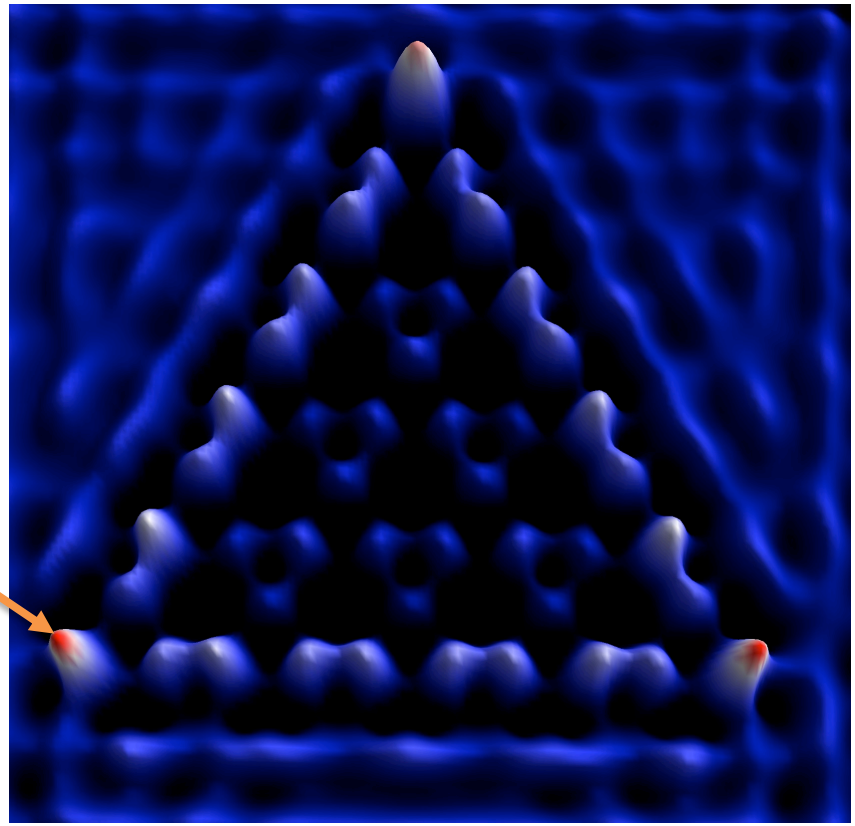
Cornering the zero-mode
Designing a HOTI

Sander Kempkes

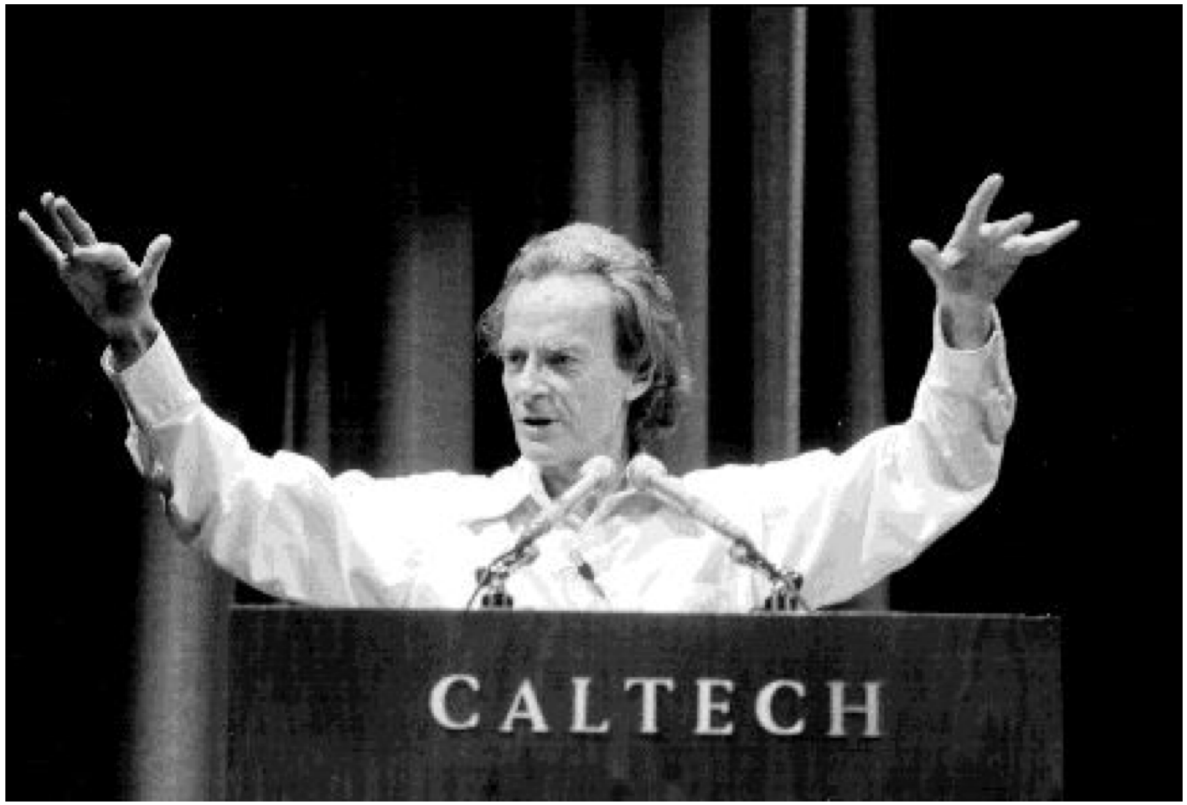
Universiteit Utrecht

Protected corner mode
in dimerized Kagome lattice



Artificial lattices - Feynman's legacy

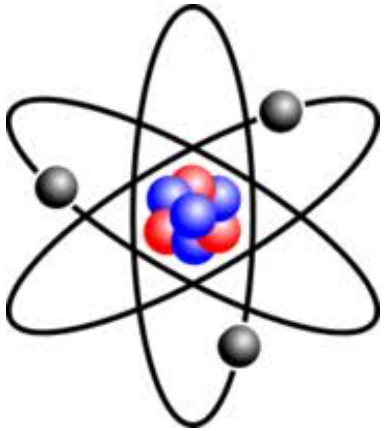
There's plenty of room at the bottom



Richard Feynman
Nobel Prize winner
1918-1988

Cold atoms in optical lattices and photonic systems have been intensively studied as quantum simulators

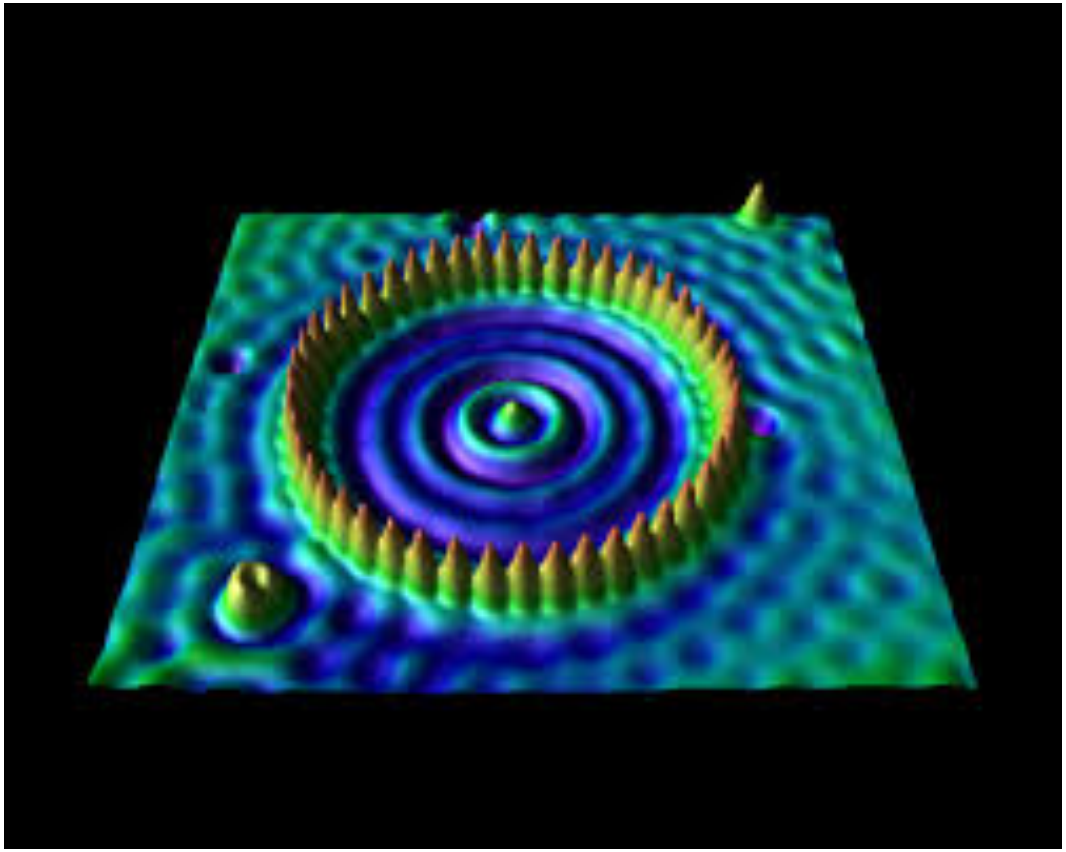
But in these fields there are atoms or photons, no electrons….



How to build quantum simulators with electrons???

Use surface states of metals like Copper (Cu)

Quantum corrals



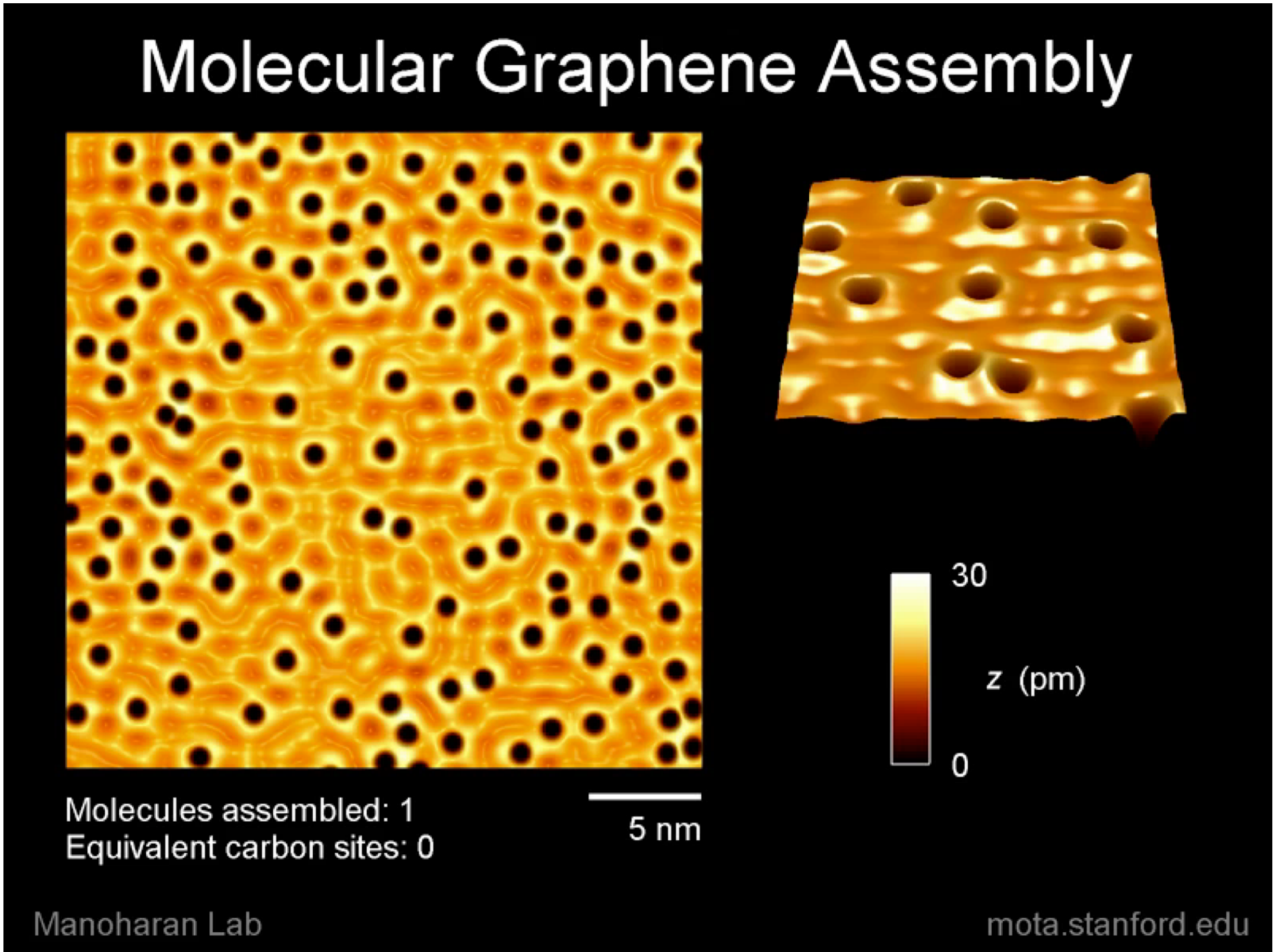
Don Eigler group, Science 262, 218 (1993)

Fe on Cu(111)

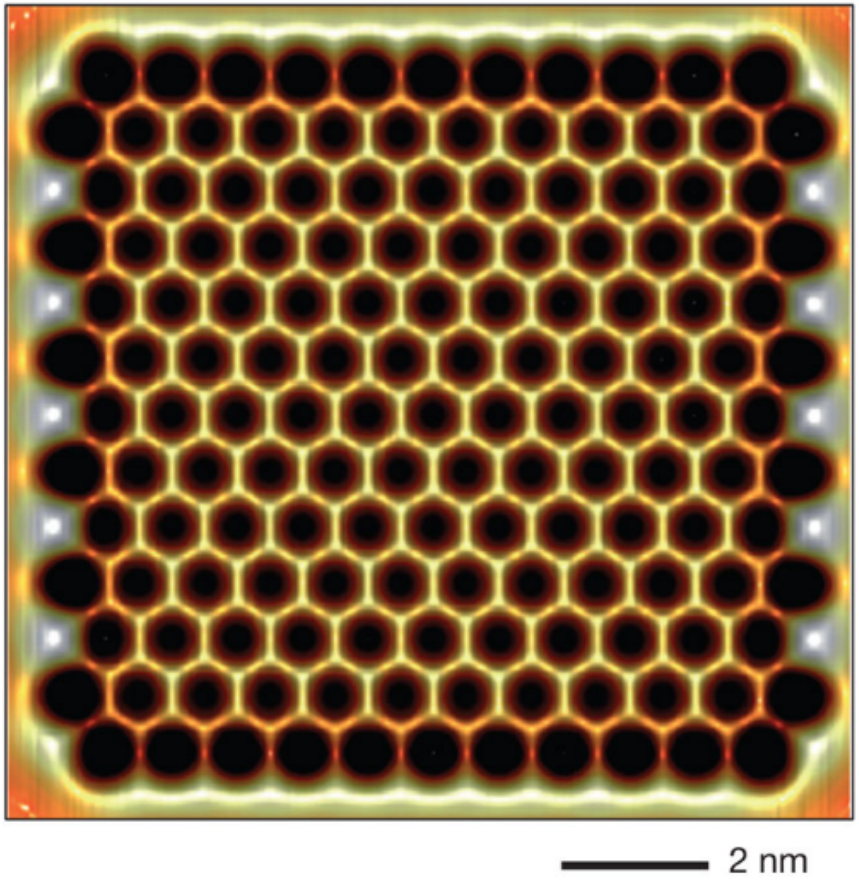
Manoharan group Stanford

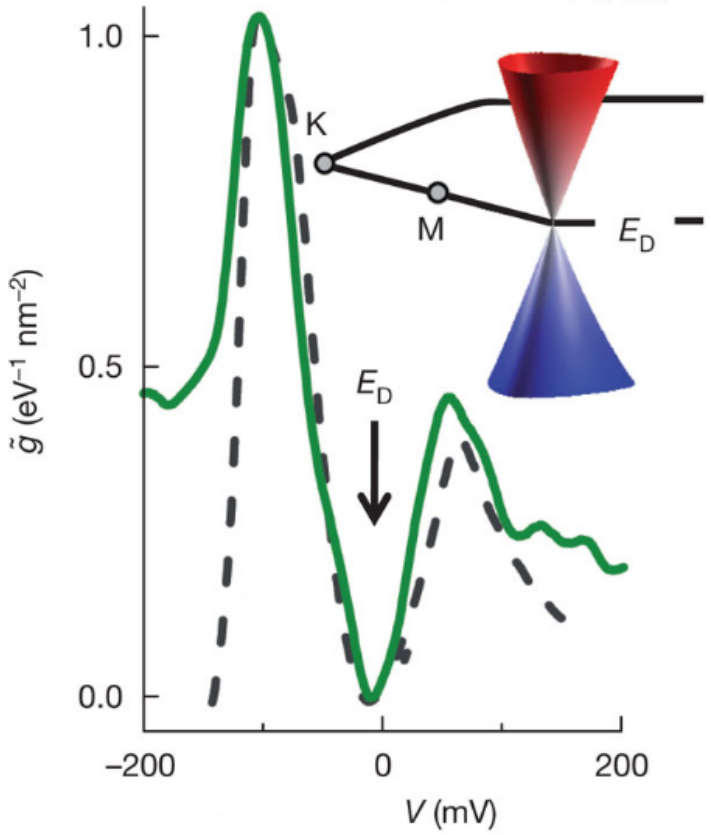
CO on Cu

Gomes *et al.*, Nature 483 (2012)



Artificial graphene

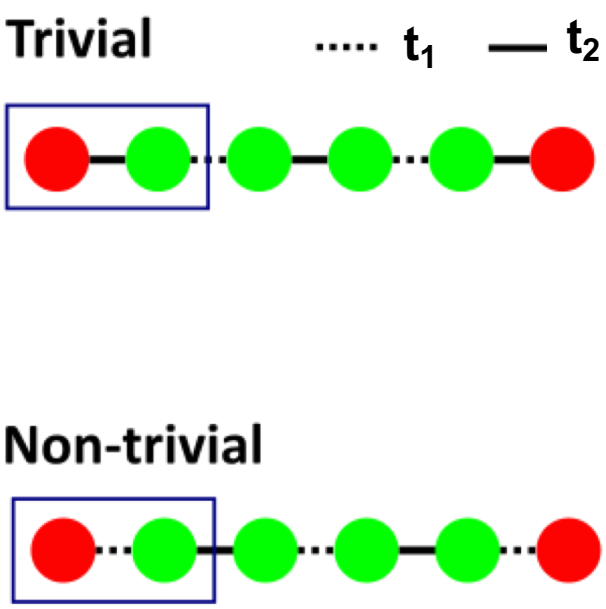


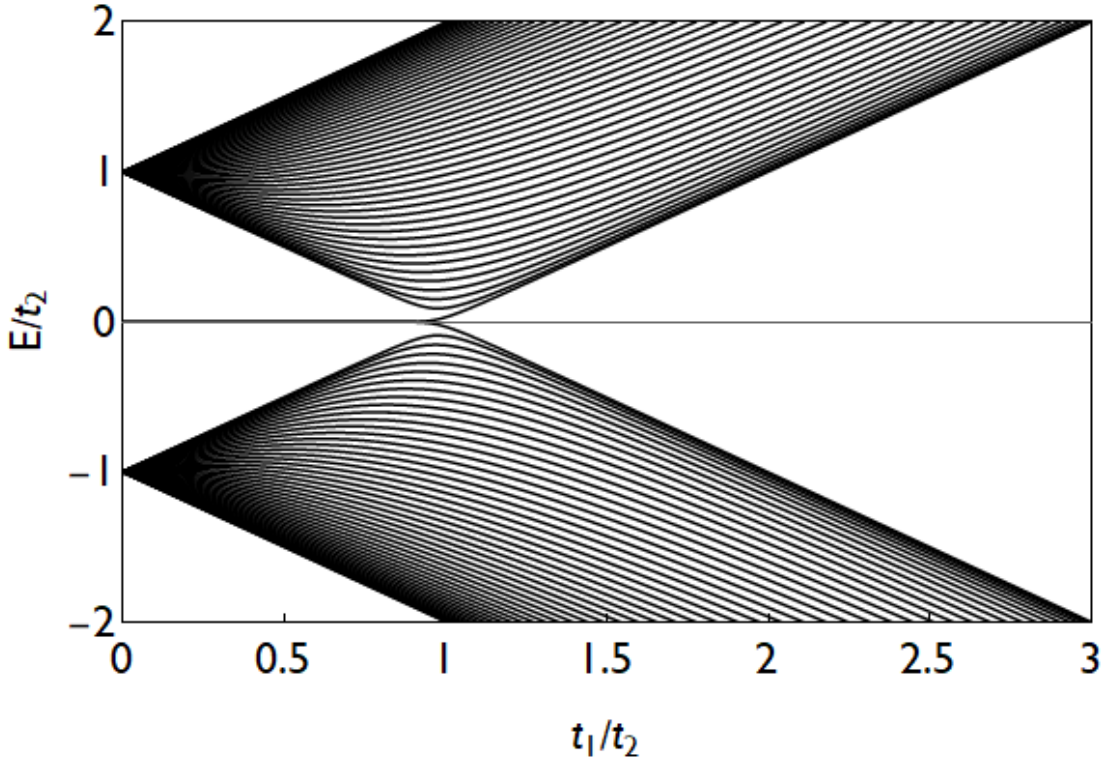


Gomes *et al.*, Nature 483 (2012)

How to design a HO(TI) in this experiment?

The SSH model





Zero modes protected by chiral symmetry

$$H_1 + H_2 = 0$$
$$\Gamma^{-1} H_1 \Gamma = H_2 \longrightarrow \Gamma^{-1} H \Gamma = -H$$

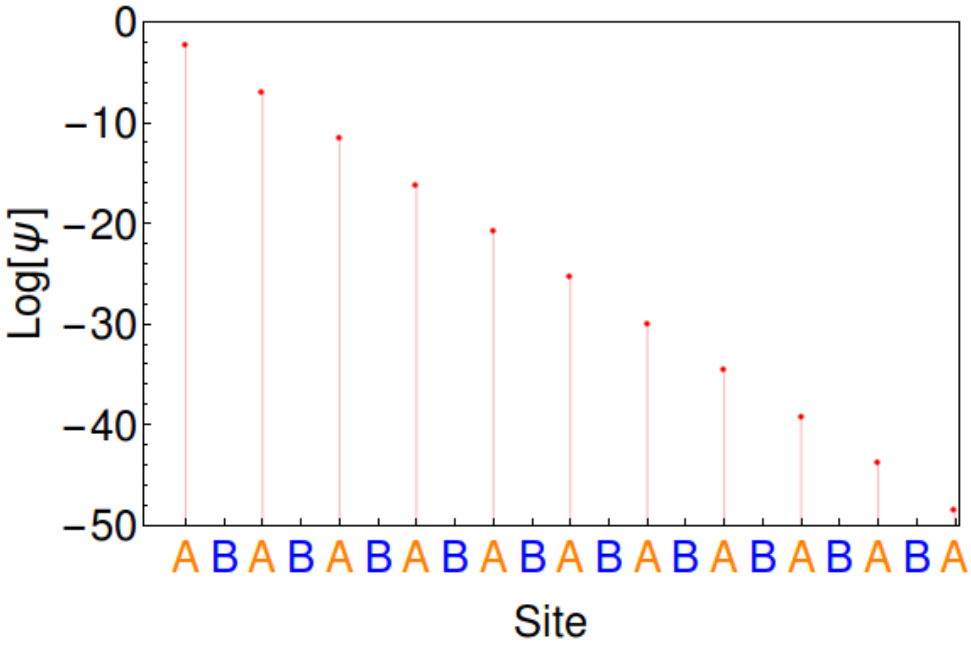
Always two eigenfunctions with eigenvalues + E and -E

$$H|\Psi\rangle = E|\Psi\rangle$$
$$H\Gamma|\Psi\rangle = -\Gamma H|\Psi\rangle = -E\Gamma|\Psi\rangle$$

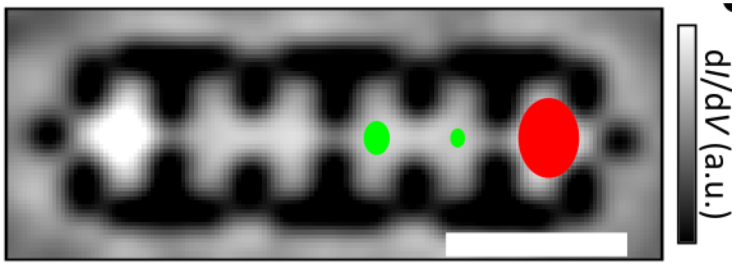
Now if E=0, $H|\Psi\rangle = \Gamma H|\Psi\rangle = 0$

Which means the wavefunctions have full support on only one sublattice

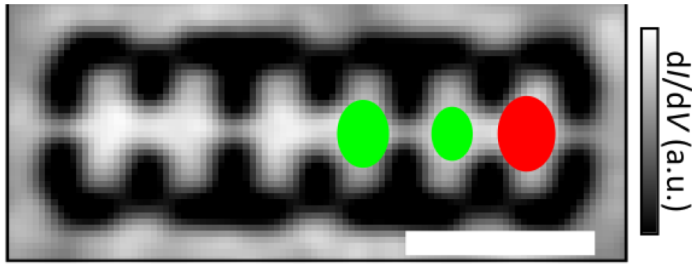
Exponential localization on only one sublattice



Experiment



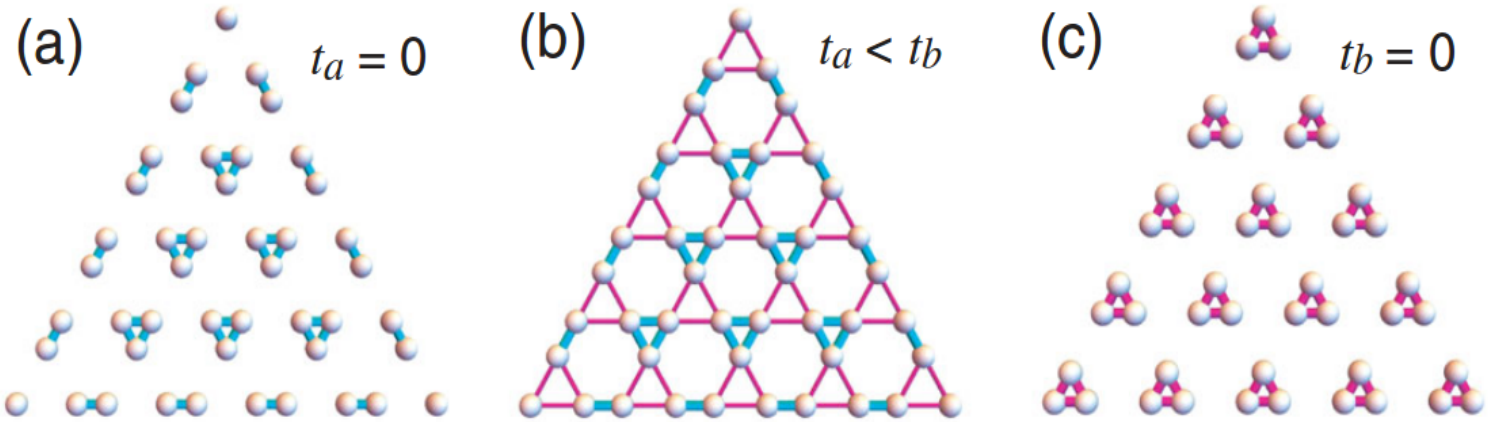
Topological phase



Trivial phase

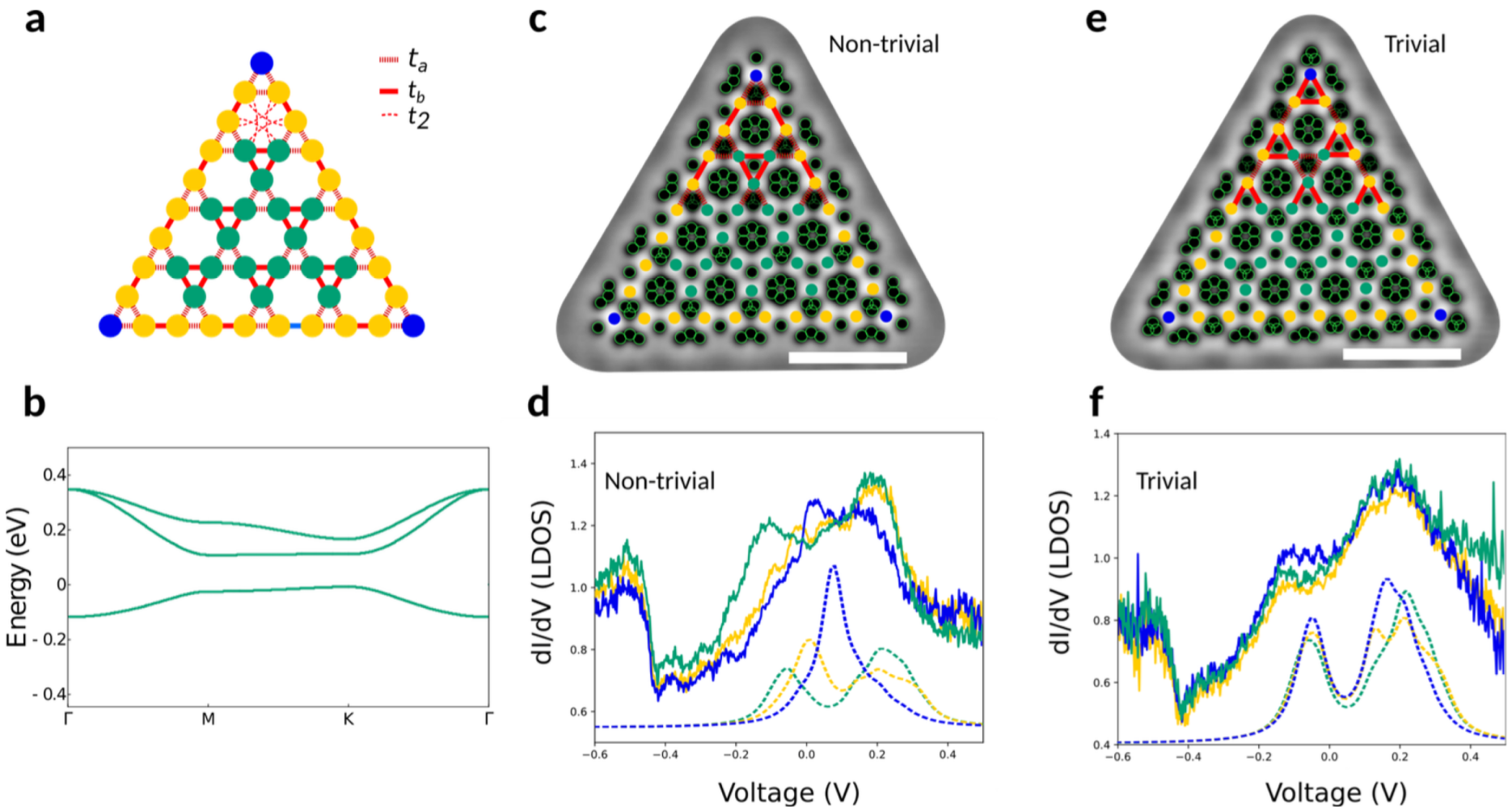
A higher-order TI

- “Breathing” Kagome lattice (strong/weak bonds)



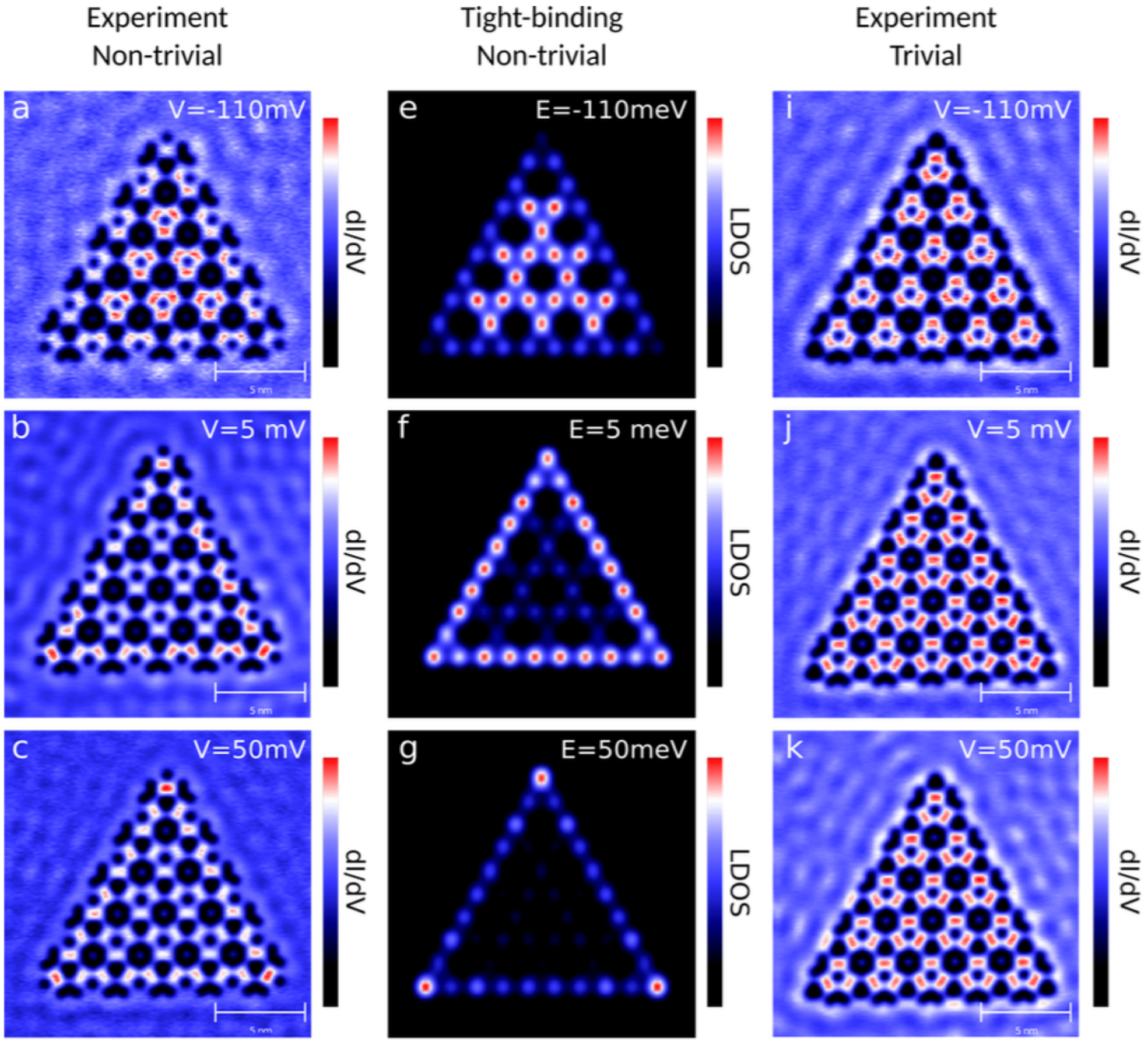
Ezawa, PRL **120,** 026801 (2018)

Design Kagome lattice



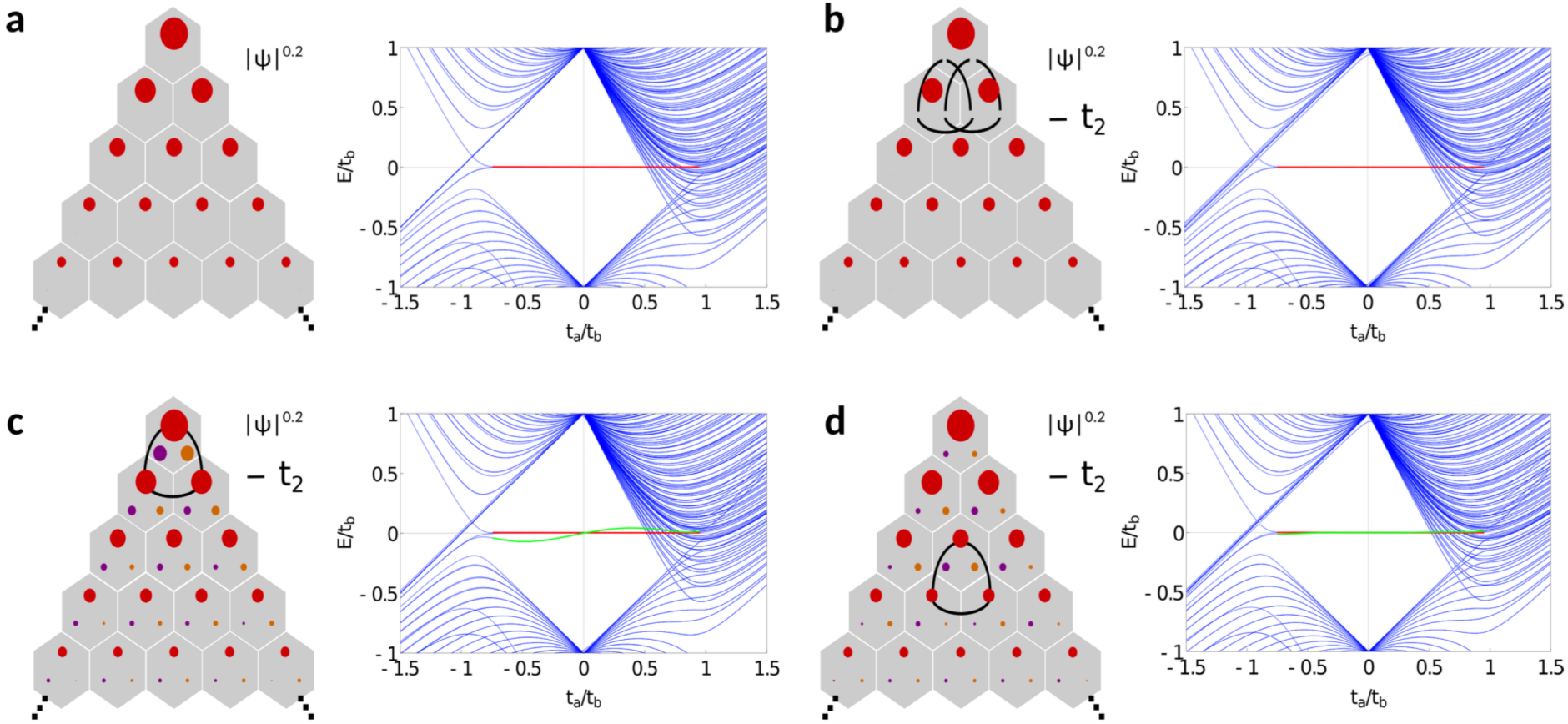
S. Kempkes, M. Slot et al, unpublished (2019)

LDOS Maps

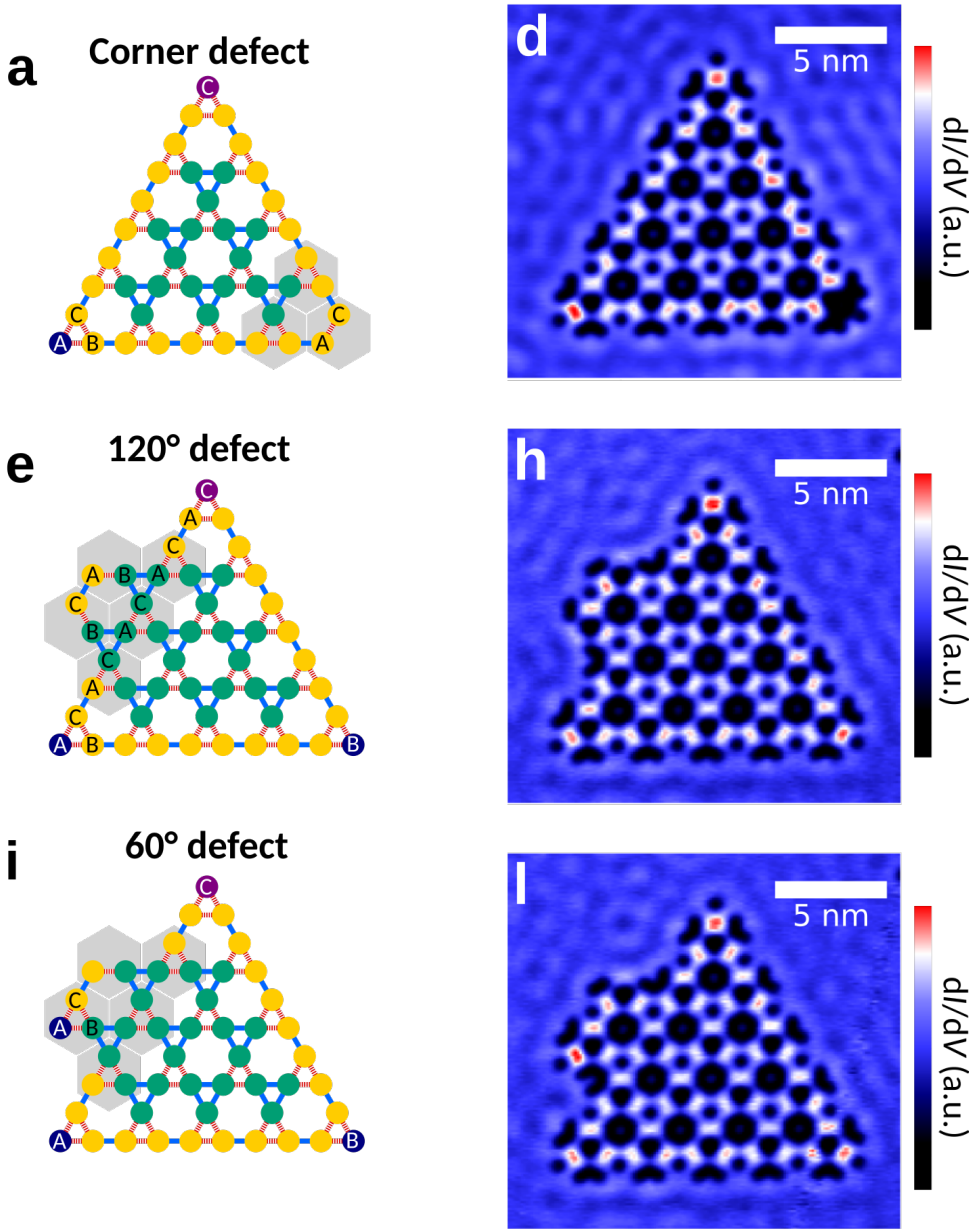

Experiment
Non-trivial
Tight-binding
Non-trivial
Experiment
Trivial
a
V=-110mV
dI/dV
e
E=-110meV
LDOS
i
V=-110mV
dI/dV
b
V=5 mV
dI/dV
f
E=5 meV
LDOS
j
V=5 mV
dI/dV
c
V=50mV
dI/dV
g
E=50meV
LDOS
k
V=50mV
dI/dV

Who is protecting the zero mode?

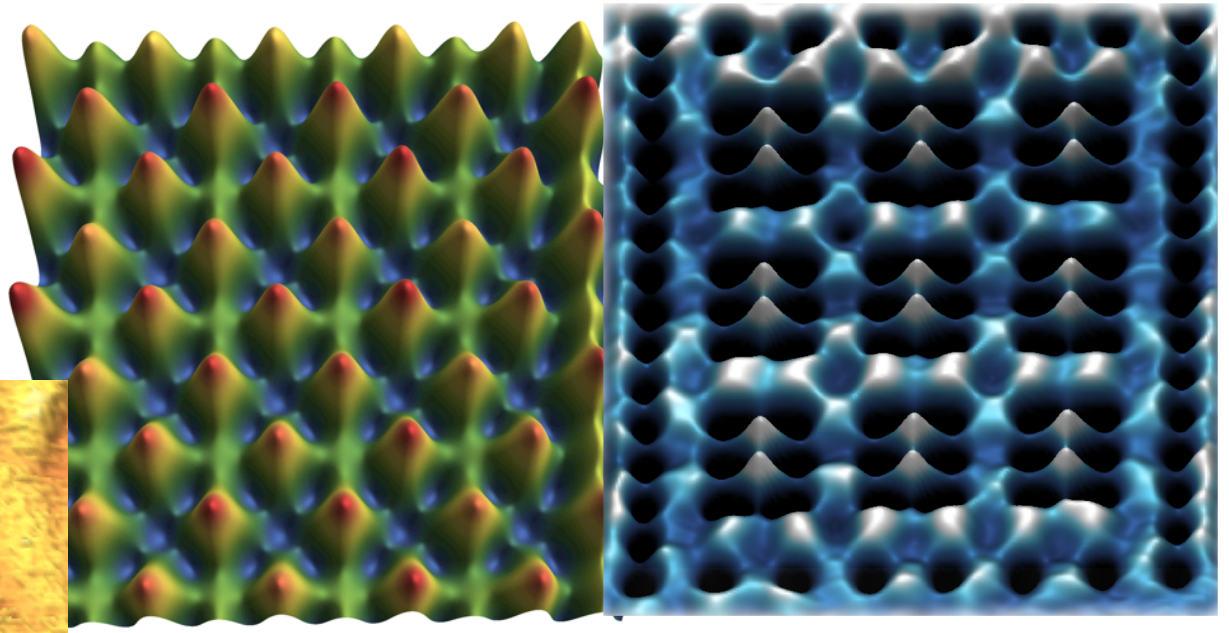
A generalized chiral symmetry



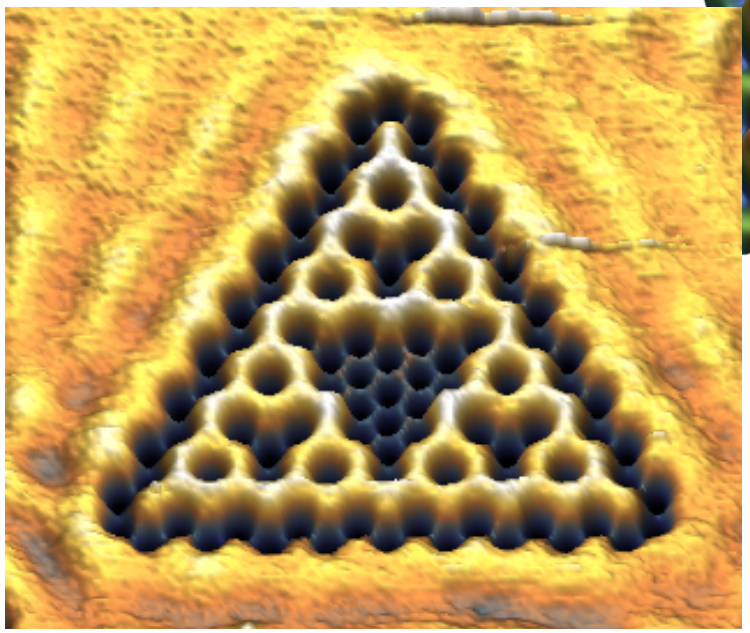
Robust zero modes



Other work



Orbital degree of freedom in articifial Lieb lattice



Electrons in fractal dimensions

Conclusions

- Experimentally built a topological Kagome
- LDOS measured agrees very well with muffin-tin and tight-binding calculations
- Novel type of topology protecting mechanism
- Fractionalization of charge

Collaborators

Cristiane de Morais Smith

Daniel Vanmaekelbergh

Ingmar Swart

Jette van de Broeke

Marlou Slot

Dario Bercioux

Wladimir Benalcazar