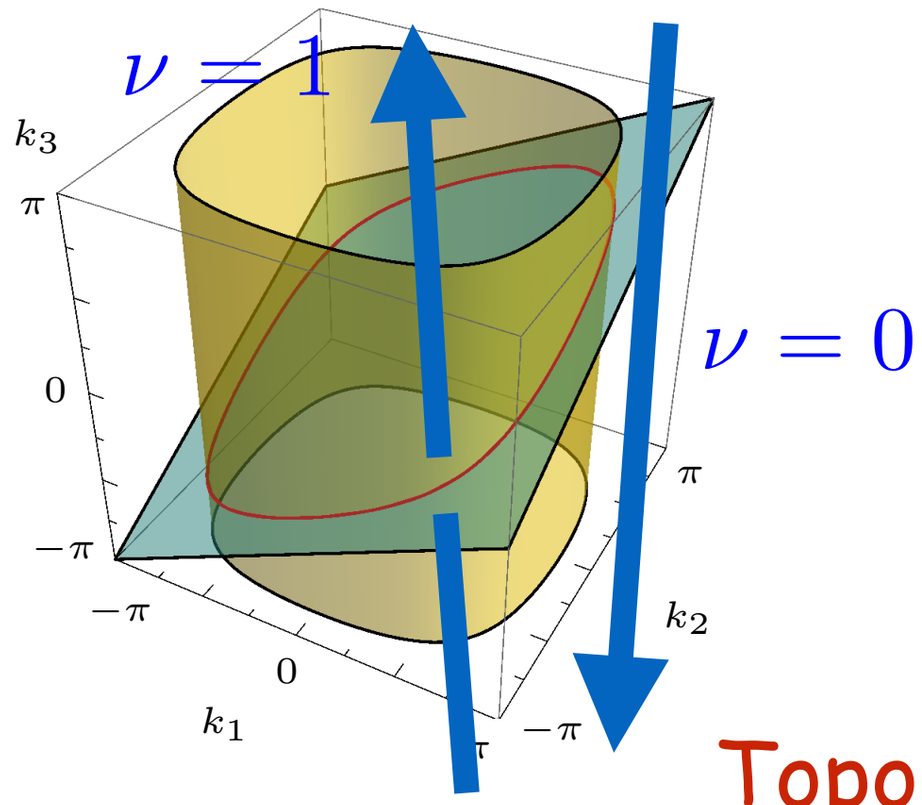
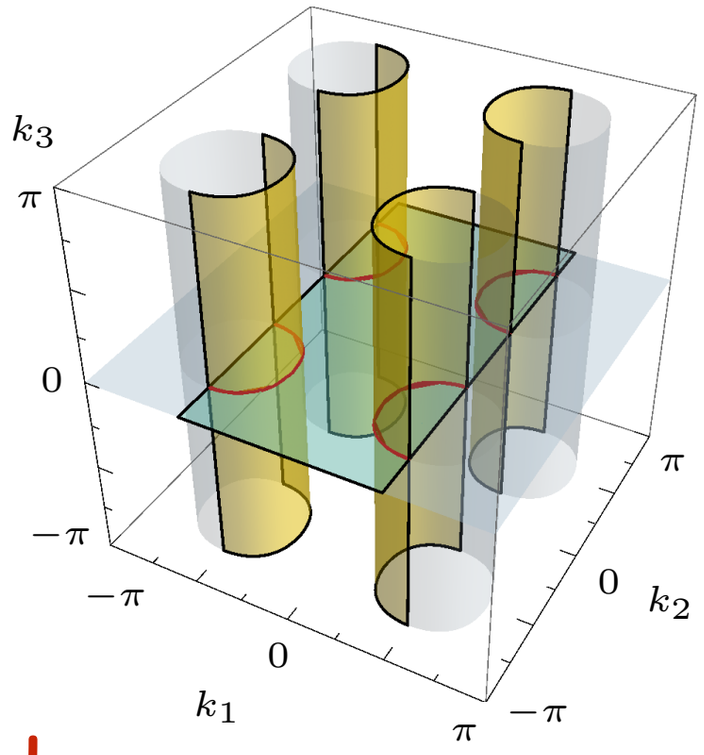
0-FLUX SECTOR
HYPERHONEYCOMB



π-FLUX SECTOR
STRIPYHONEYCOMB



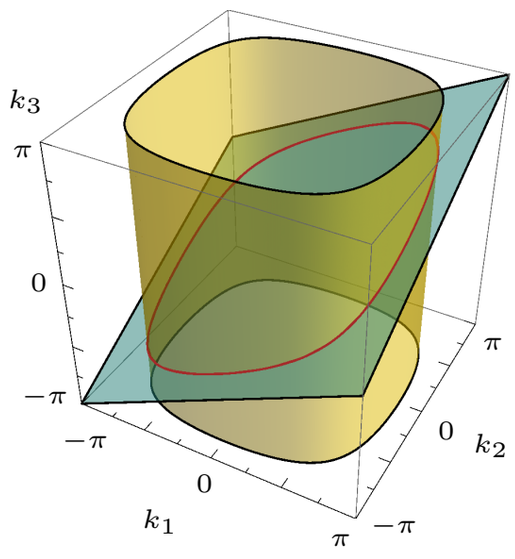
Topological
Spinon "Semi-metal"

$$\nu = \frac{1}{4\pi i}\oint \mathrm{d}k \mathrm{Tr}[D_{\mathbf{k}}^{-1}\partial_k D_{\mathbf{k}} - (D^\dagger)_{\mathbf{k}}^{-1}\partial_k D_{\mathbf{k}}^\dagger]$$

Topological Invariant

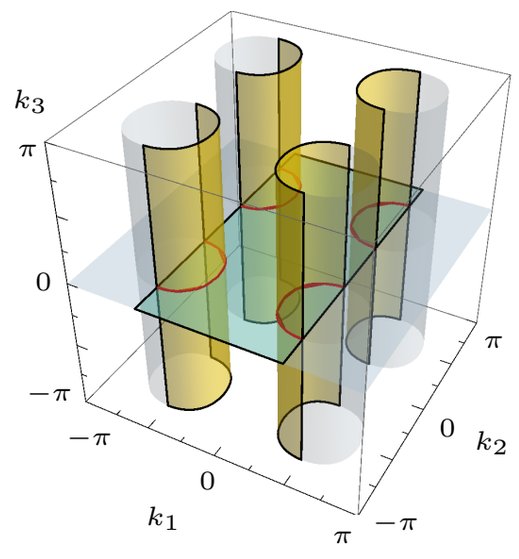
R. Schaffer, E. Lee, Y.-M. Lu, Y. B. Kim, PRL 2015

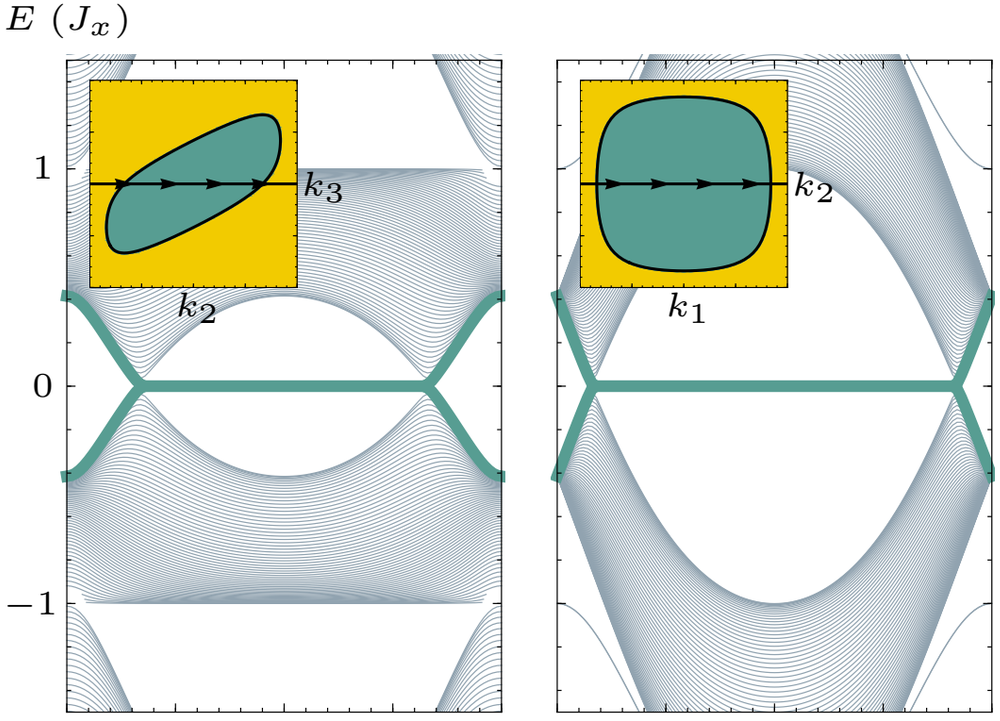
0-FLUX SECTOR
HYPERHONEYCOMB



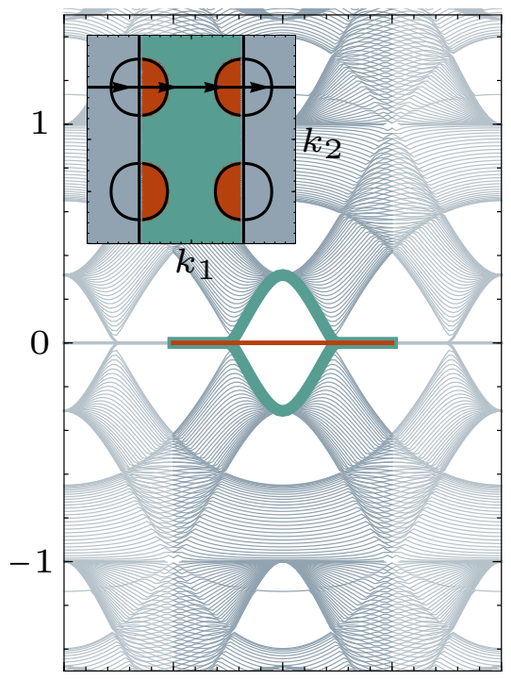
Surface Majorana States

π-FLUX SECTOR
STRIPYHONEYCOMB





(d) (100) surface (e) (001) surface



(g) (001) surface; $\delta = 1$

Strong Coupling Limit: Localized Pseudo-Spin Model

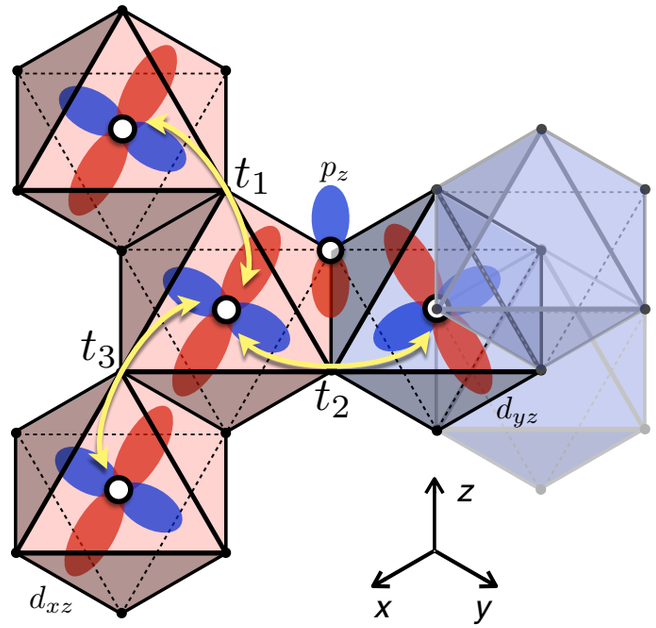
$$H = \sum_{\langle ij\rangle \in \alpha\beta(\gamma)} \left[J\vec{S}_i \cdot \vec{S}_j + KS_i^\gamma S_j^\gamma + \Gamma\left(S_i^\alpha S_j^\beta + S_i^\beta S_j^\alpha\right)\right]$$

e.g. In the limit of $U, J_H \gg \lambda \gg t$

$$J = \frac{4}{27}\left[\frac{6t_1(t_1+2t_3)}{U-3J_H} + \frac{2(t_1-t_3)^2}{U-J_H} + \frac{(2t_1+t_3)^2}{U+2J_H}\right]$$

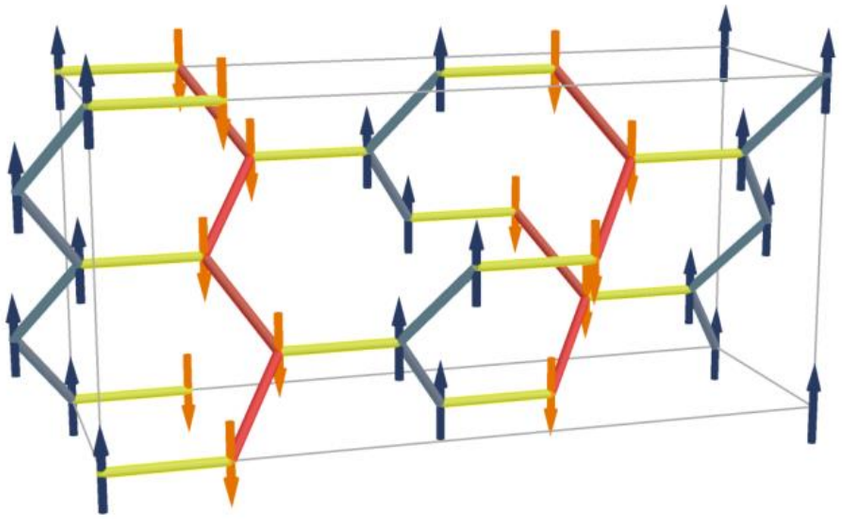
$$K = \frac{8J_H}{9}\left[\frac{(t_1-t_3)^2 - 3t_2^2}{(U-3J_H)(U-J_H)}\right],$$

$$\Gamma = \frac{16J_H}{9}\left[\frac{t_2(t_1-t_3)}{(U-3J_H)(U-J_H)}\right].$$

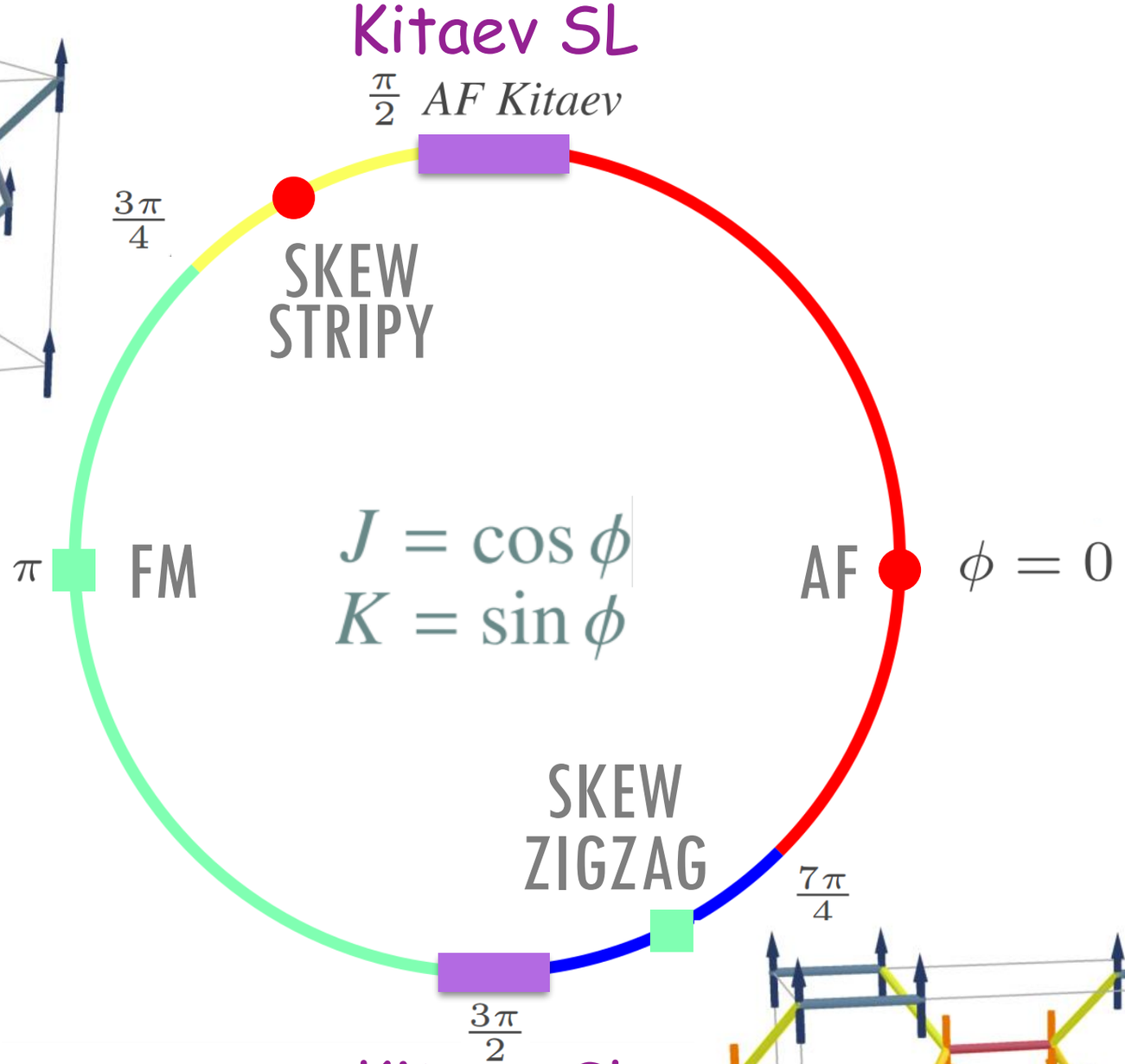


$$t_1 = \frac{t_{dd\pi} + t_{dd\delta}}{2}, \quad t_2 = \frac{t_{pd\pi}^2}{\Delta_{pd}} + \frac{t_{dd\pi} - t_{dd\delta}}{2}, \quad t_3 = \frac{3t_{dd\sigma} + t_{dd\delta}}{4},$$

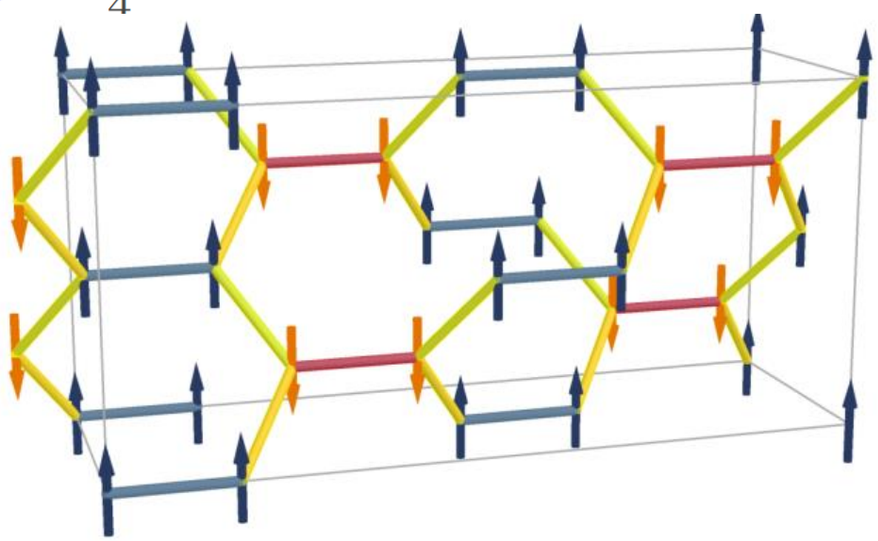
Heisenberg-Kiatev Phase Diagram



E. Lee,
R. Schaffer,
S. Bhattacharjee,
Y. B. Kim (2013)



$$H = \sum_{\langle ij \rangle \in \gamma} J\vec{S}_i \cdot \vec{S}_j + K S_i^\gamma S_j^\gamma$$

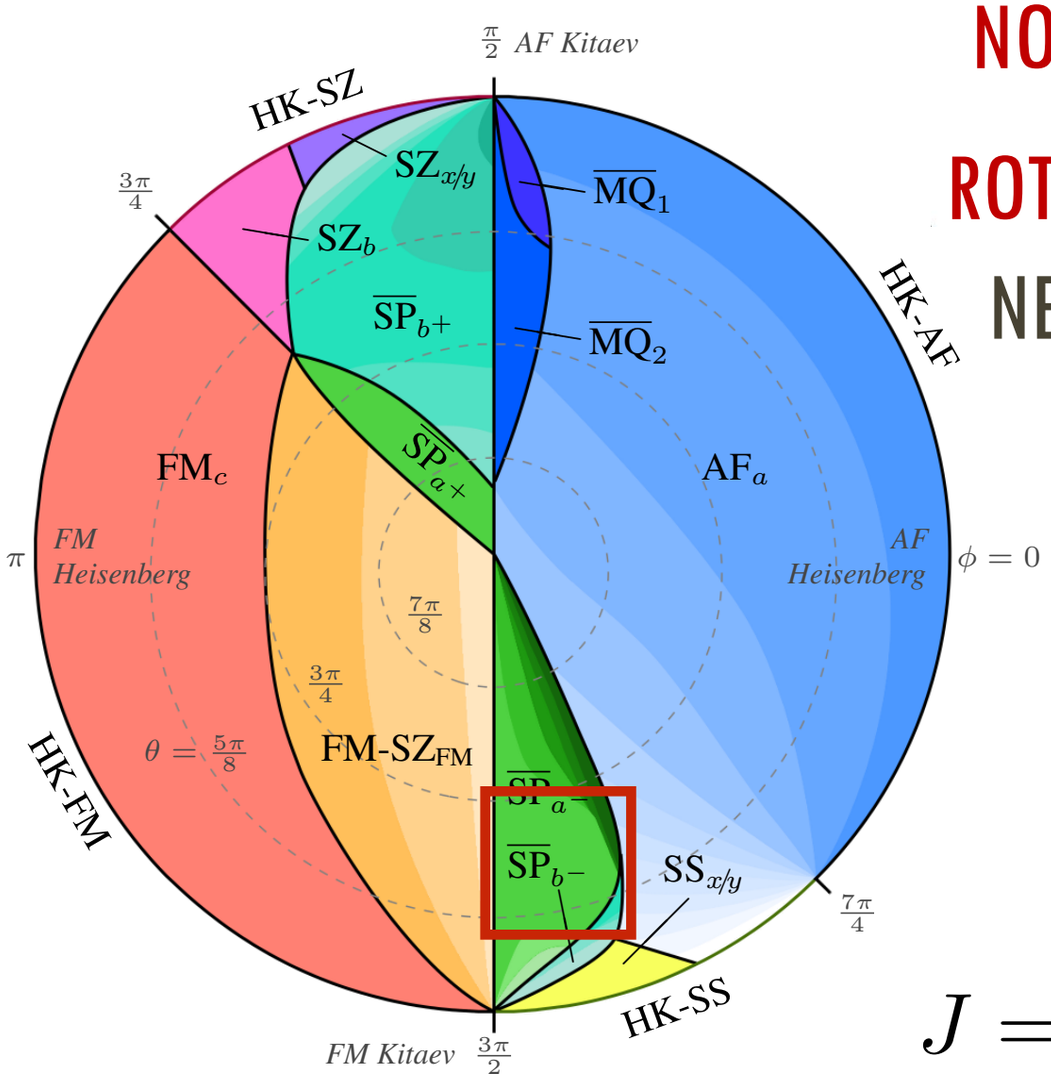


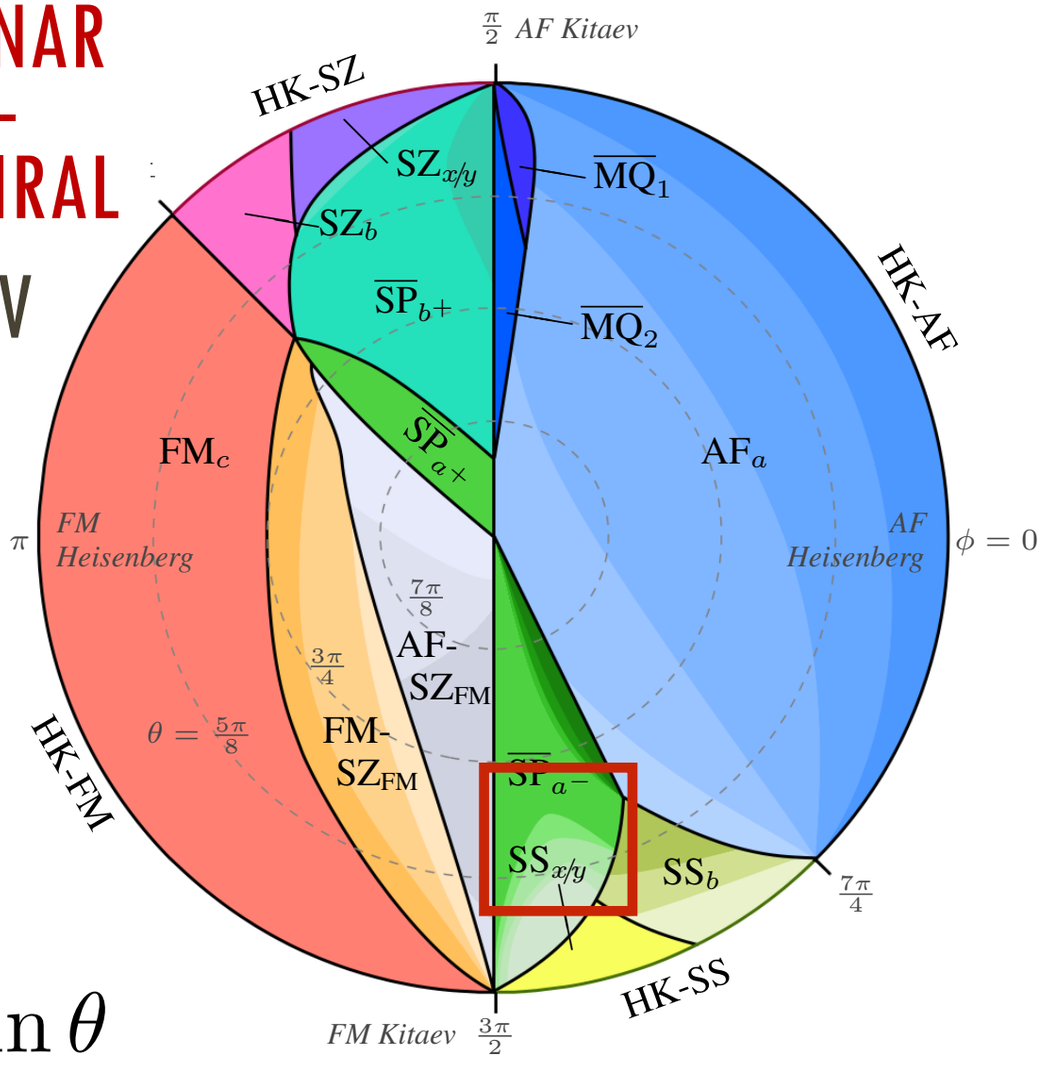
$$H = \sum_{\langle ij \rangle \in \alpha(\beta\gamma)} JS_i \cdot S_j + KS_i^\alpha S_j^\alpha + \Gamma^\alpha (S_i^\beta S_j^\gamma + S_i^\gamma S_j^\beta)$$

E. K.-H. Lee, Y. B. Kim (2014)

INCOMMENSURATE NON-COPLANAR COUNTER-ROTATING SPIRAL

NEAR KITAEV LIMIT





$$J = \cos\phi \sin\theta$$
$$K = \sin\phi \sin\theta$$
$$\Gamma = \cos\theta$$

HYPERHONEYCOMB

STRIPYHONEYCOMB