Topological Two-Dimensional Polymers: a chemistry way towards quasiparticle physics

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Quasiparticles and collective excitations have been in the focus of condensed matter physics of the past decades. Their in-depth exploration has led to a significantly better understanding of the nature of matter in a quite general sense, beyond the boundaries of the materials-oriented disciplines. Following Carlo Beenakker, by taking "what nature offers" and to deeply explore the intriguing physics inherent to known and newly developed materials has led to the discovery and ultimately the deliberate control of many exotic phenomena, including topological insulators, Majorana fermions, skyrmions and polaritons, to name just a few. The impact of this research is not restricted to condensed matter physics or the related emerging field of quantum materials, it indeed drives our very fundamental understanding of matter.
In my talk I will demonstrate a path beyond "what nature offers", extending the realm of quantum materials to "what is mathematically possible and chemically feasible". I will show that the proper and precise arrangement of molecular building blocks in regular lattices, linked together by strong bonds with controlled electronic interactions [1], opens the door to advance electronics and optoelectronics, to manifest exotic physics with Dirac points and flat bands [2] (Figure 1), and to establish new chemical concepts that allow us to face current global challenges. I will bridge our work on two-dimensional semiconductors to the rather novel class of crystalline two-dimensional polymers, a materials class that relies solely on the compounds of organic chemistry, and thus is abundant, non-toxic and potentially bio-compatible.

References

[1] M. A. Springer, T.-J. Liu, A. Kuc, T. Heine, Chem. Soc. Rev. 49 (2020) 2007-2019.
[2] Y. Jing and T. Heine, Nature Materials, 19 (2020) 823–829.

Figures

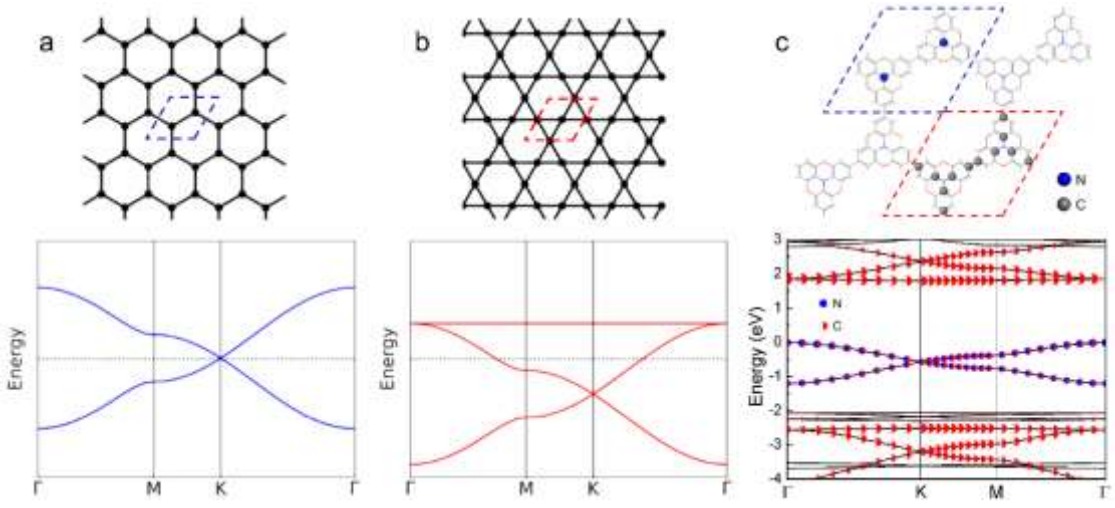

Figure 1: Tight-Binding band structure of the (a) honeycomb and (b) the kagome lattice. (c) Atomistic band structure (DFT) calculated for a honeycomb-kagome polymer based on heterotriangulenes.