Elektronska gustoća stanja trodimenzionalnog polumetala s invertiranim vrpcama

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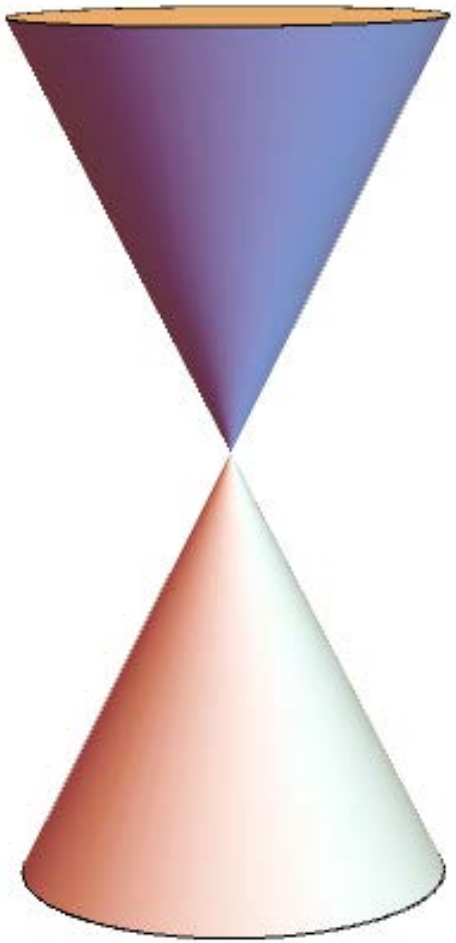
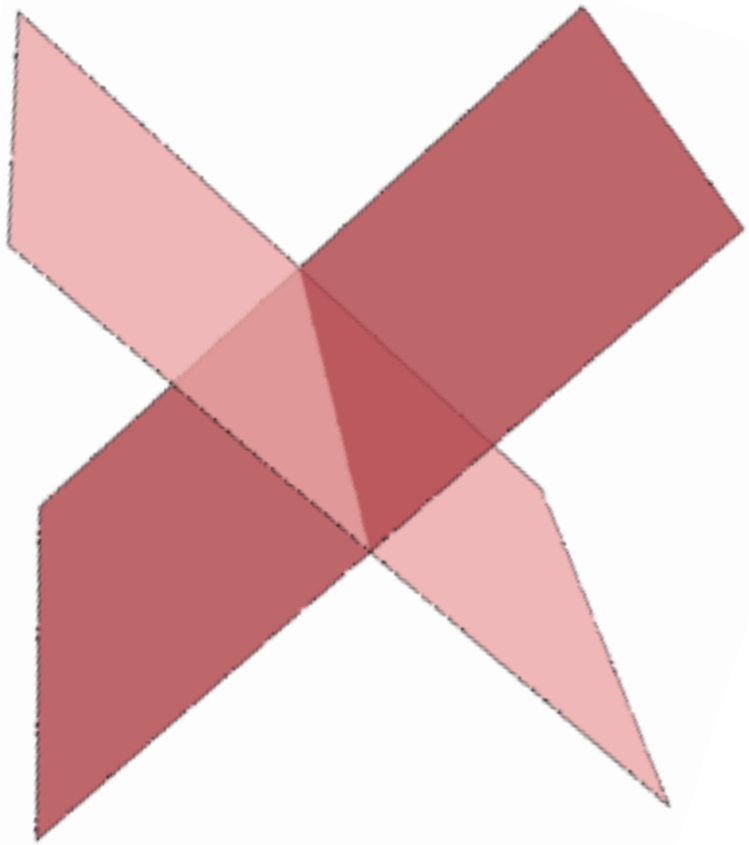
Pregled

3D Topološki polumetali



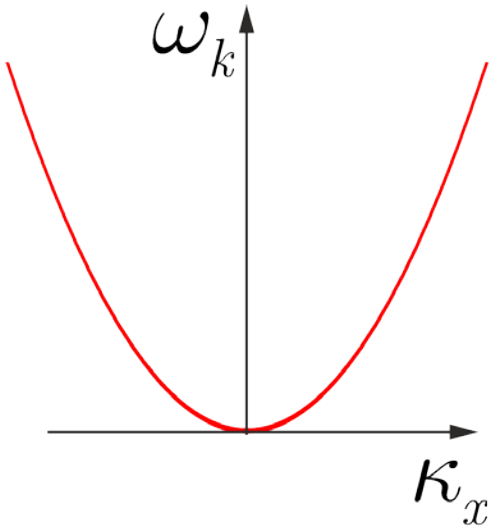
grafen



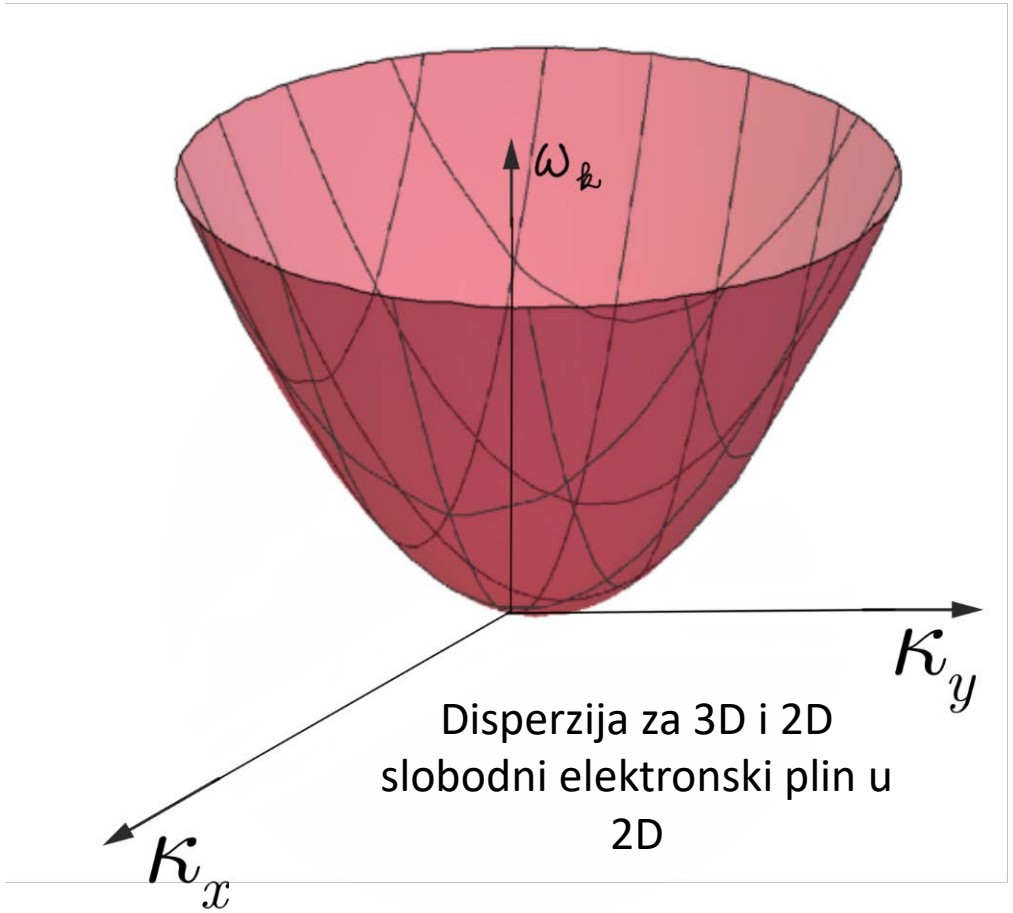
nodal line polumetali

Elektronska gustoća stanja

3D i 2D gustoća stanja slobodnog elektronskog plina

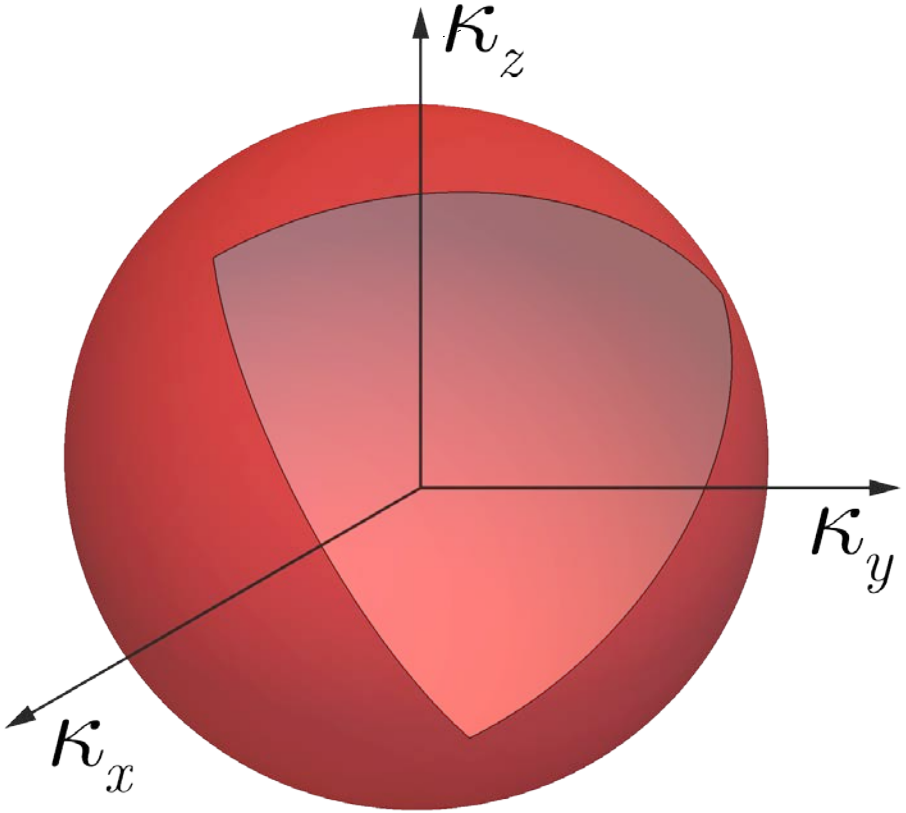


Disperzija za 3D i 2D slobodni elektronski plin u 1D

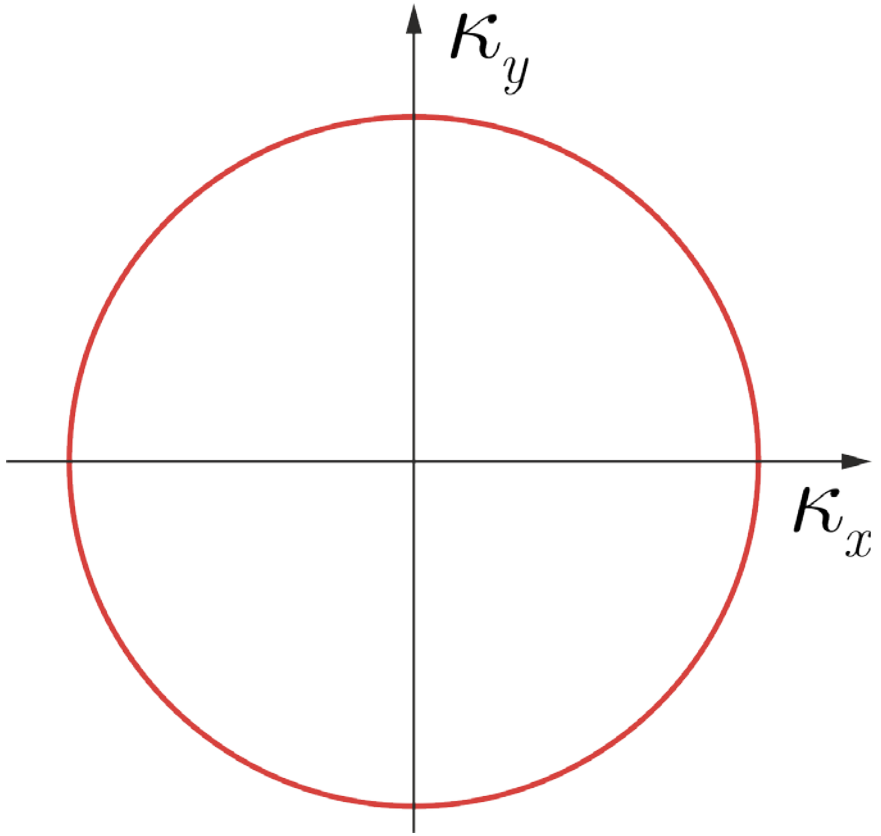


Disperzija za 3D i 2D slobodni elektronski plin u 2D

3D i 2D gustoća stanja slobodnog elektronskog plina



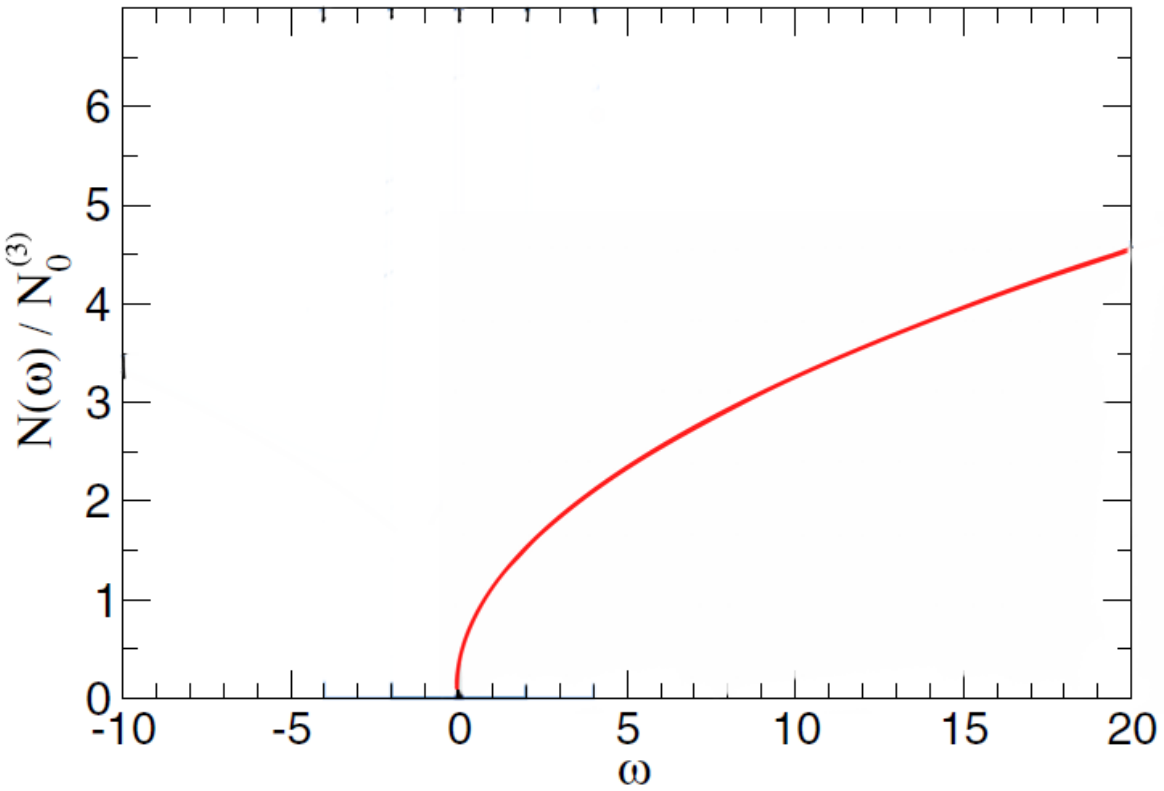
Fermijeva ploha za 3D slobodni elektronski plin



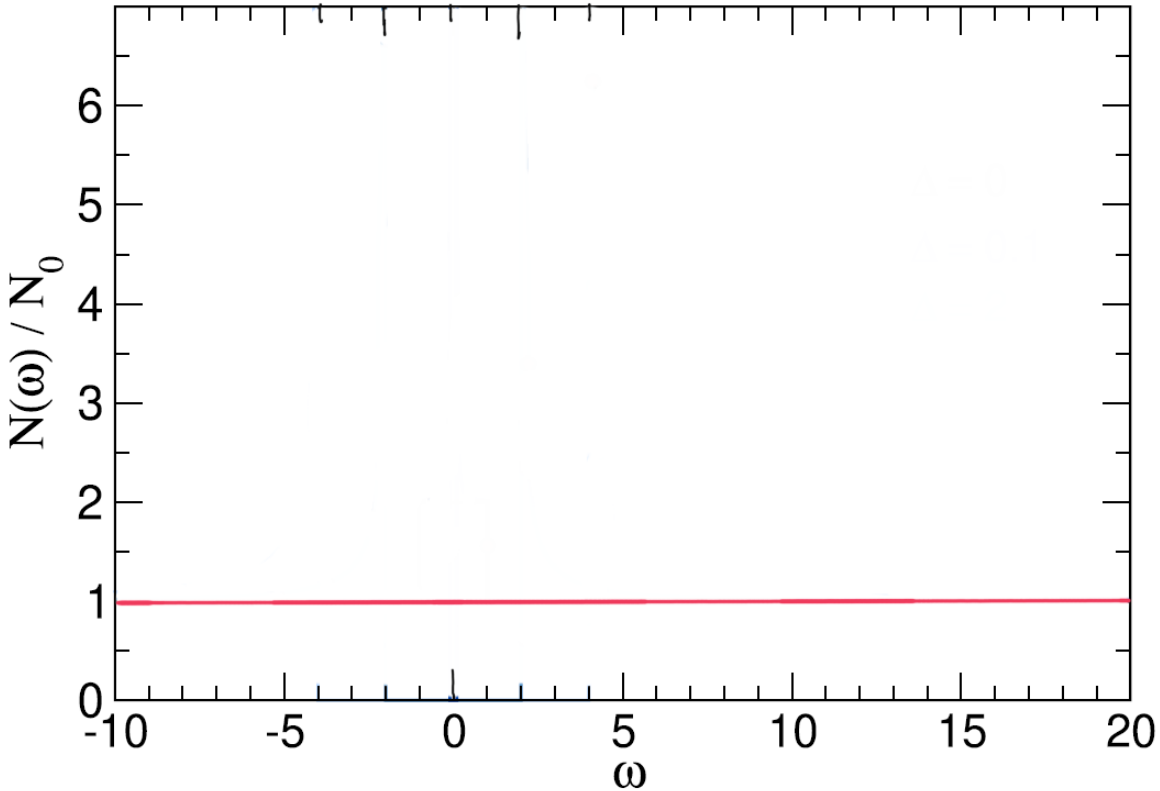
Fermijeva ploha za 2D slobodni elektronski plin

3D i 2D gustoća stanja slobodnog elektronskog plina

Gustoća stanja u 3D proporcionalna je $\sqrt{\omega}$.



Gustoća stanja u 2D je konstanta.

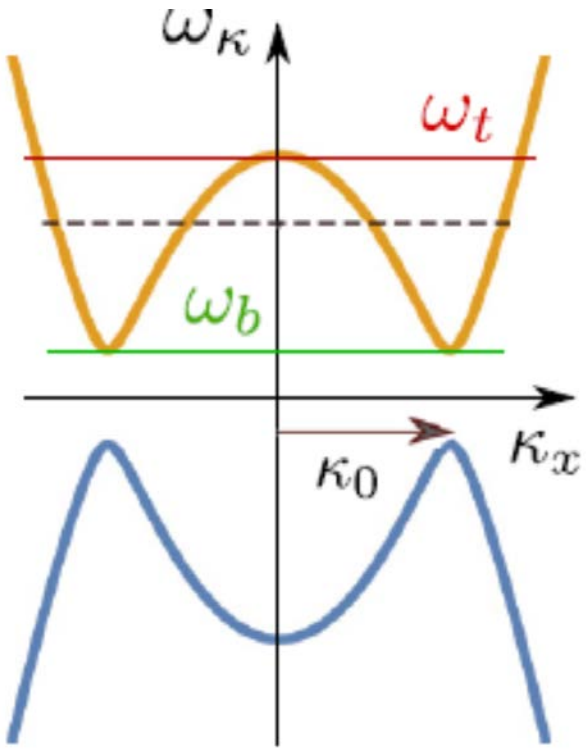


$$\omega_b = \Delta, \qquad \omega_t = \sqrt{1+\Delta^2}$$

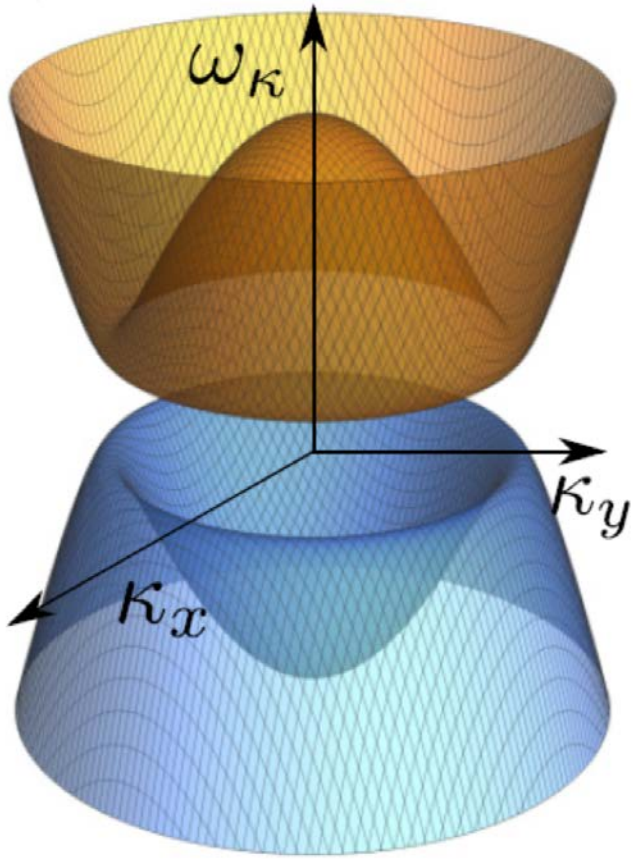
Dvovrpčani Hamiltonijan

$$\hat{H} = (A - Bk^2)\sigma_z + C\sigma_x$$

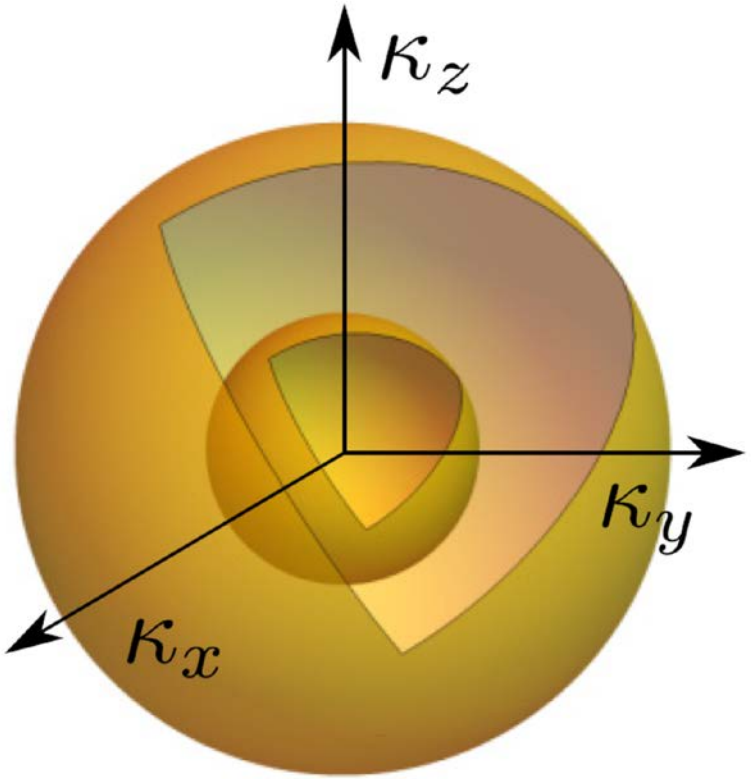
$$\omega_\kappa = \pm\sqrt{(1-\kappa^2)^2 + \Delta^2}$$



Invertirane vrpce u 1D.



Invertirane vrpce u 2D.



Fermijeva ploha 3D sustava.

Gustoća stanja (DOS) za 3D polumetal s invertiranim vrpcama

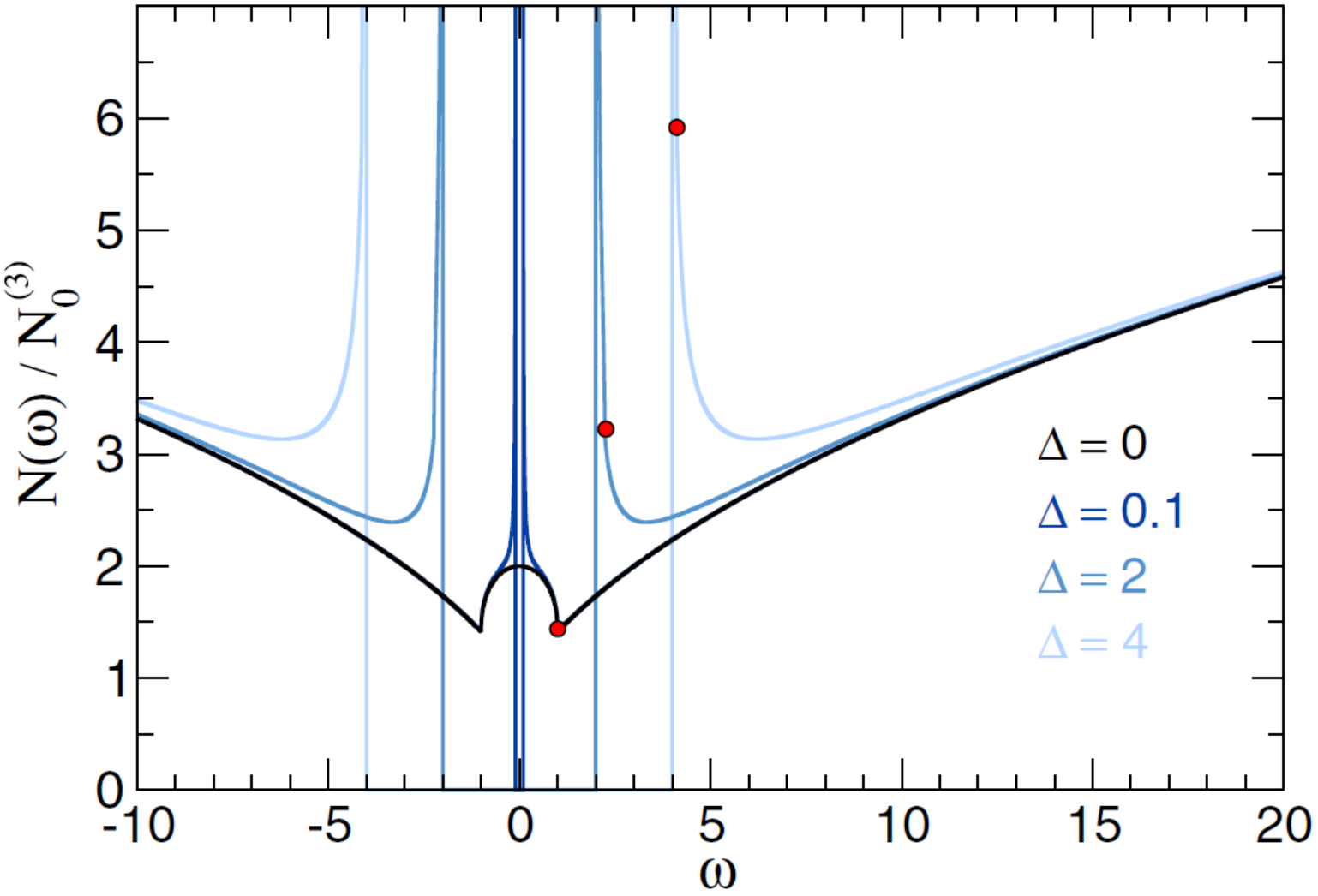
- gustoća stanja po jedinici volumena po definiciji je $N(\varepsilon) = \frac{2}{V}\sum_{\mathbf{k}} \delta(\varepsilon - \varepsilon_{\mathbf{k}})$

$$N(\omega) = \frac{1}{\pi^2}\sqrt{\frac{A}{B^3}}\int \kappa^2\, d\kappa\, \delta\left(\omega - \sqrt{(1-\kappa^2)^2 + \Delta^2}\right)$$

$$\delta(\ldots) = \sum_{\kappa_0} \delta(\kappa - \kappa_0)\left|\frac{\omega}{2\kappa_0(1-\kappa_0^2)}\right|$$

$$N(\omega) = N_0^{(3)}\frac{|\omega|}{\sqrt{\omega^2 - \omega_b^2}}\Theta(|\omega| - \omega_b)\Big[\left(1 + \sqrt{\omega^2 - \omega_b^2}\right)^{\frac{1}{2}} + \Theta(\omega_t - |\omega|)\left(1 - \sqrt{\omega^2 - \omega_b^2}\right)^{\frac{1}{2}}\Big]$$

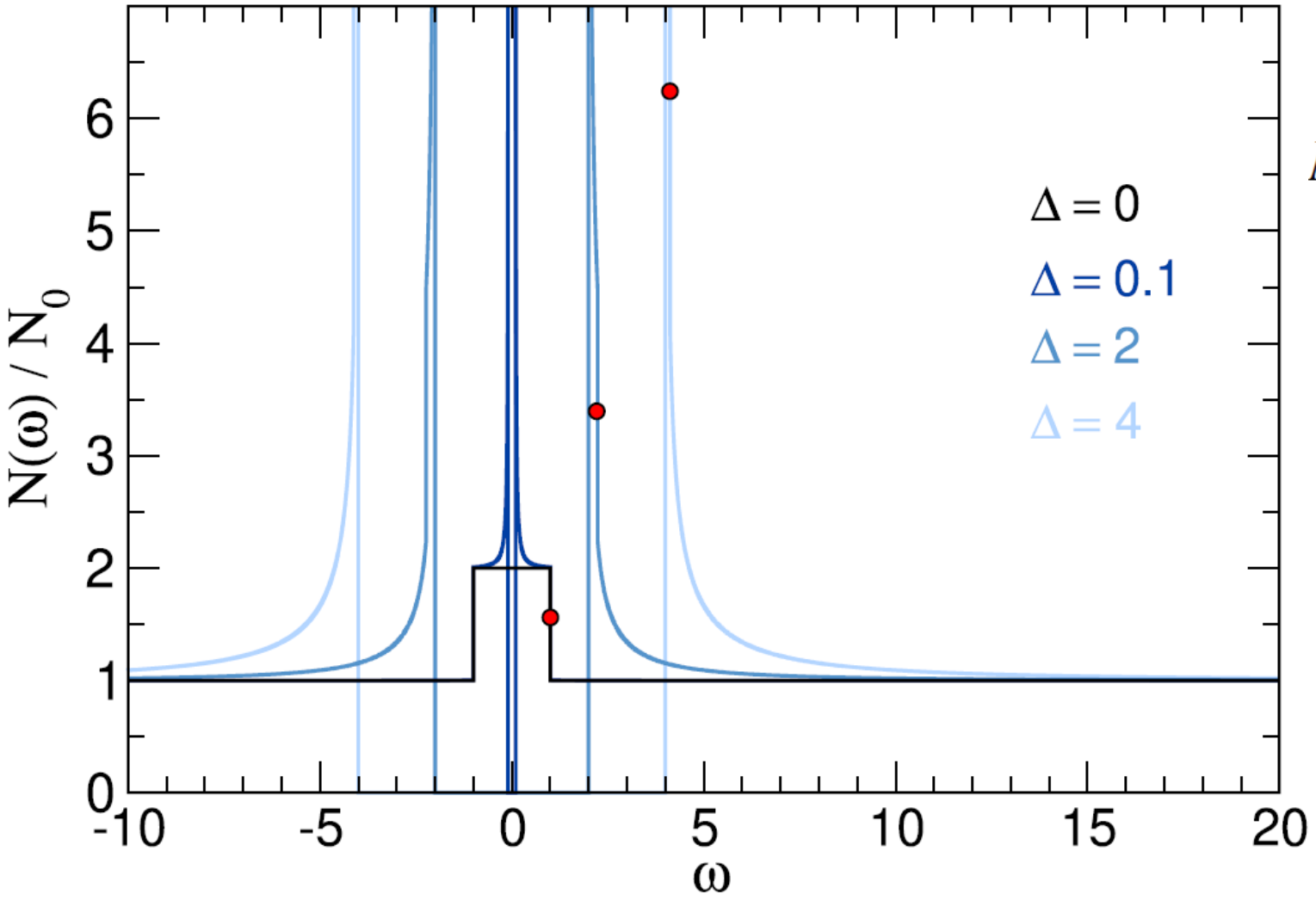
Gustoća stanja (DOS) za 3D polumetal s invertiranim vrpcama



$$N(\omega) \approx N_0^{(3)} \sqrt{\frac{2\omega_b}{\omega - \omega_b}}, \quad \omega \gtrsim \omega_b,$$

$$N(\omega) \approx N_0^{(3)} \sqrt{\omega}, \quad \omega \gg \omega_b.$$

Gustoća stanja (DOS) za 2D polumetal s invertiranim vrpcama



$$N(\omega) = N_0 \frac{|\omega|}{\sqrt{\omega^2 - \omega_b^2}} \Theta(|\omega| - \omega_b)$$

$$[1 + \Theta(\omega_t - |\omega|)]$$

Rasprava

- Usporedba za 3D
  - za Δ=0 (NSSM) vidljiv je kupolasti oblik
  - za Δ>0 pri energiji $\omega = \omega_b$ pojavljuju se korijenski singulariteti
  - za $\omega = \omega_b$ korijenski singulariteti označeni su crvenim kružićima
  - za $\omega \gg \omega_t$ gustoća stanja je $\propto \sqrt{\omega}$
- Usporedba za 2D
  - za Δ=0 (NSSM) step oblik
  - za Δ>0 (GSM) pri energiji $\omega_b = \Delta$ pojavljuju se divergencije
  - za $\omega \gg \omega_t$ gustoća stanja je konstantna

Zaključak

- usporedba 3D i 2D DOS:
  - U NSSM fazi, kupolasti oblik zamijenjen je step strukturom u intervalu energija (-1,1)
  - konačni procijep u GSM fazi daje korijenske divergencije za ω_b

- usporedba 3D i 2D DOS sa 3D i 2D slobodnim elektronskim plinom
  - u limesu visokih energija, dobivamo gustoće stanja za slobodni elektronski plin

Literatura

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