Weyl Triplons in $SrCu_2(BO_3)_2$

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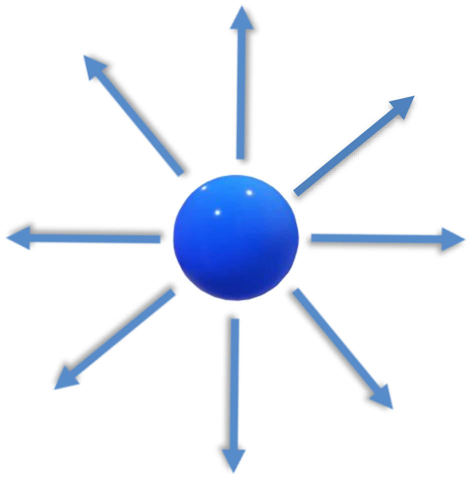
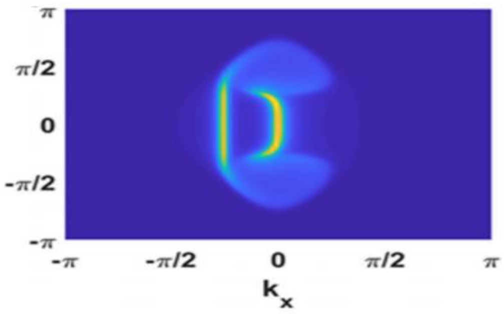
Weyl Points

- Source of Berry-curvature in reciprocal space

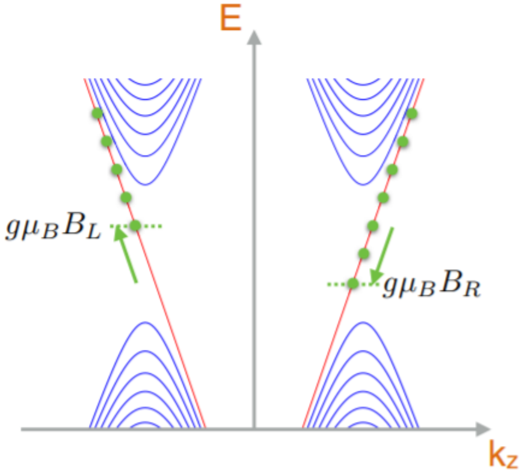


- Phenomenon:

(1)Surface Arcs



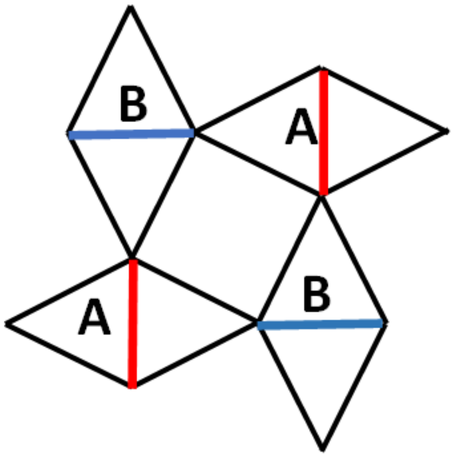
(2) Chiral Anomaly



PHYSICAL REVIEW B 99, 214413 (2019)

Introduction to SrCu2(BO3)2:
A Shastry-Sutherland Magnet

- Shastry-Sutherland magnet is orthogonal dimer magnet.

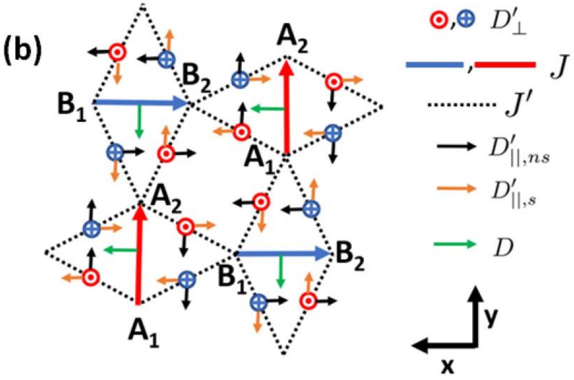


- Hamiltonian

$$H = J \sum_{\langle ij \rangle, l} S_{i,l} \cdot S_{j,l} + J' \sum_{\langle\langle ij \rangle\rangle, l} S_{i,l} \cdot S_{j,l}$$

Introduction to SrCu2(BO3)2: A Shastry-Sutherland Magnet

- The ground state of SrCu2(BO3)2 is of orthogonal dimer, but the Hamiltonian contains Dzyaloshinskii-Moriya interaction.



- Hamiltonian

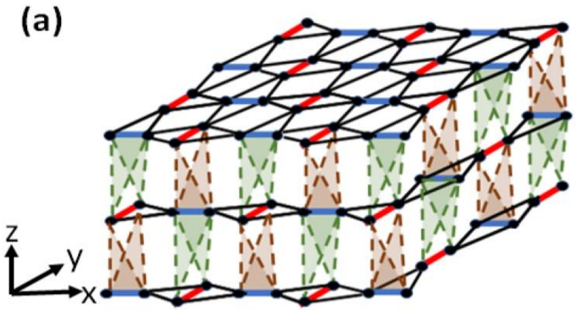
$$H = J \sum_{\langle ij \rangle, l} S_{i,l} \cdot S_{j,l} + J' \sum_{\langle\langle ij \rangle\rangle, l} S_{i,l} \cdot S_{j,l} + D \cdot \sum_{\langle ij \rangle, l} (S_{i,l} \times S_{j,l}) + D' \cdot \sum_{\langle\langle ij \rangle\rangle, l} (S_{i,l} \times S_{j,l})$$

– Thus the magnetic excitations known as triplons quasi-particles possesses gapped topological band structure.

Nature Communications 6, 6805 (2015)

Inclusion of interlayer interactions

- Additional interlayer interactions are added as follows,



- Hamiltonian

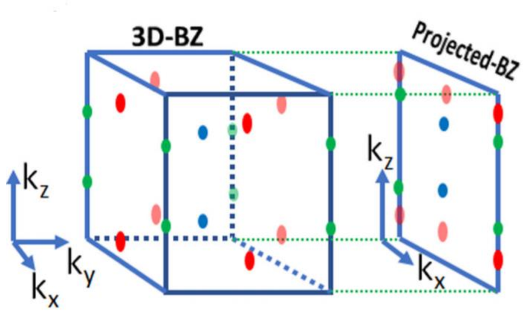
$$H = J\sum_{\langle ij\rangle,l} S_{i,l}\cdot S_{j,l} + J'\sum_{\langle\langle ij\rangle\rangle,l} S_{i,l}\cdot S_{j,l} + D\cdot\sum_{\langle ij\rangle,l}\left(S_{i,l}\times S_{j,l}\right)$$

$$+D'\cdot\sum_{\langle\langle ij\rangle\rangle,l}\left(S_{i,l}\times S_{j,l}\right) + J_z^b\sum_{\langle ij\rangle_b,\langle ll'\rangle} S_{i,l}\cdot S_{j,l'} + D_z^b\cdot\sum_{\langle ij\rangle_b,\langle ll'\rangle}\left(S_{i,l}\times S_{j,l'}\right)$$

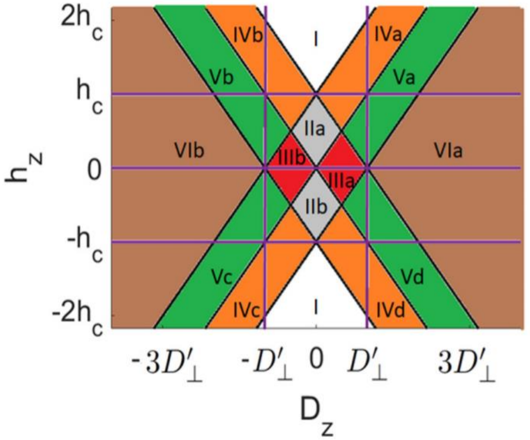
$$+J_z^g\sum_{\langle ij\rangle_g,\langle ll'\rangle} S_{i,l}\cdot S_{j,l'} + D_z^g\cdot\sum_{\langle ij\rangle_g,\langle ll'\rangle}\left(S_{i,l}\times S_{j,l'}\right)$$

Results

- The interlayer Heisenberg interaction does not temper the triplon band structure.
- the interlayer Dzyaloshinskii-Moriya interaction introduces Weyl-trplons in Brillouin zone.



Positions of Weyl-triplons



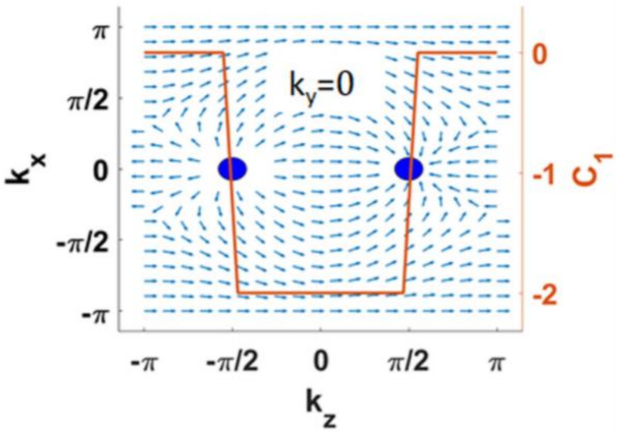
Phase Diagram

Region	Pair of Weyl points	Position of Weyl-points
I	0	(trivial gapped bands)
II	0	(Topological gapped bands)
III	2	$(0,\pi,\pm k_{z1})$, $(\pi,0,\pm k_{z1})$
IV	1	$(0,0,\pm k_{z2})$
V	3	$(0,\pi,\pm k_{z1})$, $(\pi,0,\pm k_{z1})$ and $(0,0,\pm k_{z2})$
VI	4	$(\pi,\pi,\pm k_{z3})$, $(0,\pi,\pm k_{z1})$, $(\pi,0,\pm k_{z1})$ and $(0,0,\pm k_{z2})$

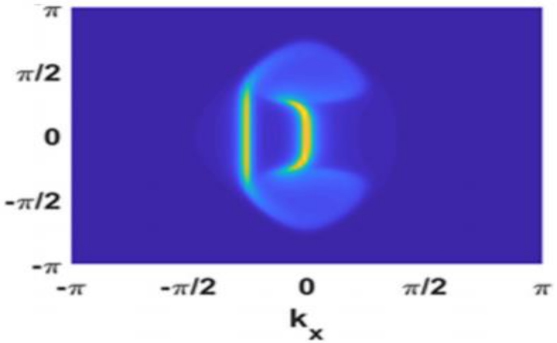
Table describing the phase regions

Results

- How do we know the band touching points are topological Weyl-points ?
  - The points are source of Berry-curvatures

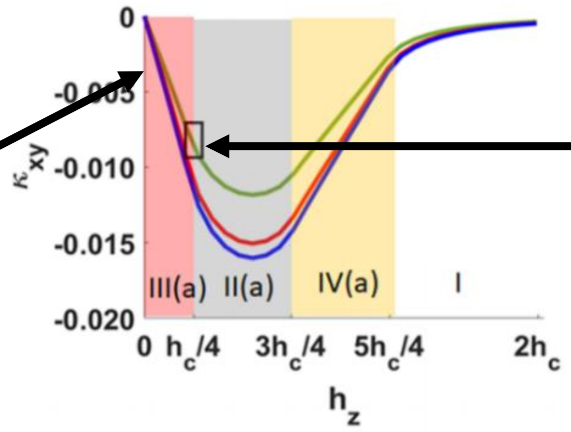


  - The triplon-arcs connects the Weyl-points with different chirality



Results

- We show the characteristic changes in the thermal Hall conductance (κ_{xy}) as a function of magnetic field (h_z).



The slope near zero magnetic field is finite

Double Derivative of thermal Hall conductance is divergent near phase transition

Thermal Hall conductance as function of magnetic field

Thanks