## Van Roosbroeck equations for 2D topological semiconductors

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The van Roosbroeck equations [1], which combine Poisson's equation with continuity equations and drift-diffusion equations for the electric current, are necessary for the theoretical modeling of many technologically important microelectronic devices such as p-n junctions, solar cells, photodiodes, etc. However, these equations have been very little used to describe topological materials.

We extend the Van Roosbroeck equation to 2D Dirac semiconductors with nonzero Berry curvature. Using the Boltzmann formalism in nonuniform systems [2,3], we show that both mobility and diffusion coefficients are by the Berry curvature.

We apply this formalism to a realistic system: a topological junction between Chern insulators with different Chern number [4,5]. Our both analytical and numerical studies suggest that the built-in potential of the junction is affected by the combined action of the Berry curvature and the magnetic field.

## References

- [1] W. van Roosbroeck, The Bell System Technical Journal, **29** (1950) 560607
- [2] G. Sundaram and Q. Niu, *Physical Review B*, **59** (1999) 14915-14925
- [3] C. Duval et al., Modern Physics Letters B, **20** (2006) 373-378
- [4] M. Allen et al., PNAS, 16 (2019) 14511-14515
- [5] D. Ovchinnikov et al., Nature Communications, **13** (2022) 5967



**Figure 1:** Band structure of a Chern insulator in a stripe geometry under a magnetic field (1.5 T) using half-BHZ model. The colour scale indicates if the electrons are located at the surface (yellow) or in the bulk (black) of the sample. The grey dashed line symbolises the Fermi level.