WS-B-1

# Quantum Spin Fluctuations and Magnon Hall Effect in Spin Scalar Chiral Ordered States in a Kondo Lattice System

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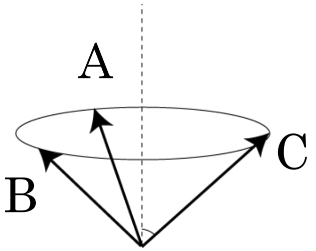
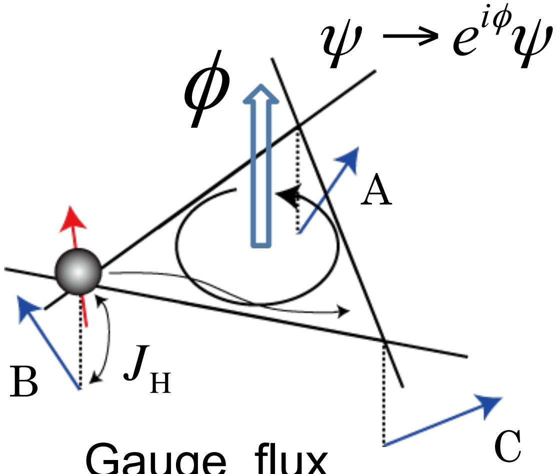
# Topological Hall Effect Driven by a Scalar Chirality

Spin configuration with a finite solid angle



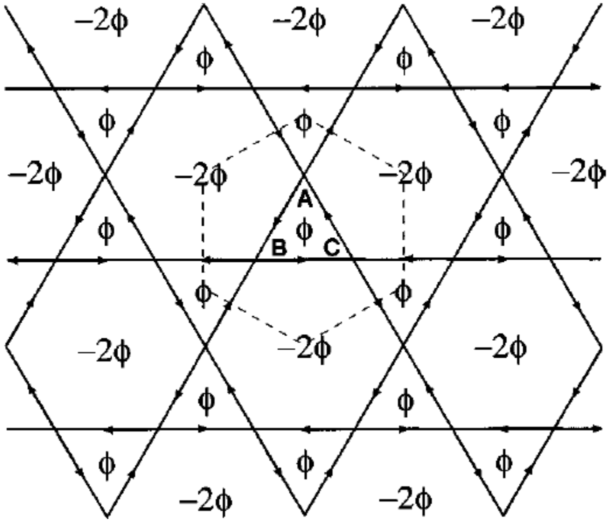
Scalar chirality
$\vec{S}_A \cdot (\vec{S}_B \times \vec{S}_C)$

Berry phase from electron hopping
A→B→C→A



Gauge flux

Distribution of flux on a kagome lattice



finite scalar chirality

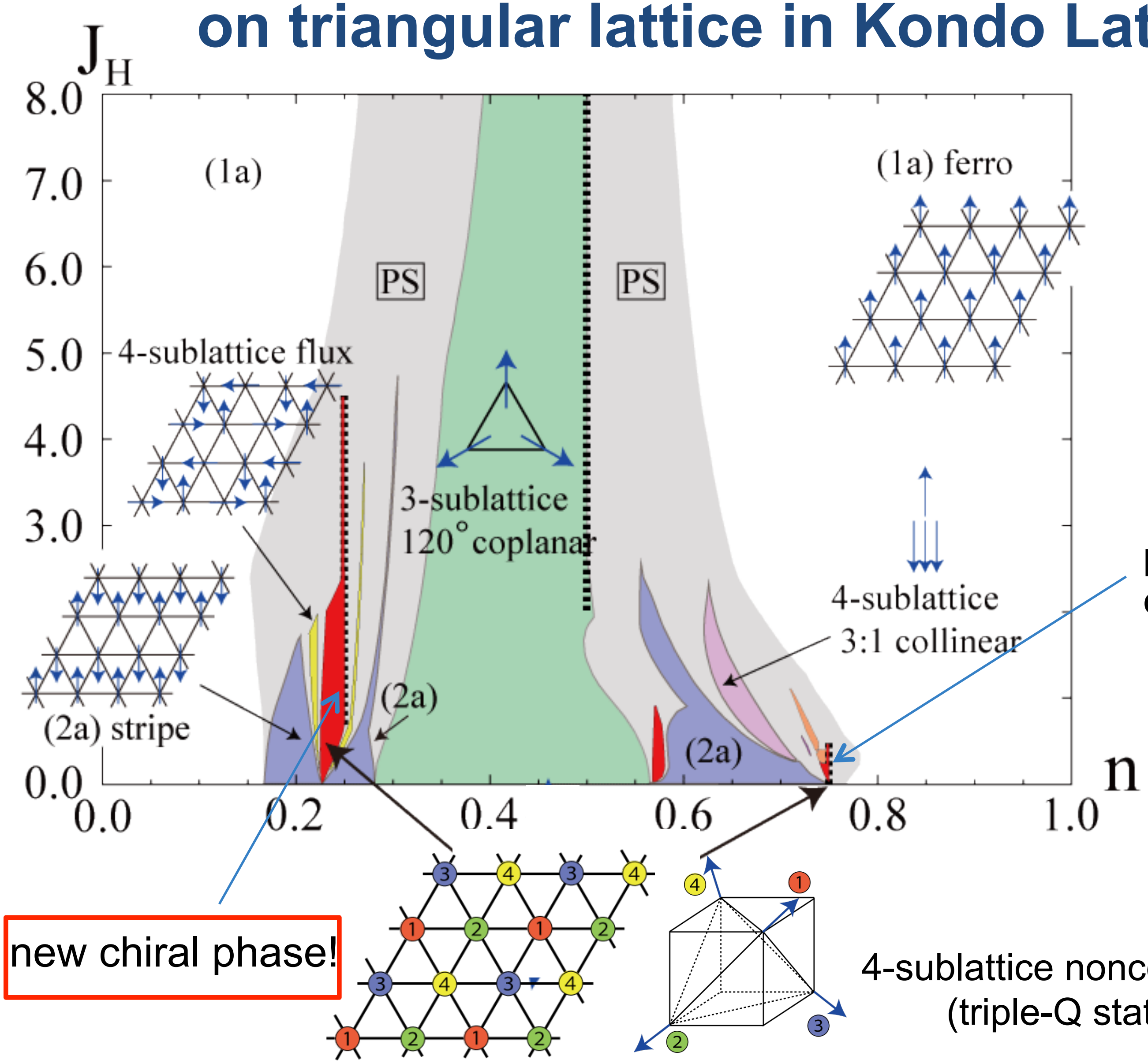
Berry phase (effective magnetic field for electrons)

Topological Hall Effect

K. Ohgushi, S. Murakami, and N. Nagaosa, Phys. Rev. B **62**, R6065 (2000).

cf) D. Loss and P. M. Goldbart, Phys. Rev. B **45**, 13544 (1992).; P. Matl *et al*., Phys. Rev. B **57**, 10248 (1998).; J. Ye *et al*., Phys. Rev. Lett. **83**, 3737 (1999).

# Our previous study : Ground state phase diagram on triangular lattice in Kondo Lattice System



Insulator

PS

Phase separation

perfect nesting driven chiral phase

[I. Martin and C. D. Batista, Phys. Rev. Lett. **101**, 156402 (2008).]

cf) [R. Shindou and N. Nagaosa, Phys. Rev. Lett. **87**, 116801 (2001).]

new chiral phase!

4-sublattice noncoplanar
(triple-Q state)

- Y. Akagi and Y. Motome, J. Phys. Soc. Jpn. **79**, 083711 (2010).
- Y. Akagi, M. Udagawa, and Y. Motome, Phys. Rev. Lett. **108**, 096401 (2012).

# Motivation

Thus far, localized spins are approximated as classical spins.
Effects of quantum fluctuations on the chiral order are interesting, but not fully understood. It is also relevant to consider the realization in real materials.

How do quantum spin fluctuations affect the nontrivial chiral order and electronic state of the system?

- To clarify how the chiral ordering is affected by quantum fluctuation.
- To clarify how magnons affect transport properties of the system.

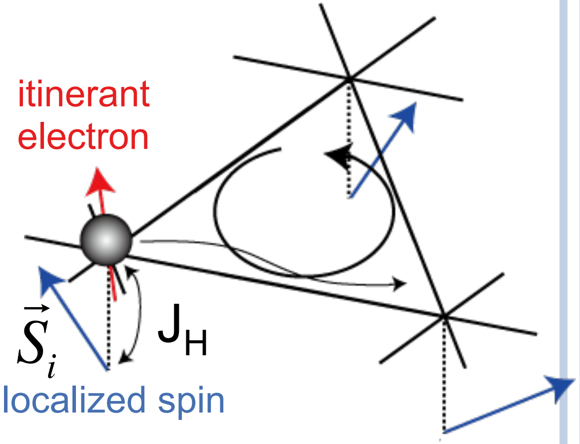
⇒ **Linear spin-wave analysis** of

Ferromagnetic Kondo Lattice Model (=double-exchange model)

$$H = -t \sum_{<i,j>,\alpha} (c^{\dagger}_{i\alpha} c_{j\alpha} + H.c.) - J_H \sum_{i,\alpha,\beta} \vec{S}_i \cdot c^{\dagger}_{i\alpha} \vec{\sigma}_{\alpha\beta} c_{i\beta}$$

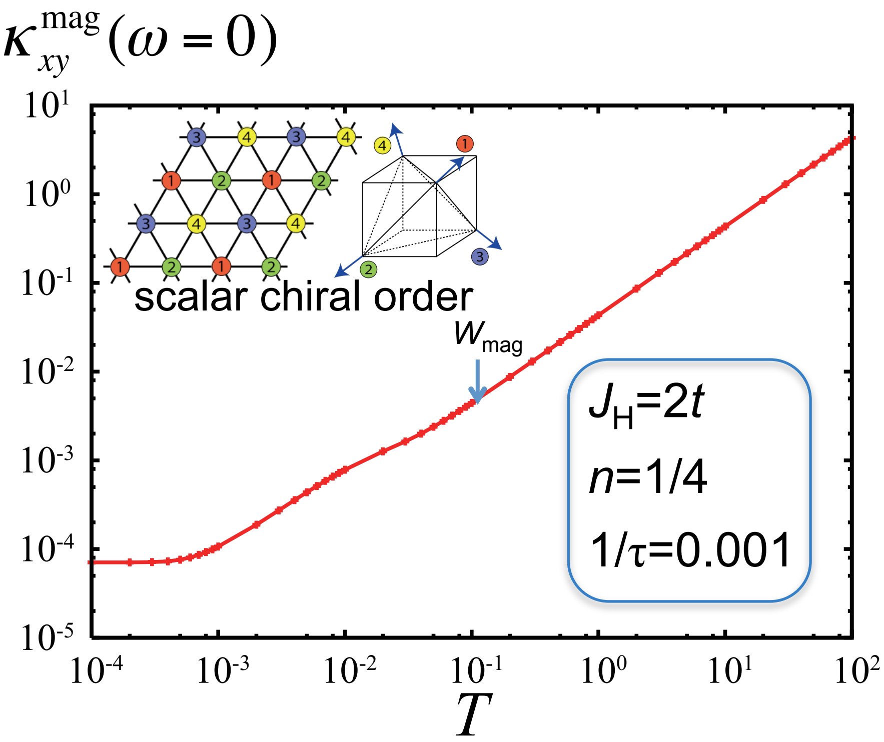
on a triangular lattice

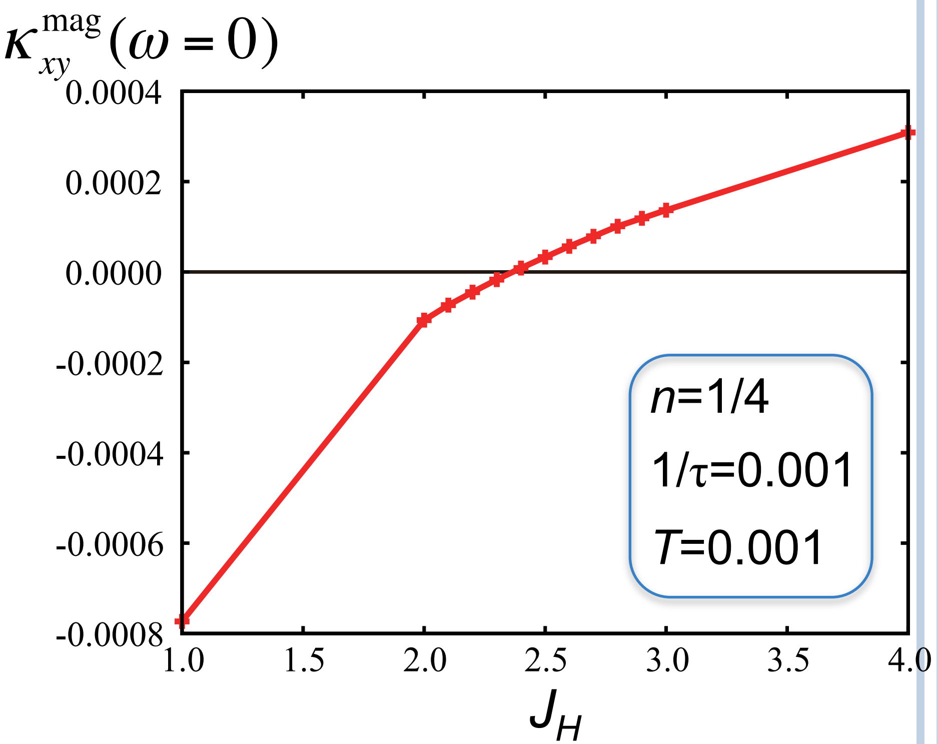
Holstein-Primakoff transformation and
1/S expansion (by using Green's function)



- N. Furukawa, J. Phys. Soc. Jpn. **65**, 1174 (1996).
- K. Penc and R. Lacaze, Europhys. Lett., **48**, 561 (1999).
- N. Shannon and A. V. Chubukov, Phys. Rev. B. **65**, 104418 (2002).
- Y. A., M. Udagawa, and Y. Motome, J. Phys. Soc. Jpn. **82**, 123709 (2013).

# Magnon Hall Effect in the Kondo Lattice Model





- $T$-linear for high-$T$
- deviation from $T$-linear behavior for low-$T$

- sign change of magnon Hall coefficient for the Hund's-rule coupling

cf) H. Katsura, N. Nagaosa, and P. A. Lee, Phys. Rev. Lett. **104**, 066403 (2010).;
R. Shindou, R. Matsumoto, S. Murakami, and J. Ohe, Phys. Rev. B **87**, 174427 (2013).

## Main Results

- stability of scalar chiral phase against quantum fluctuation
- magnon Hall effect in spin-charge coupled system
- possibility of magnon Hall effect induced by an electric field