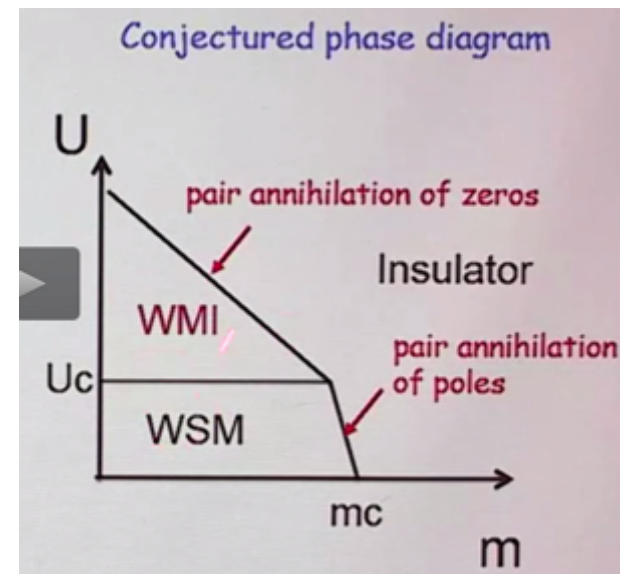
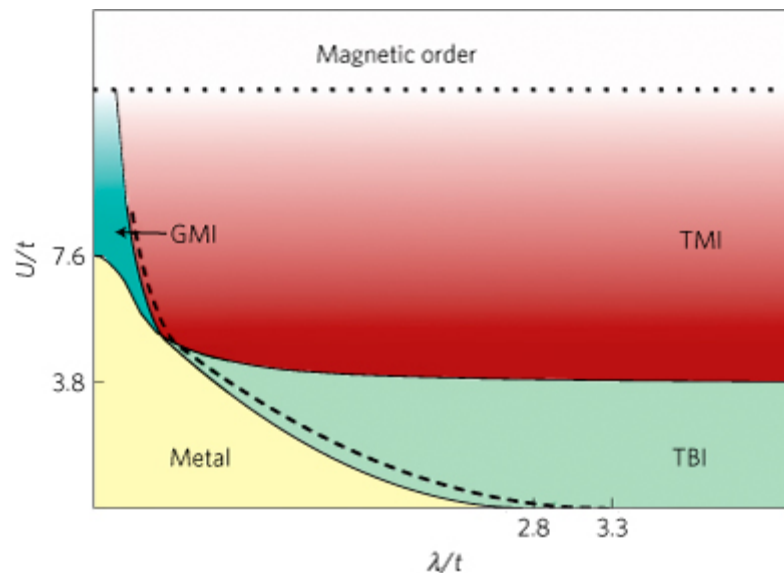


Cite me!!! or else...

Weyl++

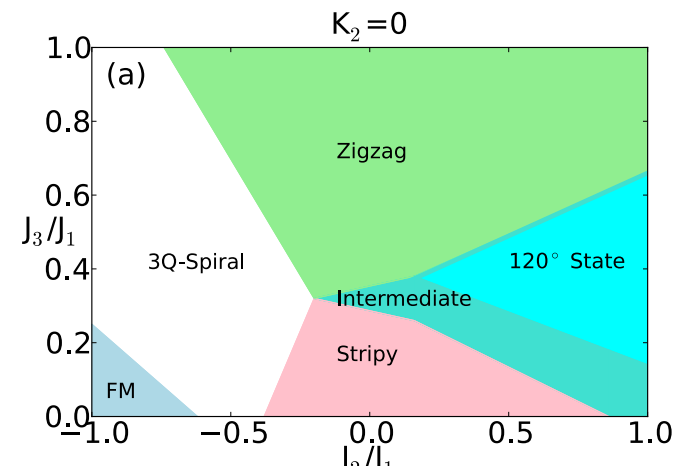
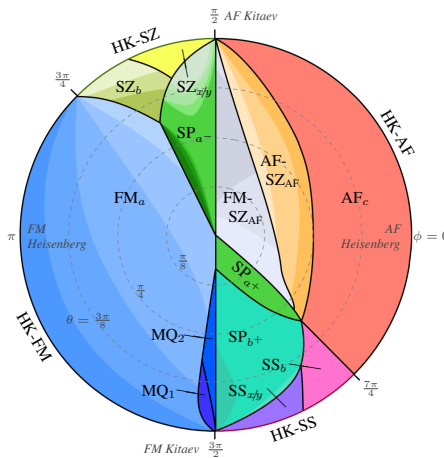
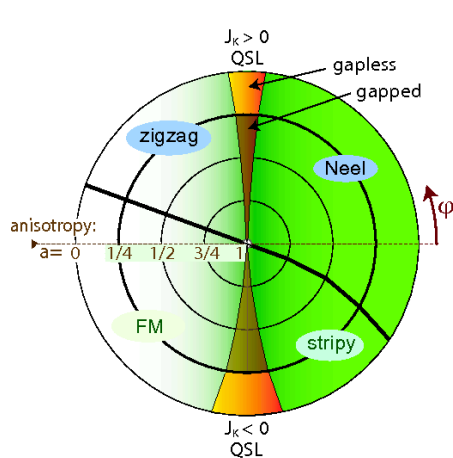
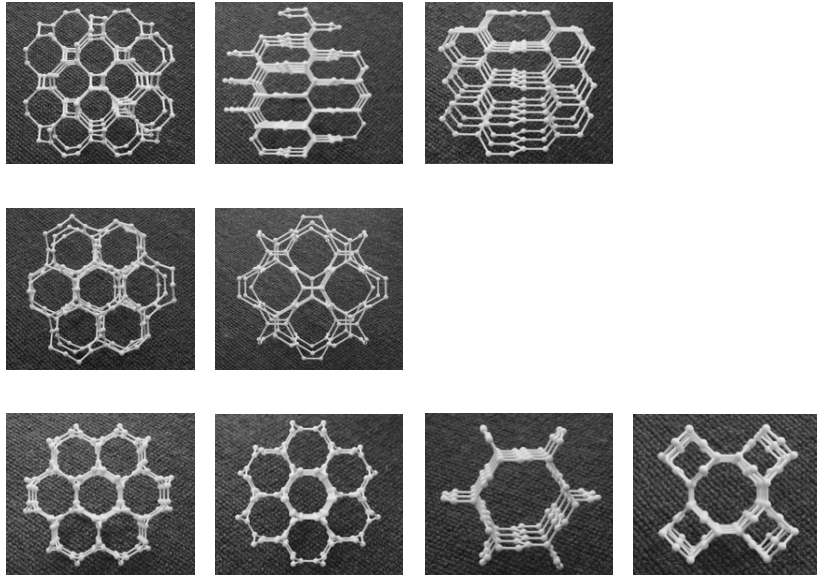
- But can we do *something* beyond weak interactions??

sorry Takagi-sensei

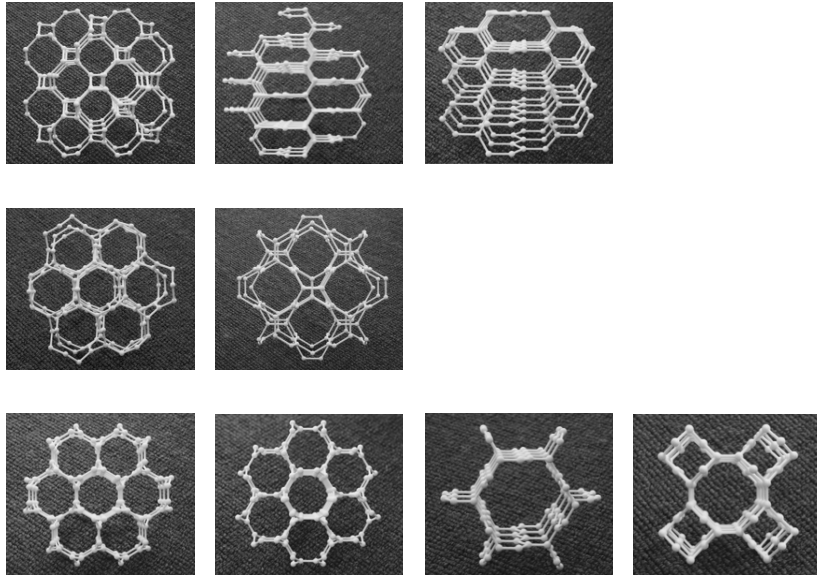


Crazy ideas...(of varying degree)...can we do better without throwing out the baby with the bathwater??

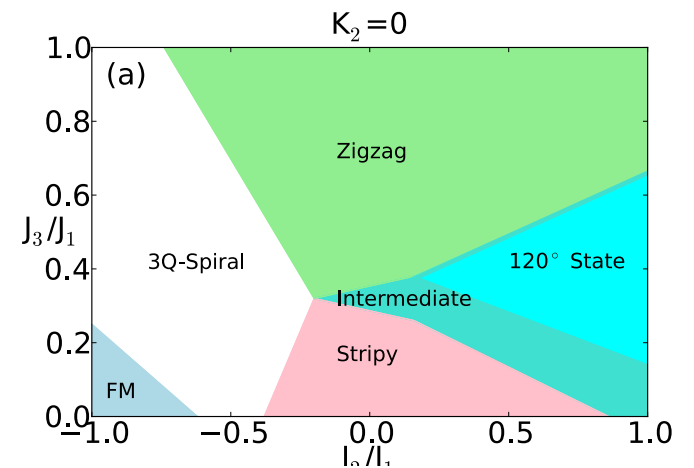
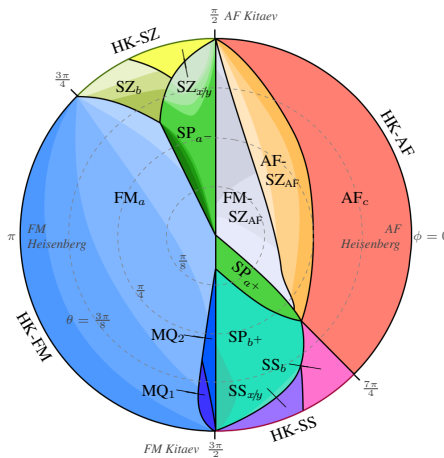
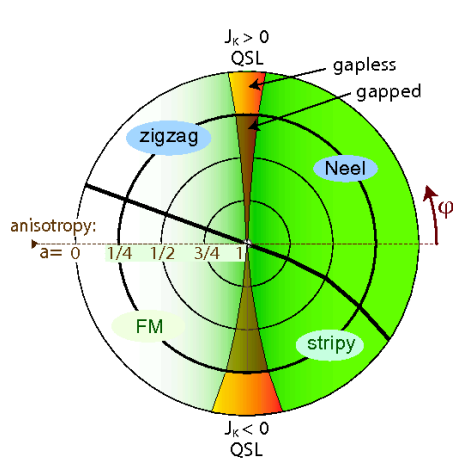
Kitaev++



Kitaev++



Non-zoological questions??



The biggest question
for theorists is obvious:

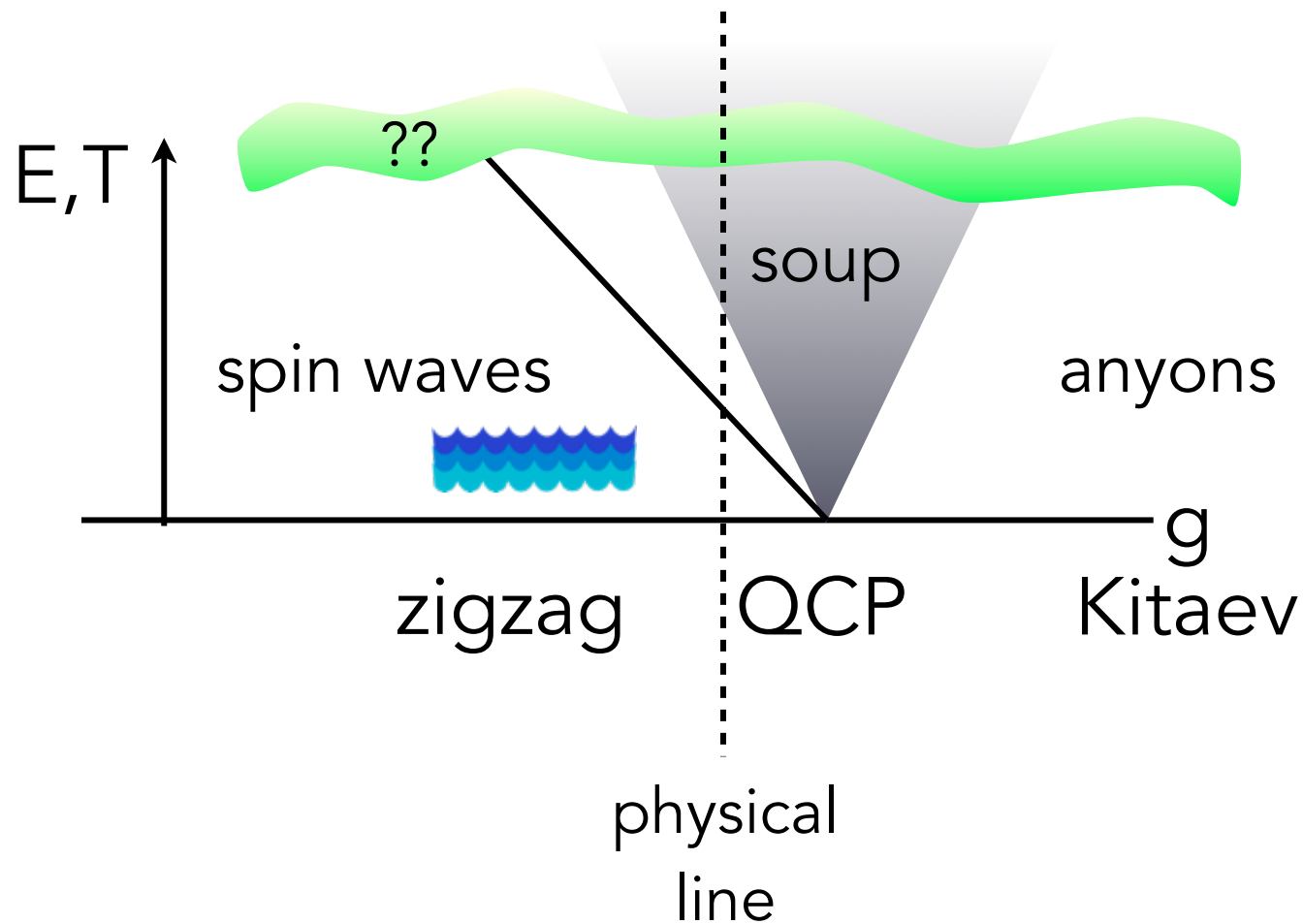
Why did Kitaev leave?



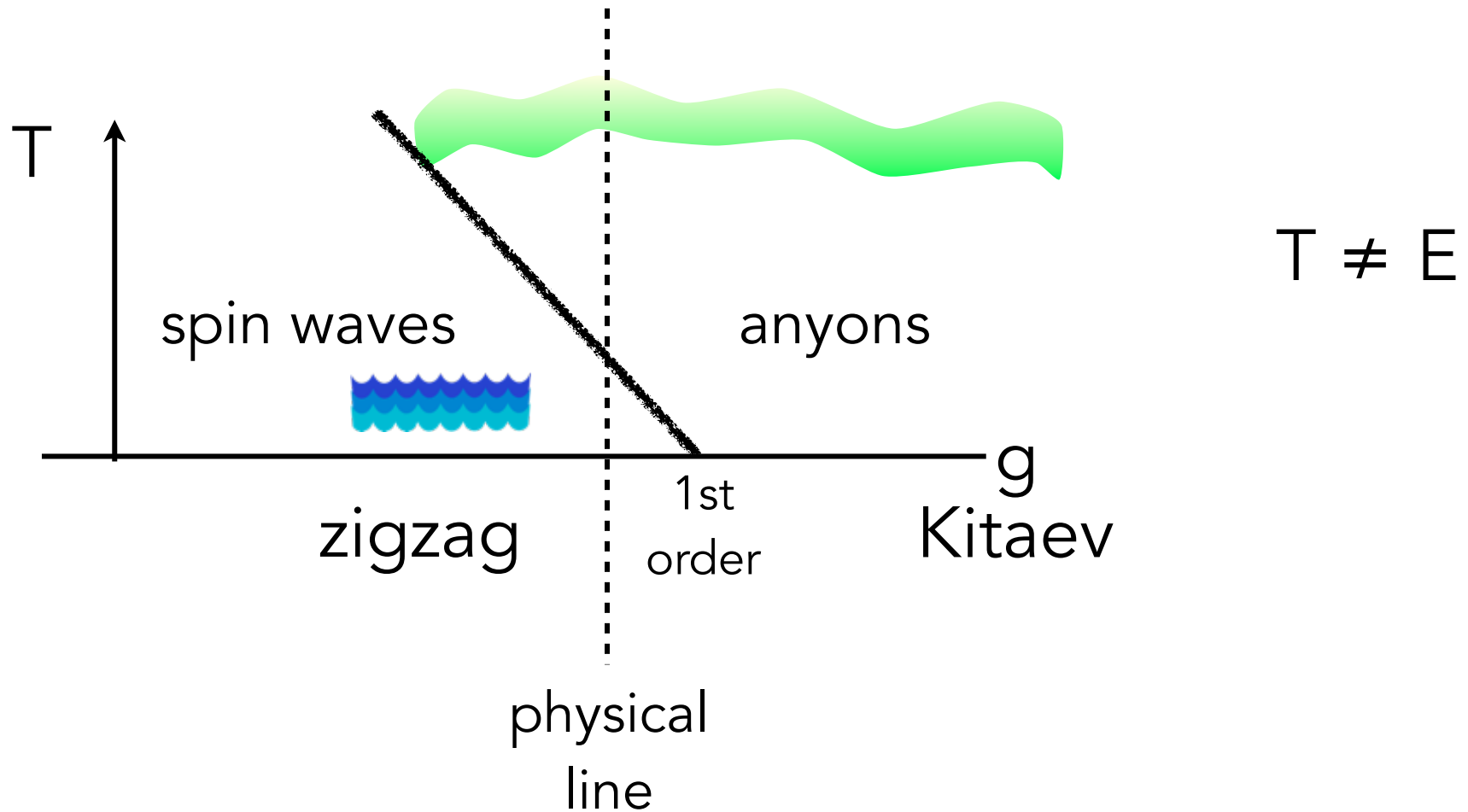
Other questions for Kitaev

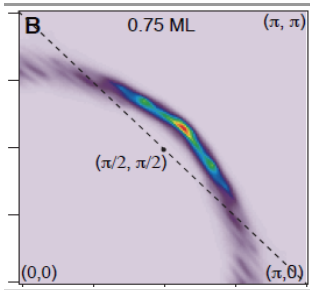
- Can we actually get one of these systems into the spin liquid phase?
- Can we do some theory better than semiclassical and Kitaev's exact but special solution?
- What does it mean to be close to the Kitaev QSL? Could you tell?

Close to Kitaev

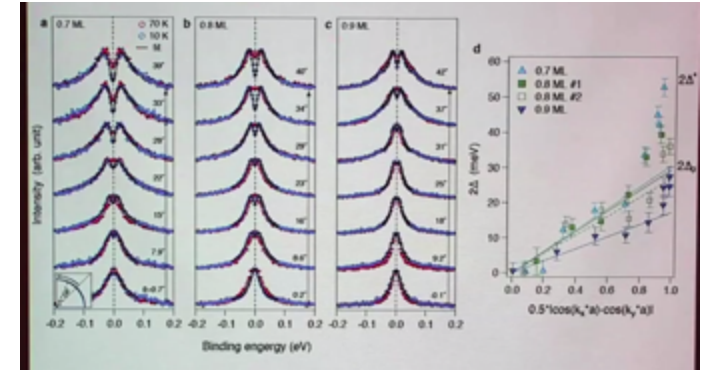


Close to Kitaev

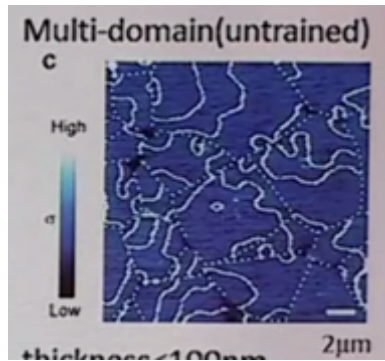




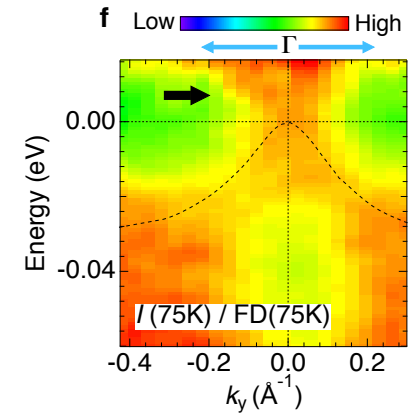
Iridates



- Beautiful experiments on Sr_2IrO_4 from BJ Kim
- Surely theorists can learn *something* about high- T_c from this? Or conversely predict something that is different from cuprates??
- Or maybe we should just place bets...



Iridates



- Rich experiments on pyrochlores, $\text{Nd}_2\text{Ir}_2\text{O}_7$ etc.
- Some theory, yet pretty much all is mean-field. However, ARPES indicates strong correlations. MFT predicts lots of nodal physics, but is it really there??

Outline

- Iridate electronic structure
- Quadratic band touching
- Field theory of quantum criticality
- Incorporation of rare earth spins
- Kondo mean field
- Strong correlation effects - band narrowing
- Fluctuation-induced first order physics
- Interplay of field, f-electron anisotropy, and Ir localization
- Field-induced nodal states
- Density matrix embedding theory
- Exact solution by AdS/CFT

Monday



Tuesday



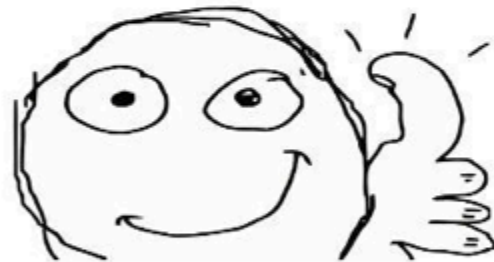
Wednesday

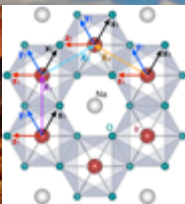


Thursday



Friday



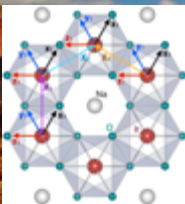


g_2	SY-LRE 1	SY-LRE 2	SET orders (tensor category w/ symmetry)
	intrinsic topo. order		
	SB-LRE 1	SB-LRE 2	symmetry breaking (group theory)
	SB-SRE 1	SB-SRE 2	
	SY-SRE 1	SY-SRE 2	SPT phases (group cohomology theory)
	g_1		



A topological world,
A new civilization!

Thank you



LSmatter



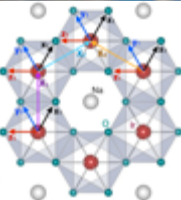
g_2	SY-LRE 1	SY-LRE 2	SET orders (tensor category w/ symmetry)
	intrinsic topo. order		
	SB-LRE 1	SB-LRE 2	symmetry breaking (group theory)
	SB-SRE 1	SB-SRE 2	
	SY-SRE 1	SY-SRE 2	SPT phases (group cohomology theory)
	g_1		



A topological world,
A new civilization!

Thank you



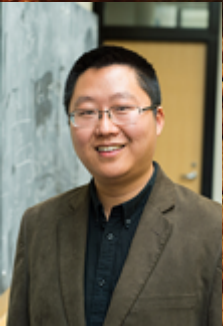
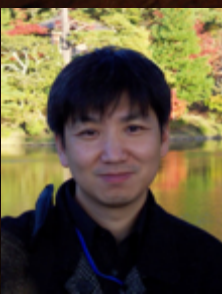


g_2	SY-LRE 1	SY-LRE 2	SET orders (tensor category w/ symmetry)
	intrinsic topo. order		
	SB-LRE 1	SB-LRE 2	symmetry breaking (group theory)
	SB-SRE 1	SB-SRE 2	
	SY-SRE 1	SY-SRE 2	SPT phases (group cohomology theory)
	g_1		



A topological world,
A new civilization!

Thank you



Let's thank all the organizers