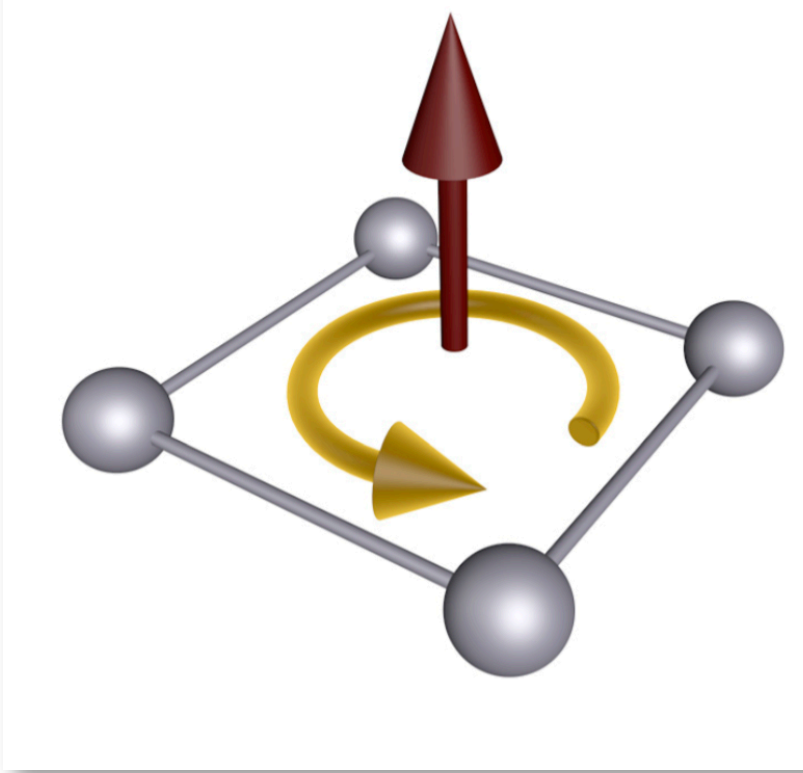
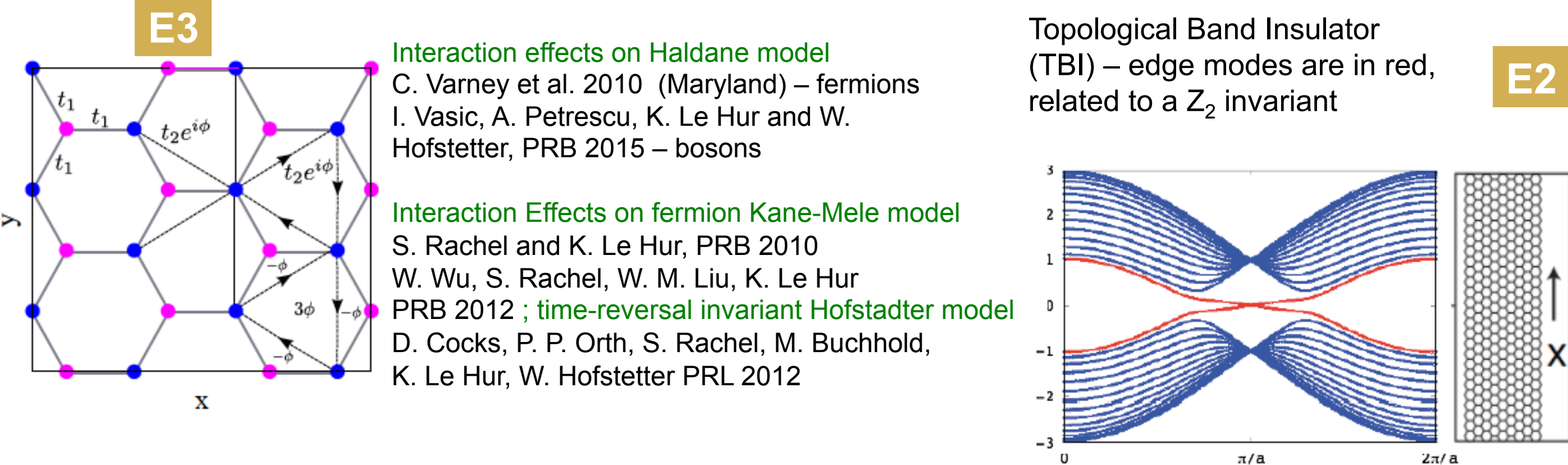




Introduction: Topology and some achievements

Bloch Band Topology : 2 “standard” models with artificial gauge fields

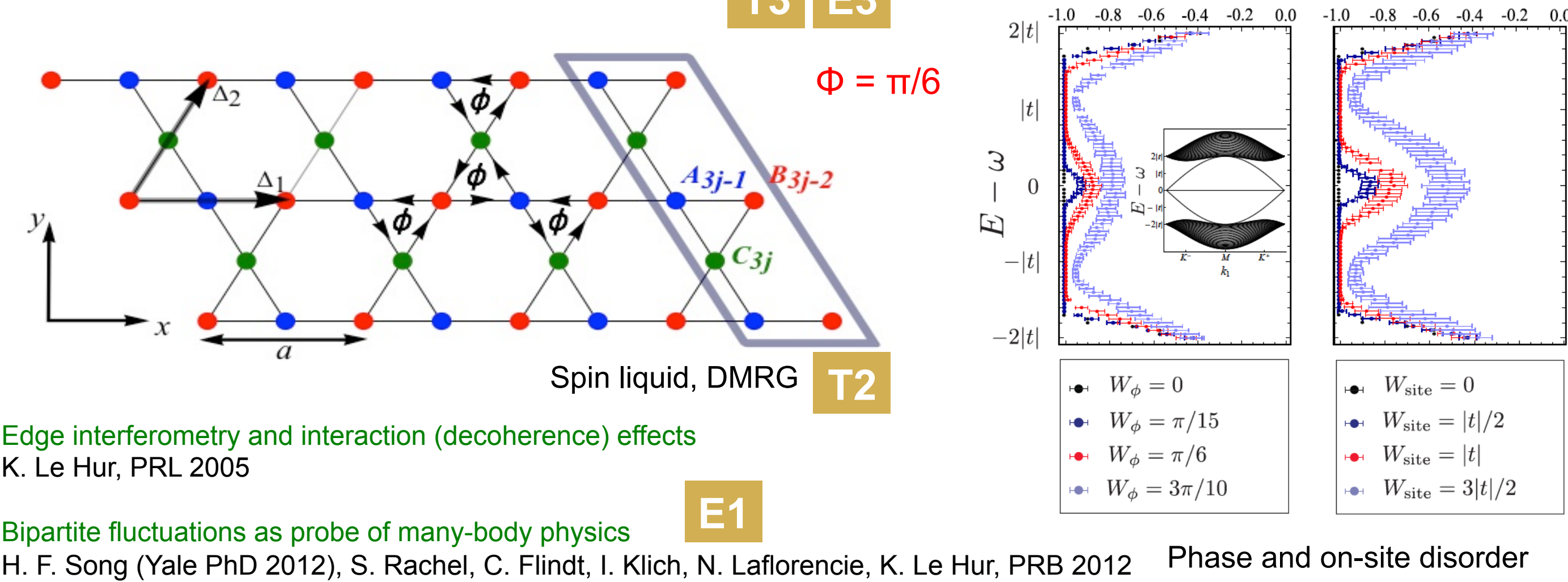
Haldane (1988) and Kane-Mele (2005) ; generalizing Harper, Azbel, Hofstadter points of view



$$\mathcal{H}_0 = \sum_i (-1)^i M c_i^\dagger c_i - \sum_{\langle i,j \rangle} t_1 c_i^\dagger c_j - \sum_{\langle\langle i,j \rangle\rangle} t_2 e^{i\phi_{ij}} c_i^\dagger c_j$$

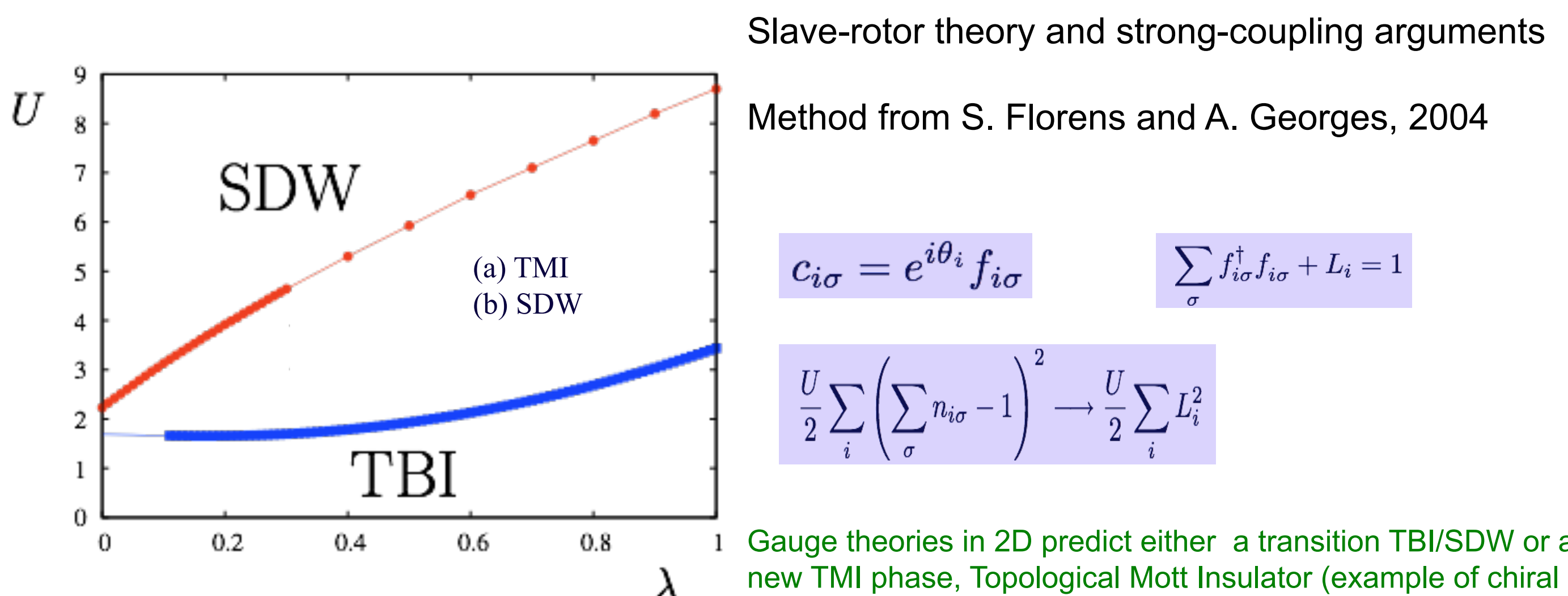
$$\mathcal{H} = -t \sum_{\langle ij \rangle \sigma} c_{i\sigma}^\dagger c_{j\sigma} + i\lambda \sum_{\langle\langle ij \rangle\rangle} \sum_{\sigma\sigma'} \nu_{ij} \sigma_{\sigma\sigma'}^\alpha c_{i\sigma}^\dagger c_{j\sigma'}$$

Haldane model on Kagome lattice : J. Koch, A. Houck, K. Le Hur, S.M. Girvin Phys. Rev. A 82, 043811 (2010)
Disorder effects on Chern number: A. Petrescu, A. Houck, K. Le Hur PRA (2012)
(relevant for study of inhomogeneities or interfaces)



Topic 1: Topology and Interactions, Fermions

Goals: Engineering the spin-1/2 Kane-Mele Hubbard model and beyond (synthetic dimensions)



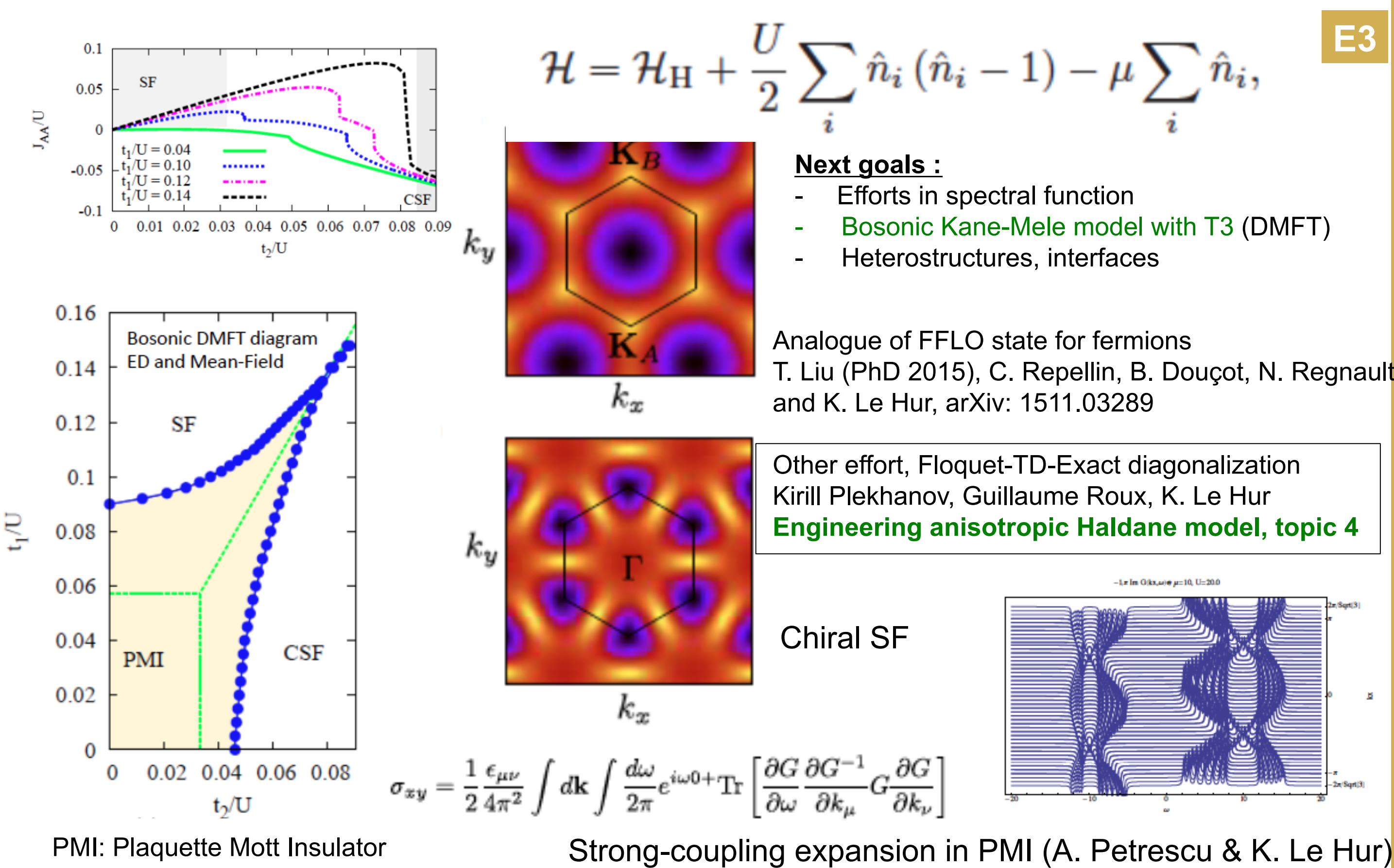
S. Rachel and K. Le Hur PRB 2010
As of September/October 2015, this highly cited paper received enough citations to place it in the top 1% of the academic field of Physics based on a highly cited threshold for the field and publication year.

See also S.S. Lee & P. Lee PRL 2005
Young, S. S. Lee, C. Kallin, PRB 2008
Pesin & Balents, Nat. Phys. 2010

Topic 2: Chiral Bosonic Systems in 2D

Bosonic Haldane model with Interactions

Ivana Vasic, Alexandru Petrescu, Karyn Le Hur and Walter Hofstetter, PRB 91, 094502 (2015)

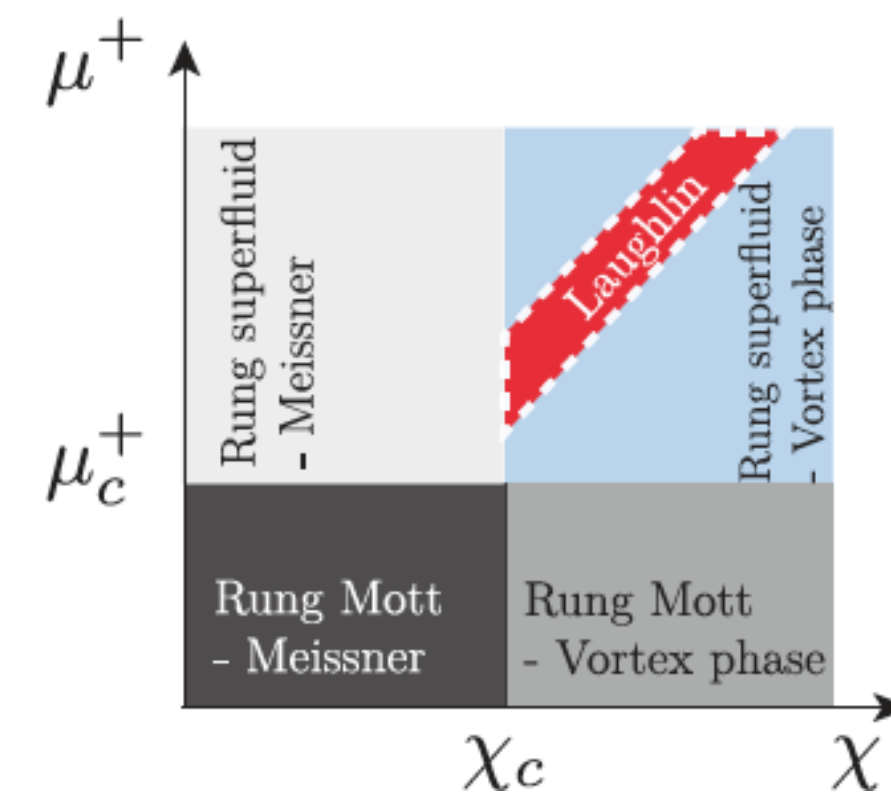


Topic 3 : Ladder Systems

Bosonic Quantum ladders and Mixtures

E1 **T2** **T5**

M. Atala, M. Aidelsburger, M. Lohse, J. T. Barreiro, B. Paredes, I. Bloch
Nature Physics 10, 588 (2014).



ED results

$$\theta_y = iP / iQ \times 2\pi$$

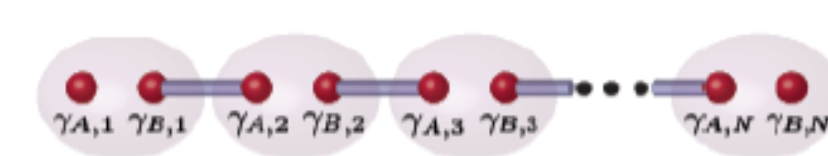
$$C = \frac{1}{N_{\text{deg}}} \times \frac{1}{2\pi} \int_0^{2\pi} d\theta_x \partial_{\theta_x} \text{Im} \log \det \hat{W}(\theta_x) = \varphi_W$$

DMRG efforts with T2: A. Petrescu, M. Piraud, I. McCulloch, G. Roux and K. Le Hur
Computation of bipartite fluctuations, entanglement entropy, currents/densities, vortex observables

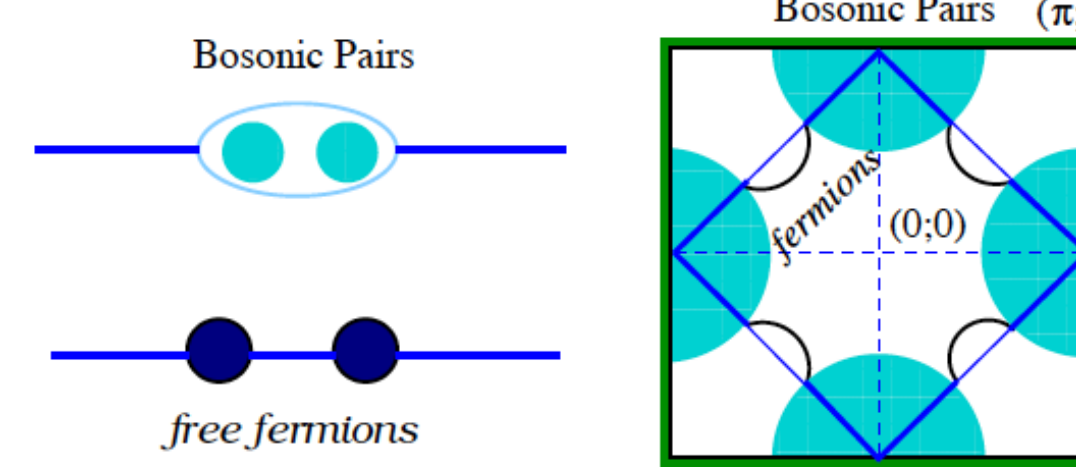
Engineering topological superfluids and Majorana ladders

T5

Floquet engineering: A. Potter, T. Morimoto, A. Vishwanath 2016
C. Bardyn, M. A. Baranov, C. V. Kraus, E. Rico, A. Imamoglu, P. Zoller, S. Diehl 2013

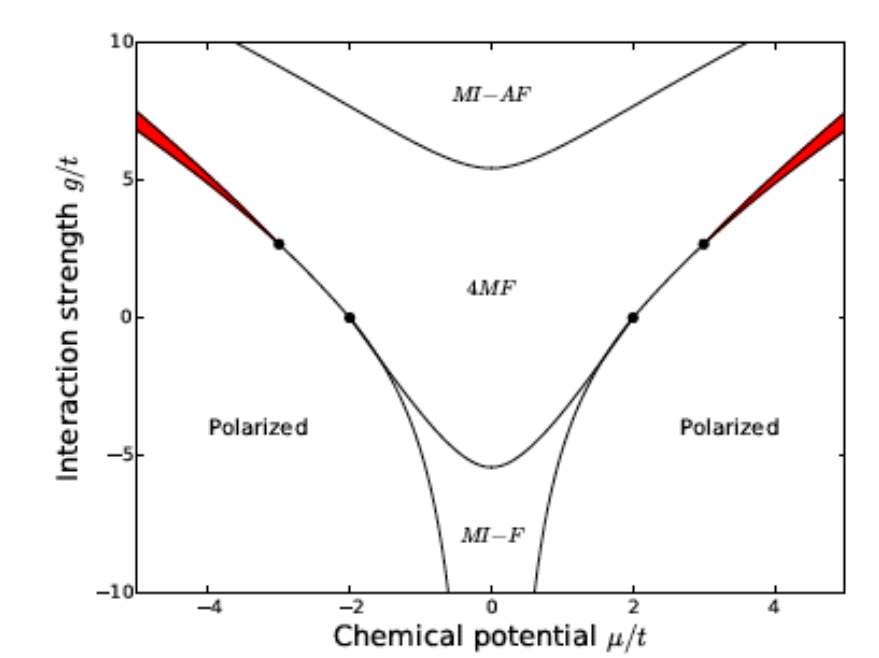


Bath (1D BEC) with preformed pairs



spinful fermion case: K. Le Hur, PRB 64, R060502 (2001)
Review K. Le Hur & T. M. Rice Annals of Physics (2009)

Robustness with interactions g between 2 chains



L. Herviou, C. Mora, K. Le Hur, arXiv:1601.02998

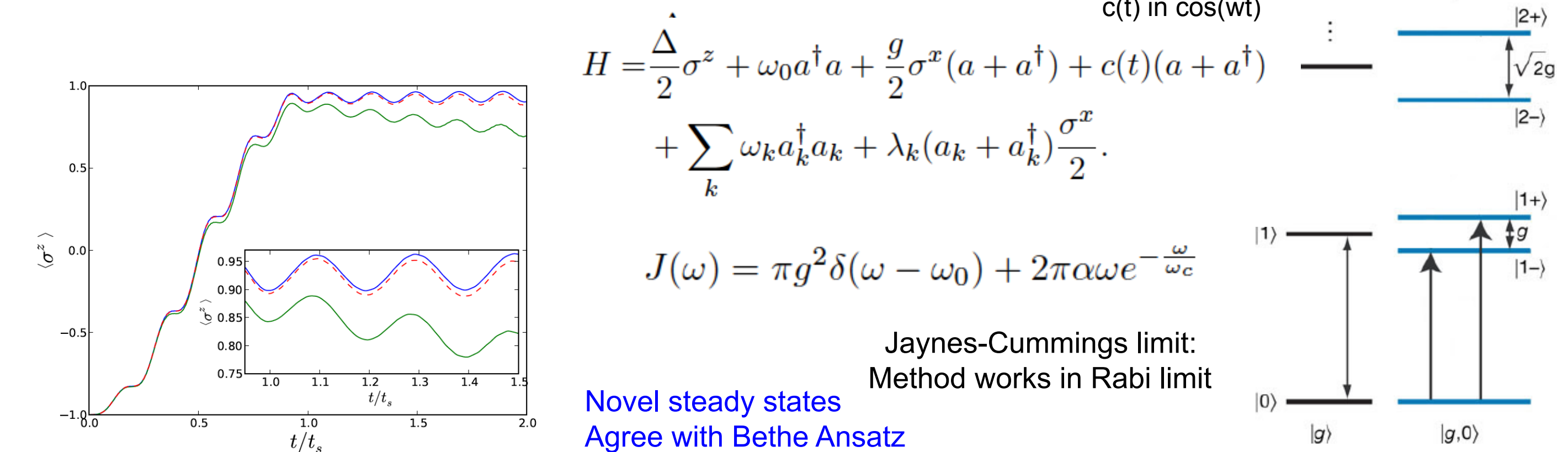
Topic 4 : Time-dependence and Interactions

Goals: Treat time-dependent interacting Hamiltonians and compare with « Floquet » phase diagram

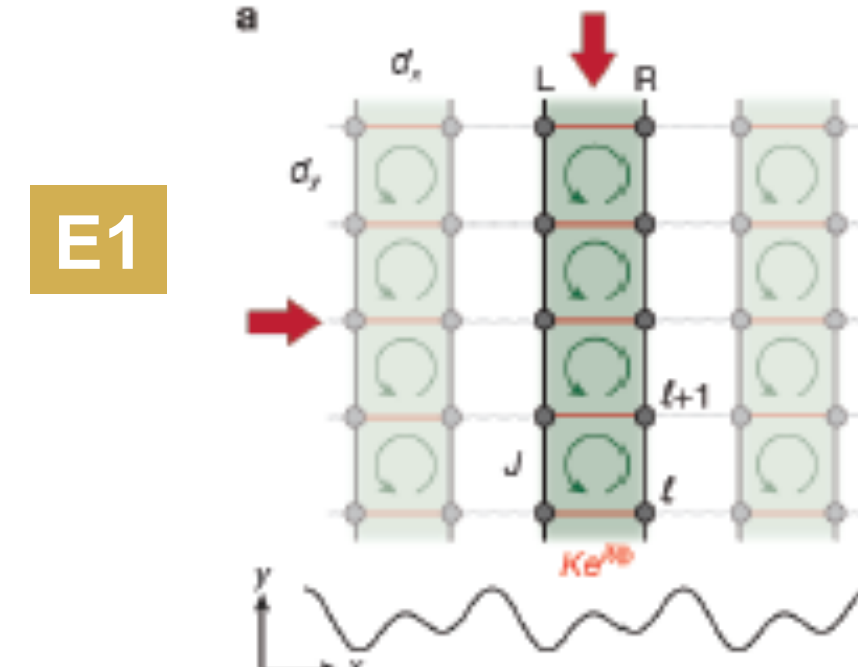
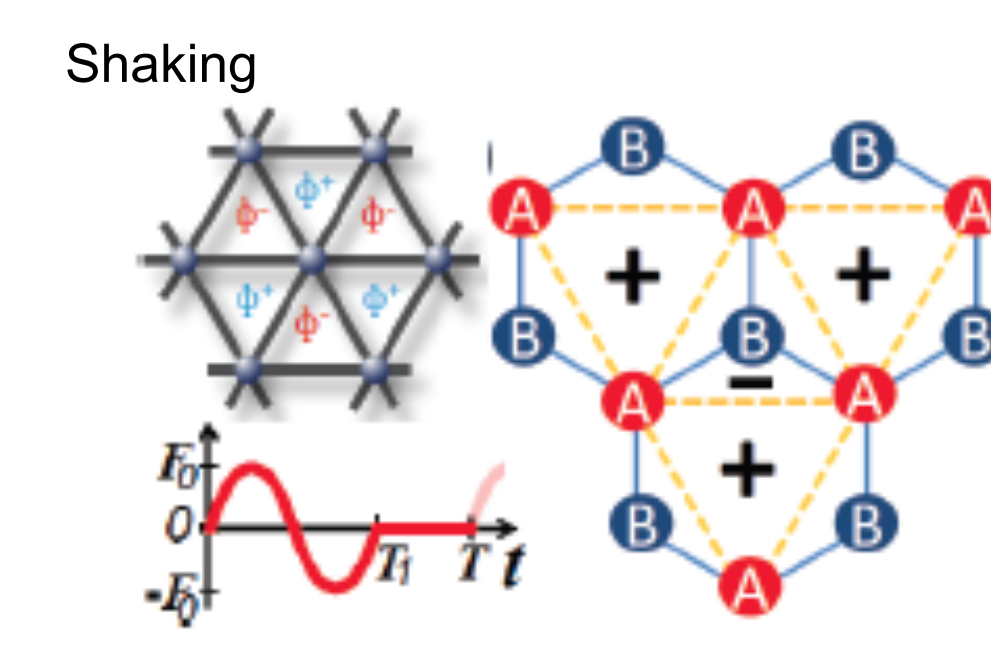
Exact Stochastic Schrodinger equation approach for periodic time-dependent Hamiltonians

P. P. Orth (PhD 2011, Yale), A. Imambekov, K. Le Hur 2010, 2013 - see supplement
L. Henriet (PhD 2016 X), Z. Ristivojevic, P. P. Orth, K. Le Hur 2014

Applications quenches, Landau-Zener interferometry and Ramsey interferometry



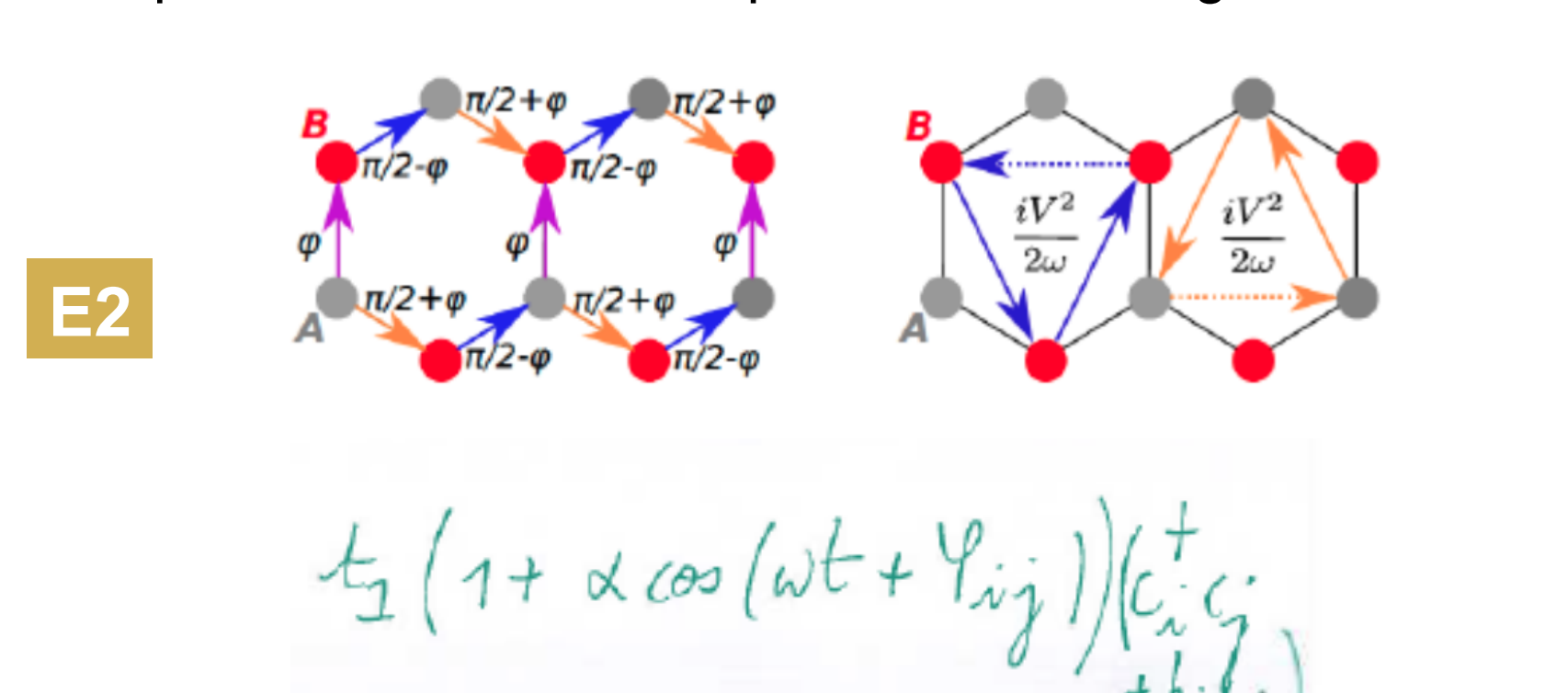
Current application: Haldane model coupled to BEC (decoherence effects on Berry phase)
Loic Henriet, Antonio Sclocchi, Karyn Le Hur



Laser-assisted

Engineering anisotropic Haldane model

Floquet+bosonization, Floquet-TD-exact diagonalization



Floquet

$$\hat{U}(T, t_0) = \mathcal{T} e^{-i \int_{t_0}^{t_0+T} \hat{H}(t) dt} = e^{-iT \hat{H}_{\text{eff}}(t_0)}$$

Dissipation, decoherence in interacting ladders: analogy to double-well Josephson (rung) coupled to a BEC ;
not unitary evolution

Complementary approach Floquet+Keldysh+DMFT with T3

T3