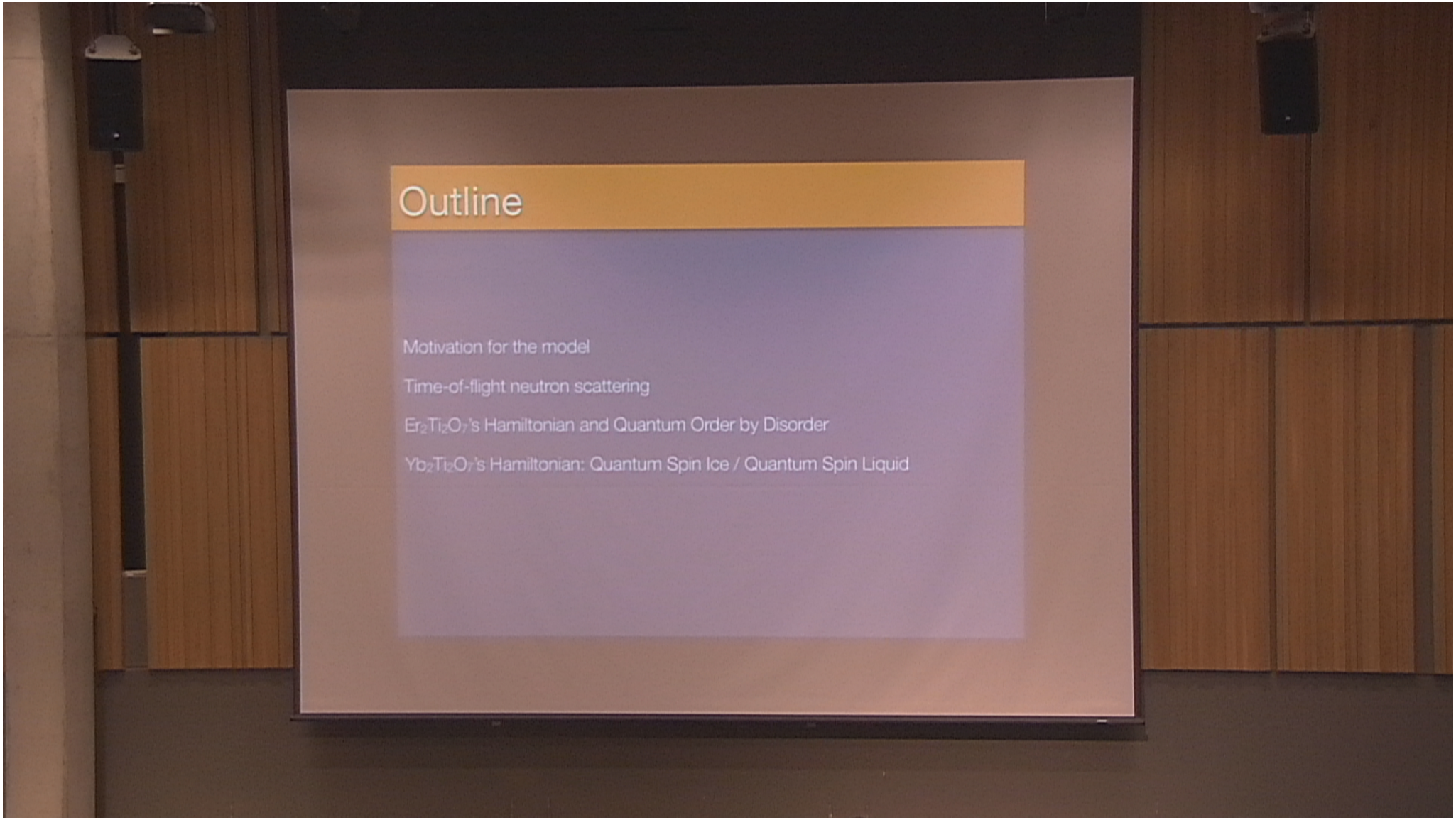
Title: Effective Spin-1/2 Hamiltonians Determined for Er2Ti2O7 & Yb2Ti2O7 Through Inelastic Neutron Scattering

Date: May 03, 2012 11:00 AM

URL: http://pirsa.org/12050035

Abstract: We used time-of-flight inelastic neutron scattering to measure the excitation spectra from field-polarized states of exotic frustrated magnets. A knowledge of these spin-wave excitations in various directions in reciprocal space allows a robust determination of exchange parameters in suitable model Hamiltonians. We have taken this approach with two pyrochlores, Er2Ti2O7 and Yb2Ti2O7, whose magnetic properties have until this point been somewhat puzzling. The model we use is an effective spin-1/2 exchange Hamiltonian that incorporates the full anisotropy allowed by symmetry at the rare earth site. Er2Ti2O7, an XY anti-ferromagnet on the pyrochlore lattice, is found to reach its unexpected ordered ground state via quantum-order-by-disorder. Meanwhile, Yb2Ti2O7's effective Hamiltonian reveals the possibility of a Coulombic quantum spin liquid through what we have revealed to be "quantum spin ice" interactions.   I will focus on the experimental side of these collaborative studies.


Outline
Motivation for the model
Time-of-flight neutron scattering
$Er_2Ti_2O_7$'s Hamiltonian and Quantum Order by Disorder
$Yb_2Ti_2O_7$'s Hamiltonian: Quantum Spin Ice / Quantum Spin Liquid

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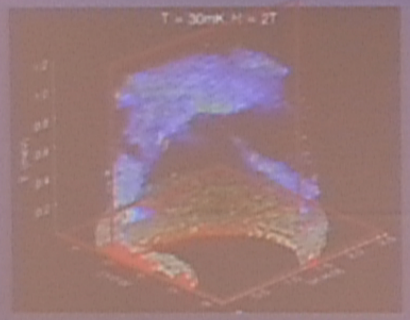
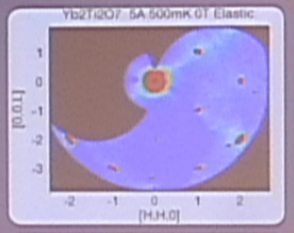
$Er_2Ti_2O_7$'s Hamiltonian and Quantum Order by Disorder

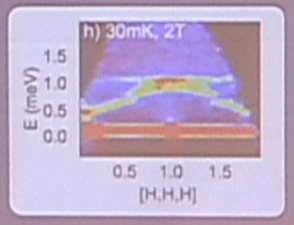
$Yb_2Ti_2O_7$'s Hamiltonian: Quantum Spin Ice / Quantum Spin Liquid

“Time of Flight” data

Can slice through this volume in several directions

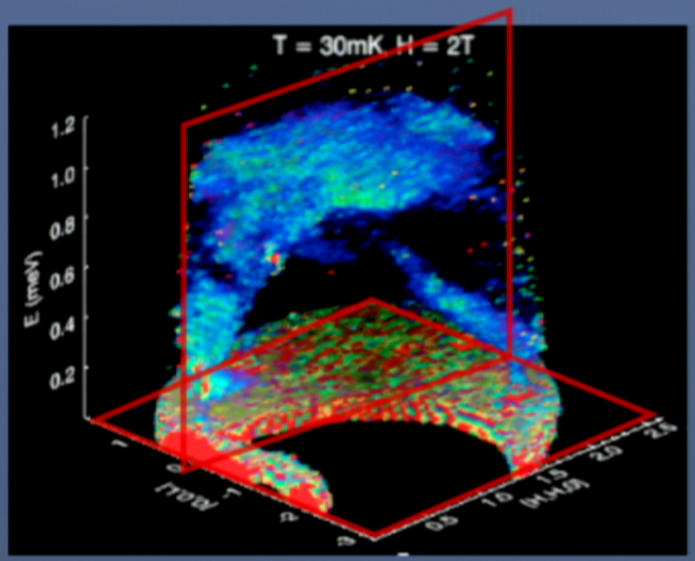


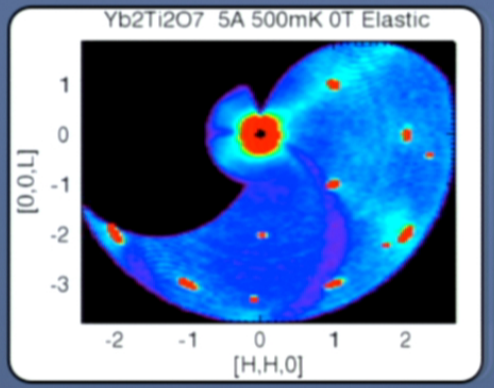


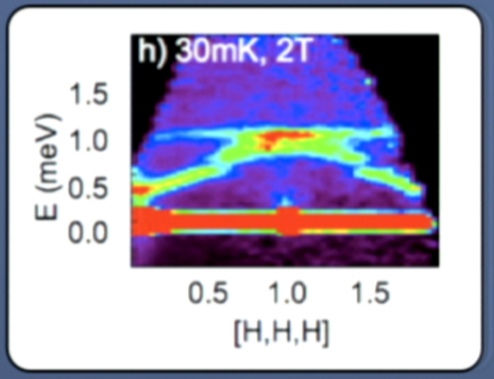


“Time of Flight” data

Can slice through this volume in several directions

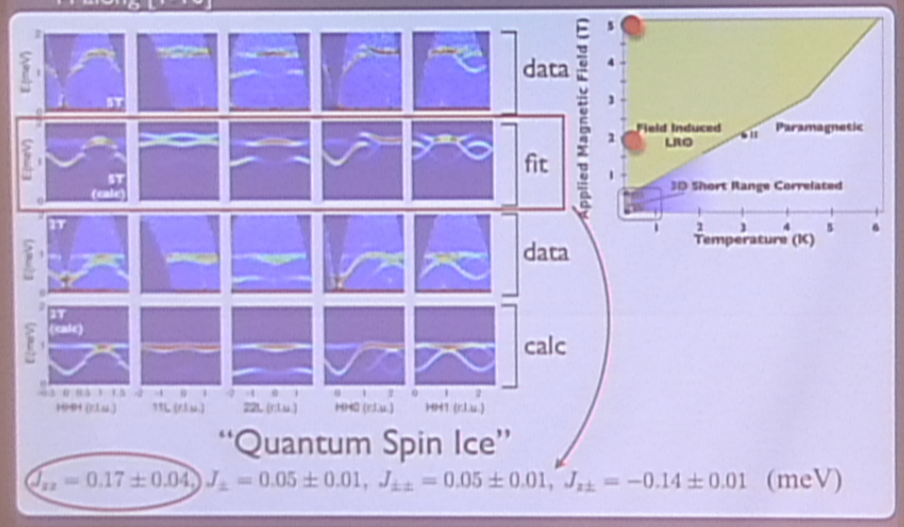






$Yb_2Ti_2O_7$ field polarized state

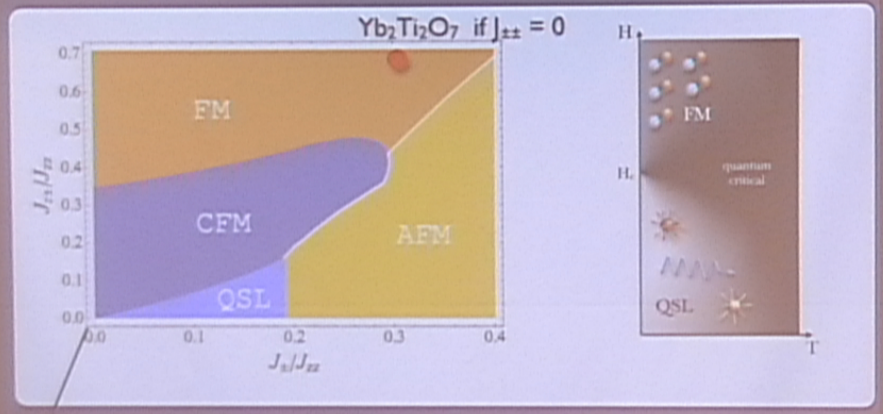
H along [1-10]



"Quantum Spin Ice"

$J_{zz} = 0.17 \pm 0.04$, $J_{\pm} = 0.05 \pm 0.01$, $J_{\pm\pm} = 0.05 \pm 0.01$, $J_{z\pm} = -0.14 \pm 0.01$ (meV)

Gauge Mean Field Phase Diagram



L. Savary, L. Balents, Phys. Rev. Lett. 108, 037202 (2012)

How close are we to the Coulomb QSL phase or Coulomb FM phase?

Successes of this Model for $Yb_2Ti_2O_7$

→ Chang *et al* show that the **diffuse scattering** in the zero-field 2D correlated state can be reproduced using parameters close to these in the effective S=1/2 Hamiltonian

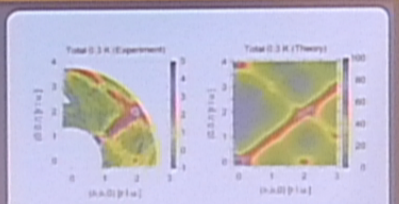
L.-J. Chang *et al*., arXiv:1111.5406 (2011)

→ Applegate *et al* show that the **specific heat** is well-described by these parameters and not by other sets of proposed parameters

R. Applegate *et al*, arXiv:1203.4569, (2012)

→Prediction by Wan *et al* of signatures for **Quantum Strings**, excitations arising from Quantum Spin Ice polarized along <100> : still waiting to see this experimentally with inelastic neutron scattering!

Y. Wan and O. Tchernyshyov, arXiv:1201.5314 (2012)



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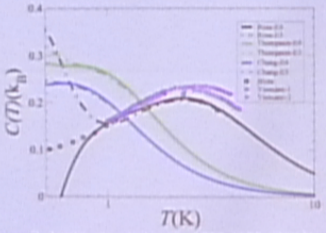

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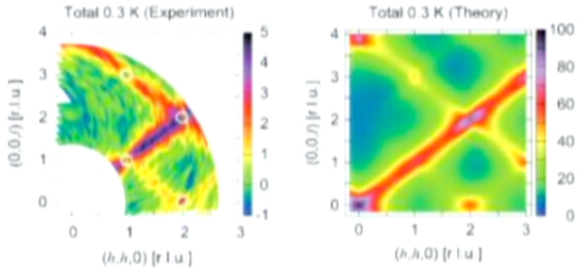

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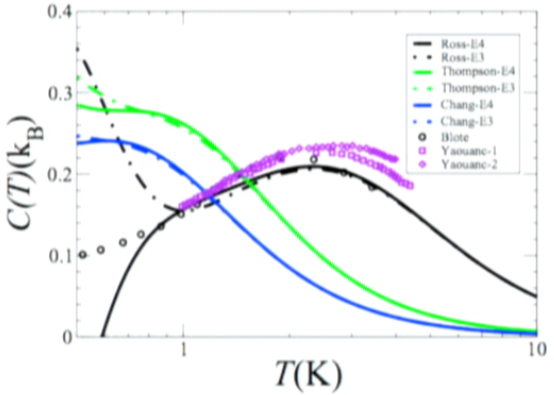

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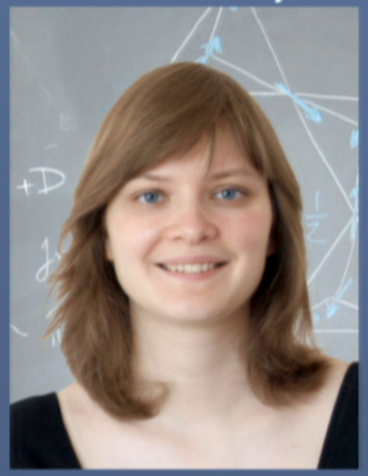
Collaboration

Lucile Savary



Leon Balents

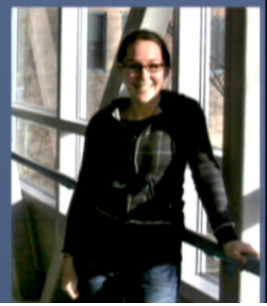
Bruce Gaulin

Jacob Ruff

Team Theory!

Team Experiment!

(me)



L. Savary, K. A. Ross, B. D. Gaulin, J. P. C. Ruff, and L. Balents, *Definitive Evidence for Order-by-Quantum-Disorder in* $Er_2Ti_2O_7$, arXiv:1204.1320v1 (2012)

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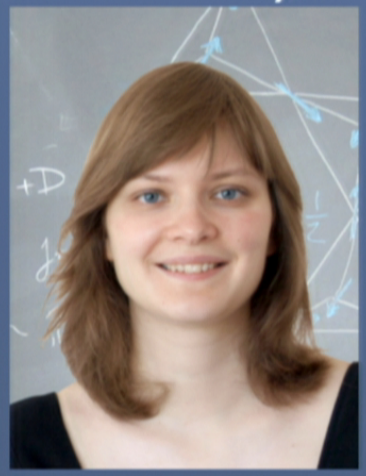

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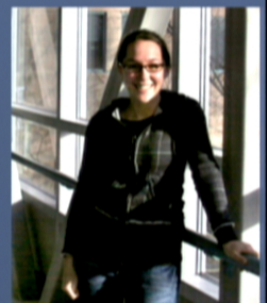

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