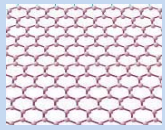
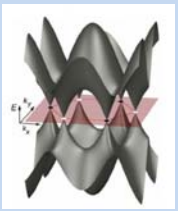
Control photonic edge states in honeycomb lattice

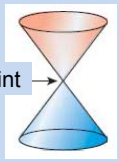
Chunfang Ouyang, Biqin Dong, Tianrong Zhan, Xinhua Hu, Xiaohan Liu and Jian Zi

Surface Physics Laboratory and Department of Physics, Fudan University, Shanghai 200433, People's Republic of China

Graphene

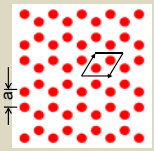




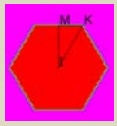


2D gas of massless Dirac fermions in graphene

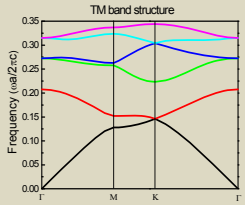
Photonic crystal



Cylinders in air



Brillouin zone



2D honeycomb lattice and band structures

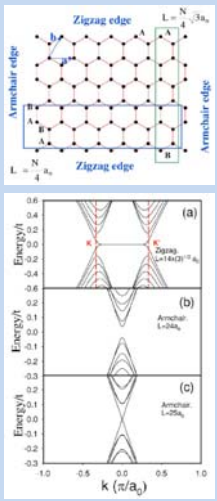
Edge States in Graphene

Graphene ribbon
period: a_0
width: L

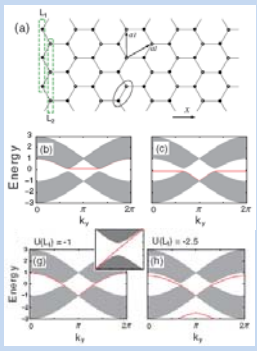
Zigzag edge dispersionless, localized states

Armchair edge insulating
$L \neq (3M+1)\, a_0$

Armchair edge metallic
$L = (3M+1)\, a_0$



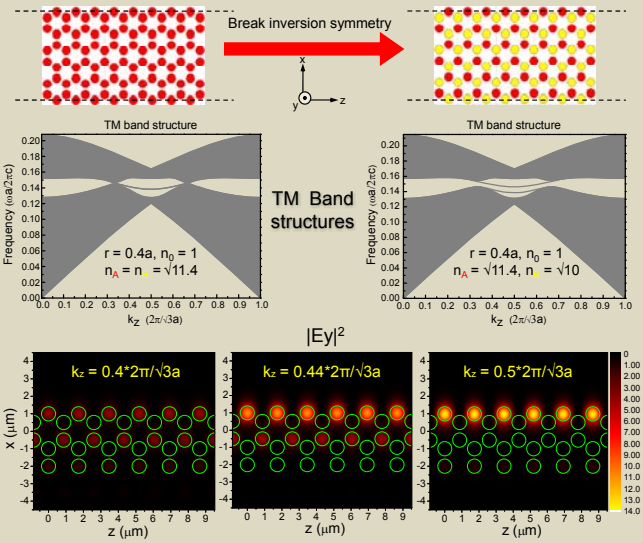
L. Brey *et al. PRB 73, 235411 (2006)*



A staggered sublattice potential $\Delta/2 = 0.1$ is applied throughout the sheet.
Edge bands dispersion can be controlled by tuning the on-site energies $U(L_1)$ of the outermost column L_1.
The gapless edge states usually reflect nontrivial topological orders in the bulk.

W. Yao *et al. PRL 102, 096801 (2009)*

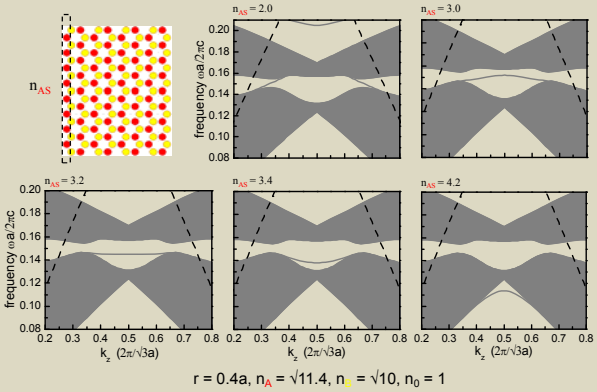
Edge states in honeycomb lattices with zigzag edges



The more closer to $k_z = \pi/\sqrt{3}a$, the more stronger localized field.

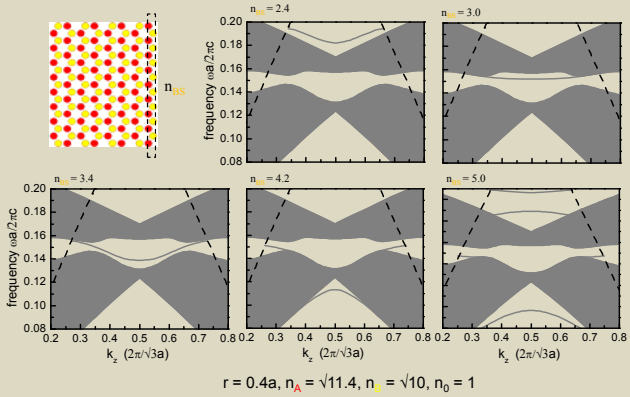
Edge states in honeycomb lattice: from gapped flat band to gapless modes

Edge states on the left boundary



r = 0.4a, n_A = √11.4, n_B = √10, n_0 = 1

Edge states on the right boundary



r = 0.4a, n_A = √11.4, n_B = √10, n_0 = 1

The edge states near $k_z = \pi/\sqrt{3}a$ are almost completely localized on the outmost rods while those near the two Dirac points are much more spread into the bulk.

Edge band dispersion can be controlled by varying the properties (refractive index or radius) of sites on the boundary, and the two edge bands can be controlled respectively.

Conclusions

- Investigate edge states in honeycomb lattices including gapped flat band and gapless modes, which is similar with edge states in graphene.
- We find that the edge-band dispersion can be continuously changed by simply tuning the on-site properties on the boundary of the system.
- These gapless edge-states should reflect non-trivial topological orders in the bulk, which is the very case in graphene.

Fudan PBG Group