Master thesis presentation

Transport current from conformal anomaly in topological semimetals

Thorvald M. Ballestad

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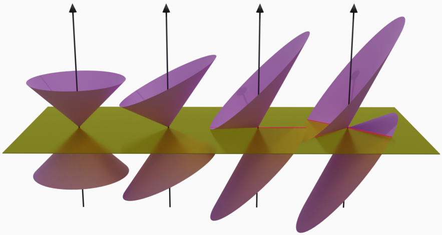


Background

Conformal anomaly in massless QED

The massless Dirac equation

$$\bar{\psi} i \partial\!\!\!/ \psi = 0. \tag{1}$$

Conformal anomaly in small perturbation limit

$$g^{\mu\nu} = \eta^{\mu\nu} + \delta g^{\mu\nu}. \tag{2}$$

The Dirac cone Hamiltonian

$$H_D = v_F s \boldsymbol{p}\boldsymbol{\sigma}. \tag{3}$$

Linear response and Luttinger's method

Temperature pertupation ∇T and gravitational potential ψ

$$\nabla\psi + \frac{\nabla T}{T} = 0. \tag{4}$$

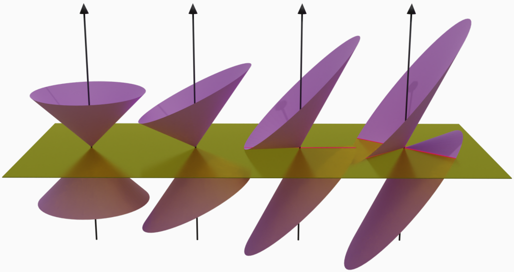
Linear response (Kubo)

$$\begin{aligned}\langle J\rangle(t,\boldsymbol{r}) = iv_F \int \mathrm{d}t'\mathrm{d}\boldsymbol{r}' \int_{-\infty}^{t'} \mathrm{d}t''\Theta(t-t') \\ \times \left\langle \left[\boldsymbol{J}^i(t,\boldsymbol{r})), T^{j0}(t'',\boldsymbol{r}')\right]\right\rangle \frac{\partial'_j T(t',\boldsymbol{r}')}{T(t',\boldsymbol{r}'}\end{aligned} \tag{5}$$

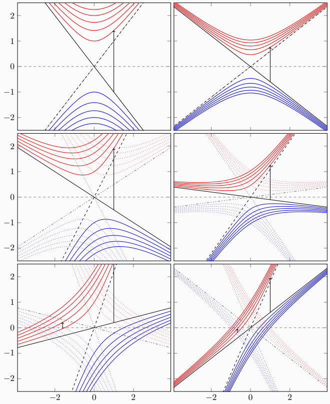
- M. N. Chernodub. "Anomalous Transport Due to the Conformal Anomaly". In: *Phys. Rev. Lett.* 117.14 (Sept. 28, 2016), p. 141601.
- M. N. Chernodub, Alberto Cortijo, and María A. H. Vozmediano. "Generation of a Nernst Current from the Conformal Anomaly in Dirac and Weyl Semimetals". In: *Phys. Rev. Lett.* 120.20 (May 14, 2018), p. 206601.
- Vicente Arjona, Maxim N. Chernodub, and María A. H. Vozmediano. "Fingerprints of the Conformal Anomaly on the Thermoelectric Transport in Dirac and Weyl Semimetals: Result from a Kubo Formula". In: *Phys. Rev. B* 99.23 (June 10, 2019), p. 235123. ISSN: 2469-9950, 2469-9969. arXiv: 1902.02358.

Type-I and Type-II

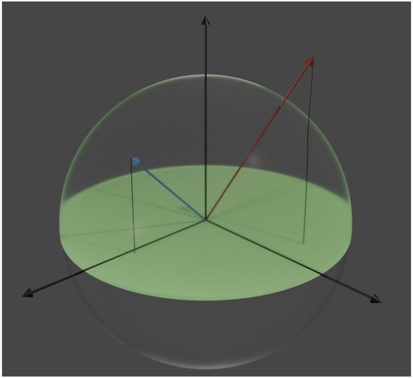
$$H = \underbrace{s v_F \boldsymbol{\sigma} \cdot \boldsymbol{p}}_{H^0} + v_F \boldsymbol{t} \cdot \boldsymbol{p}.$$



Landau levels



Type-I and Type-II



Proposition

The modulus of the *tilt vector* $\boldsymbol{t}$ separates Type-I from Type-II, with Type-II having $t > 1$.

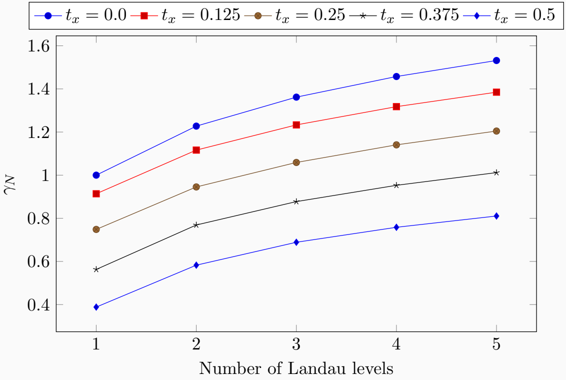
Collapse of LLs for perpendicular tilt.

Our work

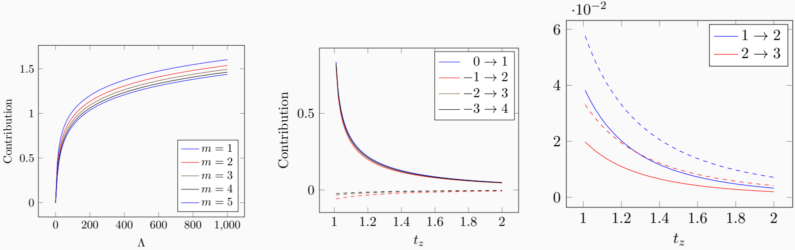
Result

The response can be directly tuned by the tilt parameter t.

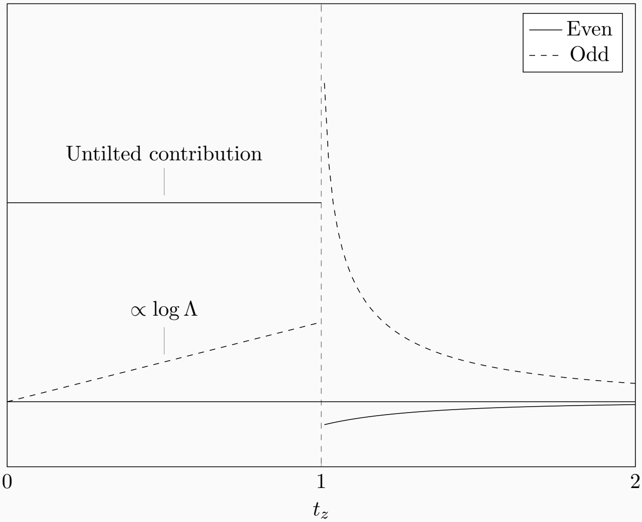
Perpendicular tilt



Parallel tilt



(a) Type-I **(b)** Type-II inter band **(c)** Type-II intraband



Even
Odd
Untilted contribution
$\propto \log \Lambda$
0
1
2
t_z

Thank you!

Energy-momentum tensor

$$\partial_\mu T^{\mu\nu} = 0. \tag{6}$$

Canonical

$$T^{\mu\nu} = \partial^\nu \bar{\psi} \frac{\delta \mathcal{L}}{\delta(\partial_\mu \bar{\psi})} + \frac{\delta \mathcal{L}}{\delta(\partial_\mu \psi)} \partial^\nu \psi - \eta^{\mu\nu} \mathcal{L}. \tag{7}$$

and dynamical

$$T^{\mu\nu} \propto \frac{\partial S}{\partial g^{\mu\nu}} \tag{8}$$

References

[1] Vicente Arjona, Maxim N. Chernodub, and María A. H. Vozmediano. "Fingerprints of the Conformal Anomaly on the Thermoelectric Transport in Dirac and Weyl Semimetals: Result from a Kubo Formula". In: *Phys. Rev. B* 99.23 (June 10, 2019), p. 235123. ISSN: 2469-9950, 2469-9969. arXiv: 1902.02358.

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[3] M. N. Chernodub, Alberto Cortijo, and María A. H. Vozmediano. "Generation of a Nernst Current from the Conformal Anomaly in Dirac and Weyl Semimetals". In: *Phys. Rev. Lett.* 120.20 (May 14, 2018), p. 206601.