11. znanstveni sastanak
Hrvatskog fizikalnog društva

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Magnetski moment sile u topološkim polumetalima

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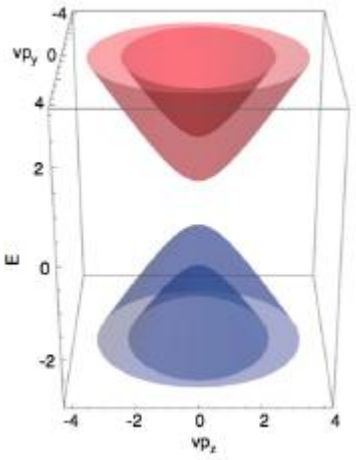
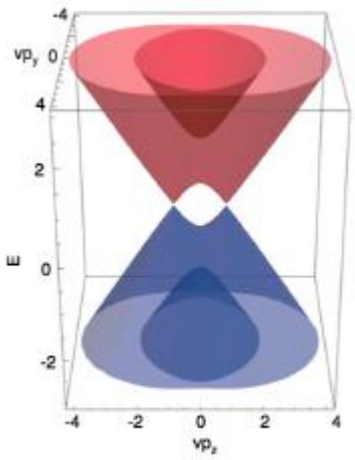
Topološki polumetali

Topološki polumetali ⟶ valentna i vodljiva vrpca dodiruju se u diskretnim točkama ili linijama u 3D. Oko mjesta dodira disperzija je linearna.



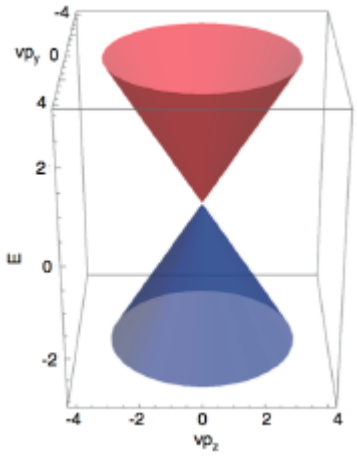
Poluvodič (maseni Dirac)



Weylov polumetal

- Par dvostruko degeneriranih točaka suprotnih kiralnosti.

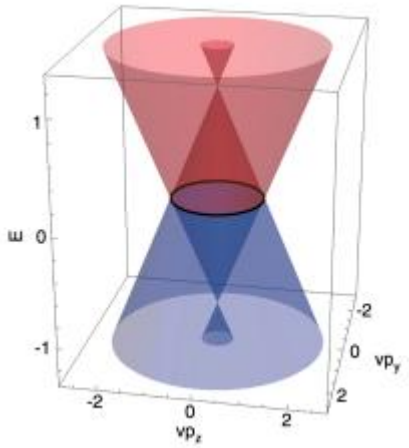
$$H = \pm \hbar v_F \vec{k} \cdot \vec{\sigma}$$



Diracov polumetal

- Četverostruko degenerirana točka (× 2).
- Dvije Weylove točke na istom $\vec{k}$.

$$H = \hbar v_F \begin{pmatrix} \vec{\sigma} \cdot \vec{k} & 0 \\ 0 & -\vec{\sigma} \cdot \vec{k} \end{pmatrix}$$

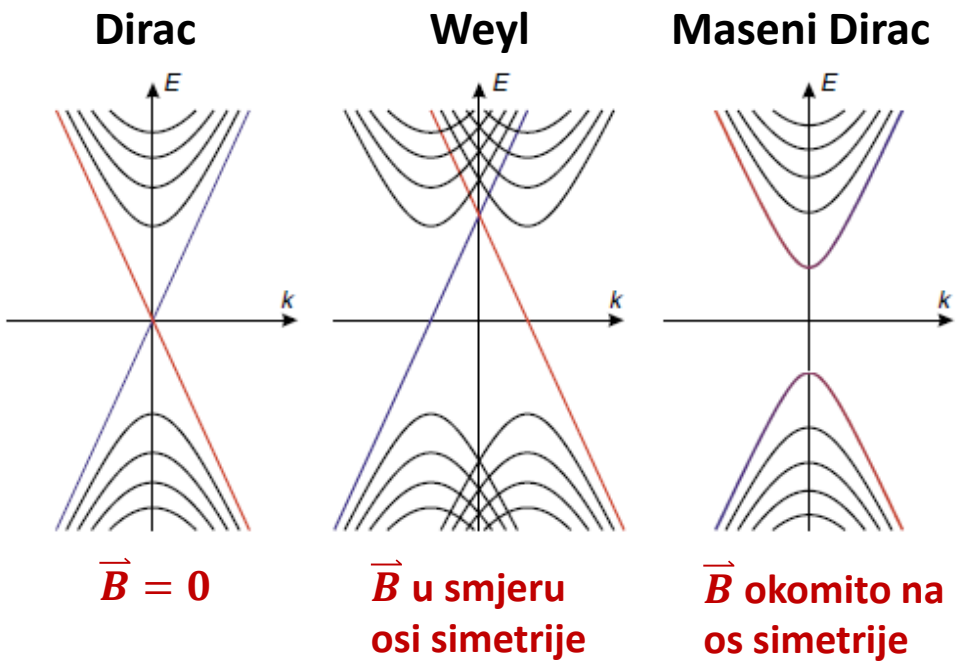


Linijski Diracov polumetal

- Vrpce se dodiruju duž linija.

E_F na, ili što bliže točkama dodira ⟶ Weylovi/Diracovi fermioni

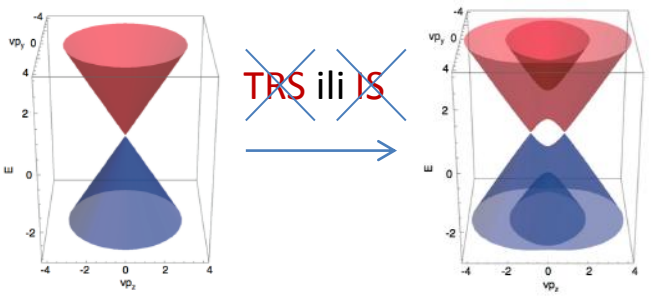
Diracov polumetal u magnetskom polju



$\vec{B} = 0$

$\vec{B}$ u smjeru osi simetrije

$\vec{B}$ okomito na os simetrije



$\vec{B}$ slama simetriju na vremensku inverziju i, ovisno o smjeru, simetriju koja čuva Diracovu točku.

Landauovi nivoi:

$$\varepsilon_{n,k} = \begin{cases} \dfrac{\hbar eB}{m}(n+\gamma) + \dfrac{\hbar^2 {k_z}^2}{2m} & \text{Trivial } (\gamma = \tfrac{1}{2}) \\ \hbar v_F \sqrt{2B(n+\gamma) + {k_z}^2} & \text{Weyl } (\gamma = 0) \\ \hbar v_F \sqrt{2B(n+\gamma+C^2 sin^2\theta) + {k_z}^2} & \text{Dirac } (\gamma = 0) \end{cases}$$

θ je kut između $\vec{B}$ i osi simetrije koja čuva Diracove točke

Diracov polumetal u magnetskom polju

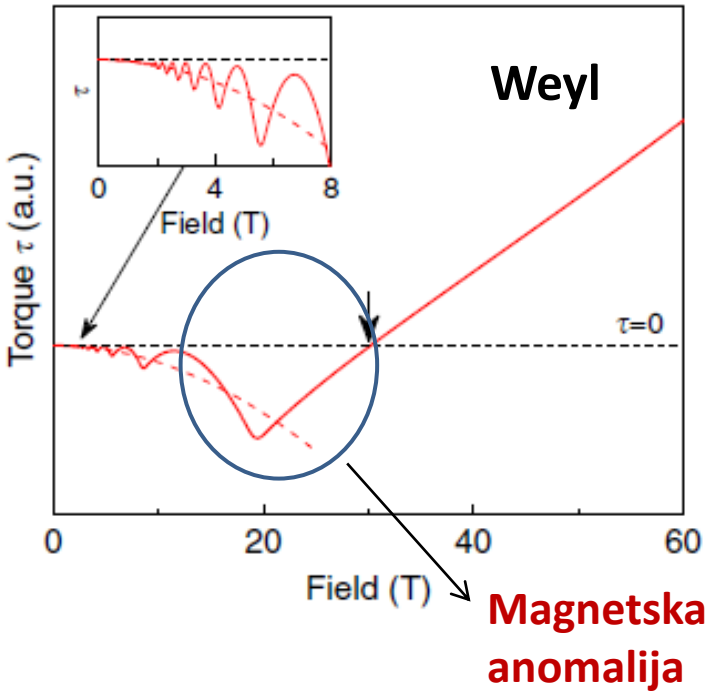
Landauovi nivoi

$$\varepsilon_{n,k} = \begin{cases} \frac{\hbar eB}{m}(n+\gamma) + \frac{\hbar^2 {k_z}^2}{2m} & \text{Trivial } (\gamma = \frac{1}{2}) \\ \hbar v_F \sqrt{2B(n+\gamma) + {k_z}^2} & \text{Weyl } (\gamma = 0) \\ \hbar v_F \sqrt{2B(n+\gamma+C^2 sin^2\theta) + {k_z}^2} & \text{Dirac } (\gamma = 0) \end{cases}$$

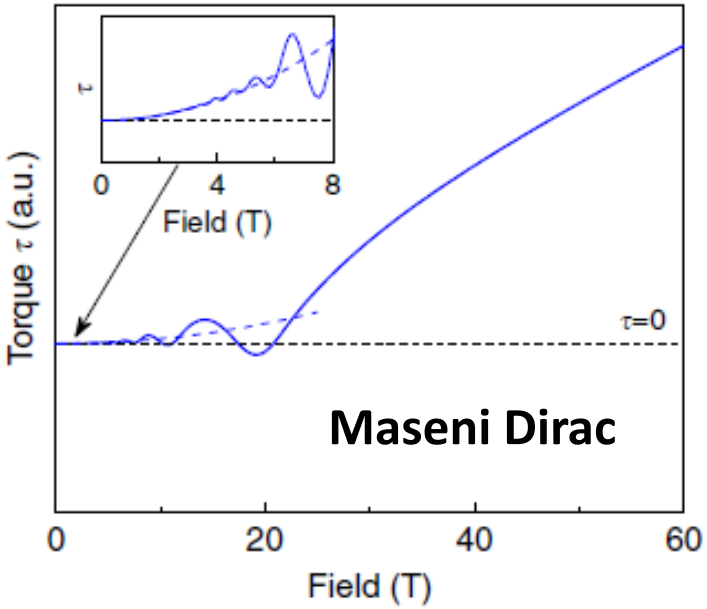
Magnetizacija u kvantnom limitu ($n = 0$)

$$M_{n=0} = -\frac{\partial \varepsilon_{0,k}}{\partial B}$$

$$\vec{\tau} = \vec{M} \times \vec{B}$$



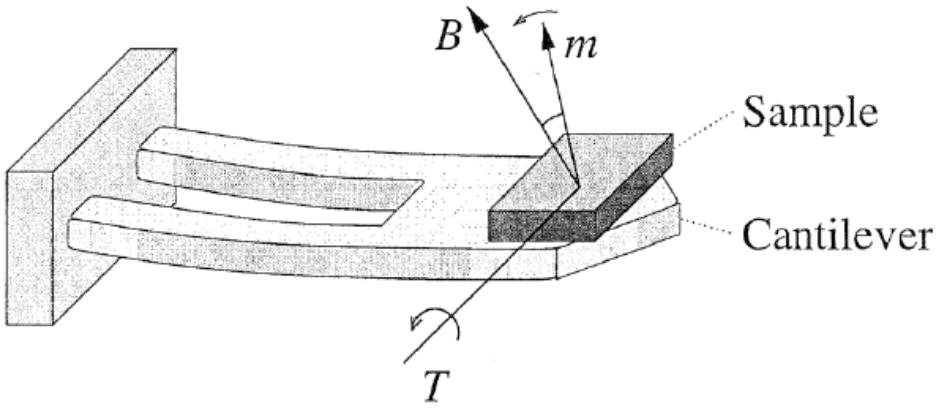
Simulirani $\vec{\tau}$ za Weylov i maseni Diracov polumetal u kvantnom limitu.



Preuzeto iz Moll, P. J. *et al* (2016). *Nature Communications*.

Mjerenje magnetskog momenta sile

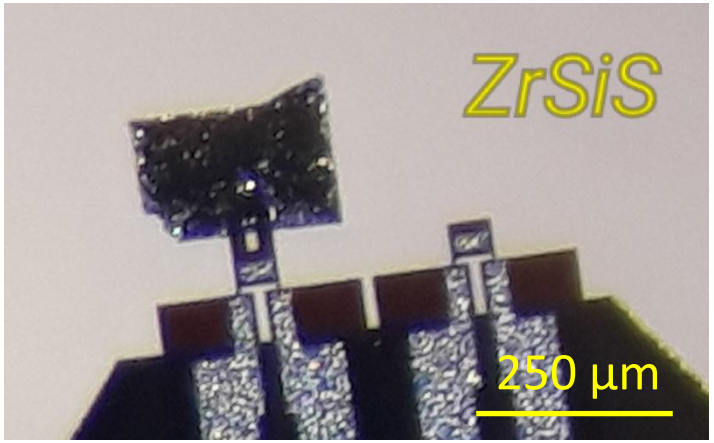
Metoda piezopoluge

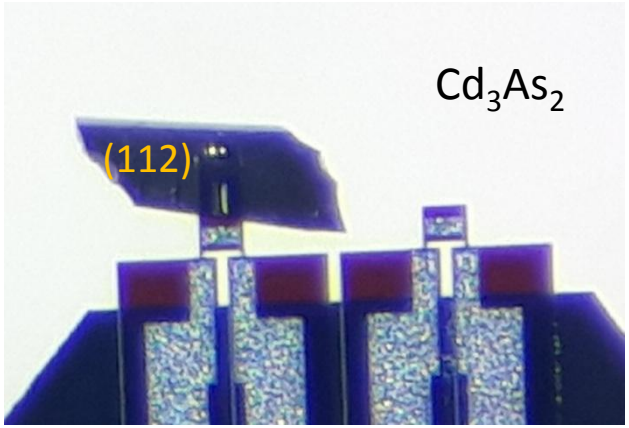


Mjeri se otpor piezootpornog senzora na polugi.

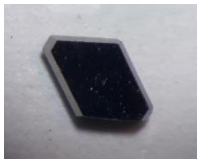
Magnetski anizotropan uzorak.

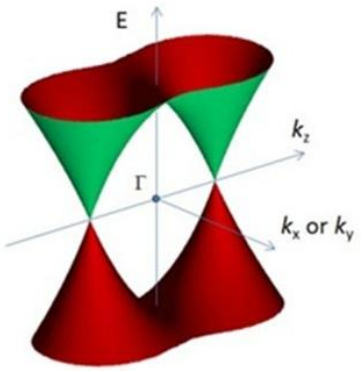
$$\vec{\tau} = \vec{M} \times \vec{B} \propto B^2$$





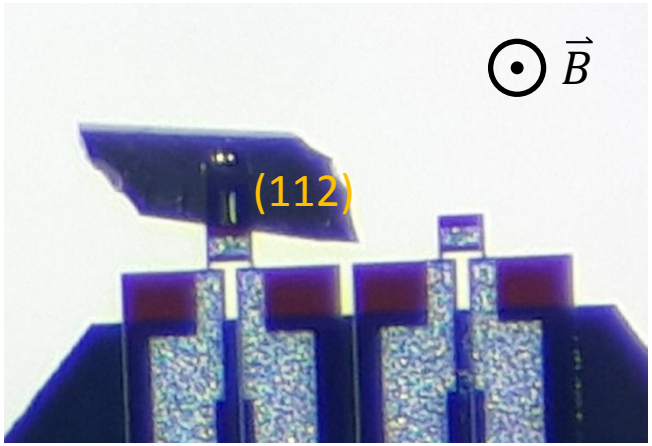
Cd_3As_2

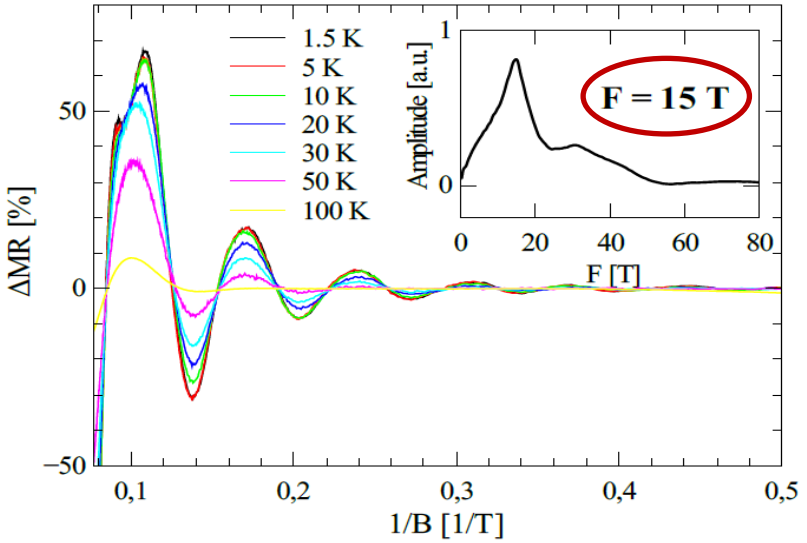




Cd_3As_2

- Diracov polumetal.
- Par Diracovih točaka na osi rotacijske simetrije.



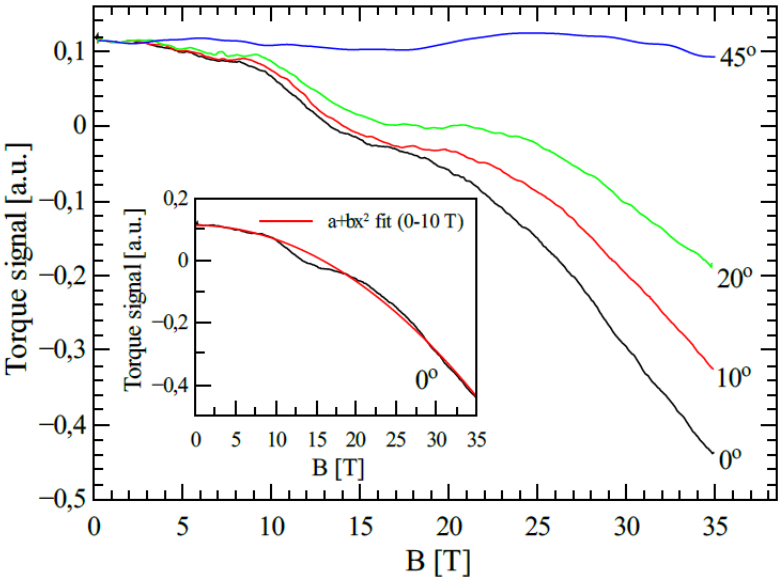


Kvantne oscilacije u magnetootporu Cd_3As_2.

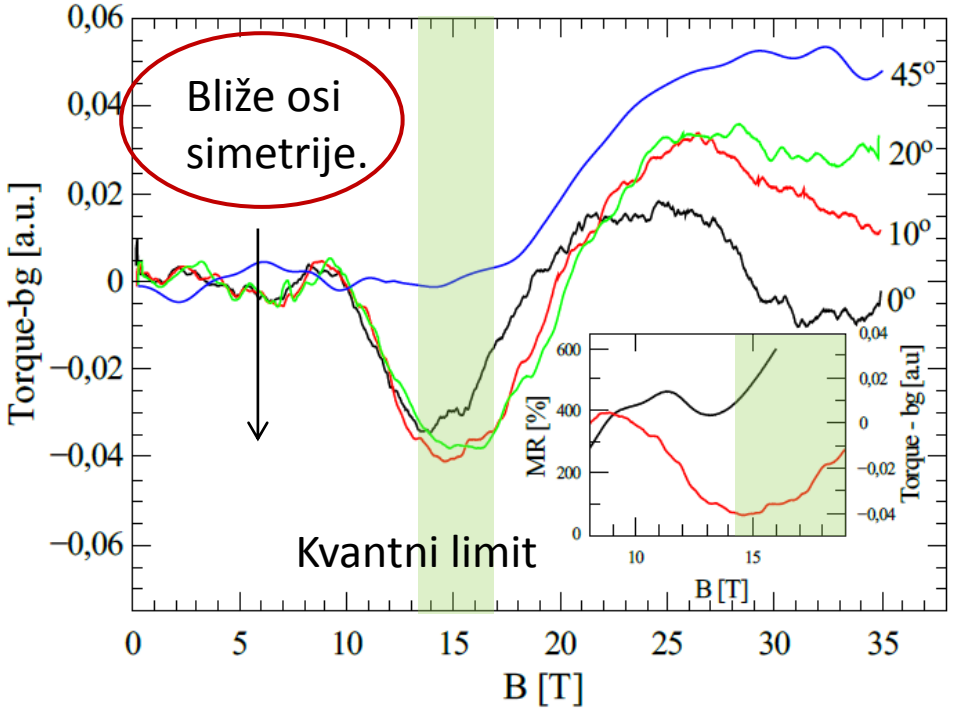
$\vec{\tau}$ je mjeren na 2 K u poljima do 35 T za različite kutove θ između polja i normale na (112) ravninu.

Cd_3As_2

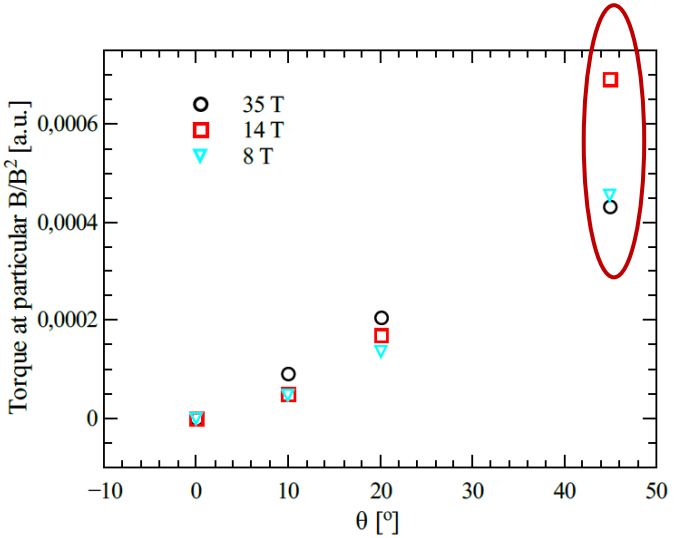
Sirovo mjerenje τ s B^2 ovisnošću.



τ -B^2 pozadina.



Vidljiva je kutno ovisna magnetska anomalija oko kvantnog limita.



τ na tri vrijednosti polja skaliran s B^2.

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Hvala na pažnji.