Mullen, Uchoa, and Glatzhofer Reply:

Kieran Mullen, Bruno Uchoa, and D. T. Glatzhofer

Phys. Rev. Lett. **116**, 249702 — Published 17 June 2016

DOI: 10.1103/PhysRevLett.116.249702

Response to Comment on "Line of Dirac Nodes in Hyper-Honeycomb Lattices"

Kieran Mullen,[1, *] Bruno Uchoa,[1] and D. Glatzhofer[2]

[1] *Homer L. Dodge Department of Physics and Astronomy, The University of Oklahoma, Norman, Oklahoma 73069, USA*

[2] *Department of Chemistry and Biochemistry, The University of Oklahoma, Norman, Oklahoma 73069, USA*

We are as interested as the the commenters [1] about the possibility of observing a Dirac loop in a real physical system. In our work [2] we showed a simple class of lattice models that possess a Dirac loop at theier Fermi level and detailed some of the physical consequences of that loop, such as the possibility of a 3D anomalous Hall effect and topological surface states in the presence of spin-orbit coupling. nodal lines . It is remarkable that these loops can occur in simple hyper-honeycomb lattices.

Soon after publication, we did a series of density functional calculations on the family of the hyperhoneycomb structures, as well as other families of lattices that are three dimensional but possess planar trigonal connectivity between sites [3]. The Dirac loops are present in all $\mathcal{H}$-N structures in the situation where the local site orbitals preserve the reflection symmetry with respect to the plane of the trigonal links. This is clearly the case of s-wave orbitals, which was considered in the tight binding model in [2]. For antisymmetric orbitals that explicitly break that symmetry, such as the case of carbon p_z orbitals, the Dirac loop in the $\mathcal{H}$-0 hyper-honeycomb lattice is pushed to the edge of the Brilouin zone so that it is unobservable. We found this to be a general behavior in $\mathcal{H}$-N lattices. This arises, as the commenters point out, in the greatly reduced overlap between p_z atoms in chains that are oriented at right angles to one another. In other families of trigonally connected structures [3], Dirac loops may be observed regardless of the symmetry of the on-site orbitals.

The critique of [1] does not invalidate the main results of our paper. While we agree that nodal lines will not be observed in the simplest carbon realizations of those lattices, we stress that Dirac loops are a generic feature to this type of lattice, and may yet be realized in other physical systems, such as optical lattices and other materials.

Acknowledgements.– K. M. was supported by NSF grant DMR-1310407. B. U. acknowledges NSF CAREER grant DMR-1352604 for support.

[1] Marcos Veríssimo-Alves, Rodrigo G. Amorim, and A. S. Martins, comment.

[2] Kieran Mullen, Bruno Uchoa, and Daniel T. Glatzhofer, Phys. Rev. Lett. 115, 026403 (2015).

[3] Kieran Mullen, Bruno Uchoa, Daniel T. Glatzhofer, Bin Wang, unpublished.

* Electronic address:kieran@ou.edu