Bulk Impurities/Vacancies in Nodal Loop Semimetals

<u>João S. Silva</u>,[1,2] Vitor M. Pereira,[1] Eduardo V. Castro,[1] and Miguel A. N. Araújo[2,3]

[1] *Centro de Física das Universidades do Minho e Porto,*
LaPMET, Departamento de Física e Astronomia,
Faculdade de Ciencias, Universidade do Porto
[2] *CeFEMA, Instituto Superior Técnico, Universidade de Lisboa*
[3] *Departamento de Física, Universidade de Évora*

Weyl nodal loop semimetals are topological semimetals where the valence and conduction bands linearly touch along one dimensional loops in momentum space. A manifestation of their non-trivial topology is the presence of zero energy surface states, induced by chiral symmetry, on surfaces parallel to the loop plane. Unlike their insulator counterparts, these exotic phases may be unstable to small perturbations that respect their topology-protecting symmetries. Results for symmetry-breaking disorder have been reported. However, the case of vacancies preserves the underlying symmetry, and remains largely open.

Here, we will discuss the effects of impurities and vacancies in the bulk of a nodal loop semimetal tight-binding model [1], as well as an effective low energy model for a circular nodal loop, where an analytical approach is tractable. We focus on the changes in the density of states (DOS), computed via a projected Green's function formalism, and study the localization of the impurity-induced bound states. We have found that a single impurity induces a peak in the DOS, which traverses zero energy as U increases, becoming sharper near the Fermi leve, in line with known literature [2]. A single cell-vacancy creates broad peaks near the Fermi level, but the system remains a semimetal, whereas orbital vacancies induce a sharp peak at zero energy. Contrary to Weyl semimetals, we found that the nodal loop has a finite critical impurity strength that yields a finite DOS at zero energy. Moreover, the impurities create bound states, whose tails go as $\sim r^{-4}$. Lastly, we also look at the linear optical response of the nodal loop semimetal in the presence of vacancies.

References:
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