Magnetic Field

Pierls' substitution

Hoppings are modified as, $t_{ij} \rightarrow t_{ij} e^{i\frac{e}{\hbar}\int_i^j \vec{A}\cdot d\vec{r}}$

$\vec{B} = B\,\hat{z}$. We choose gauges $\vec{A}_1 = (-By, 0, 0)$ and $\vec{A}_2 = (0, Bx, 0)$.

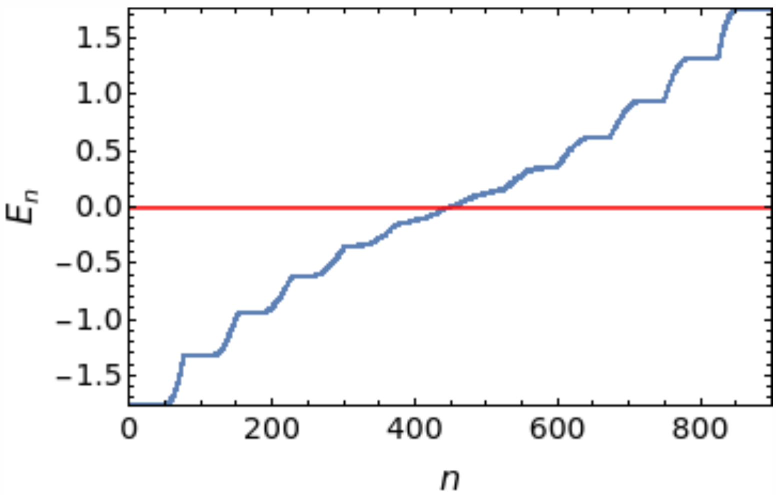
Since the gauge choice breaks translational symmetry, we use *Open Boundary Conditions*.

Set $e = \hbar = 1$.

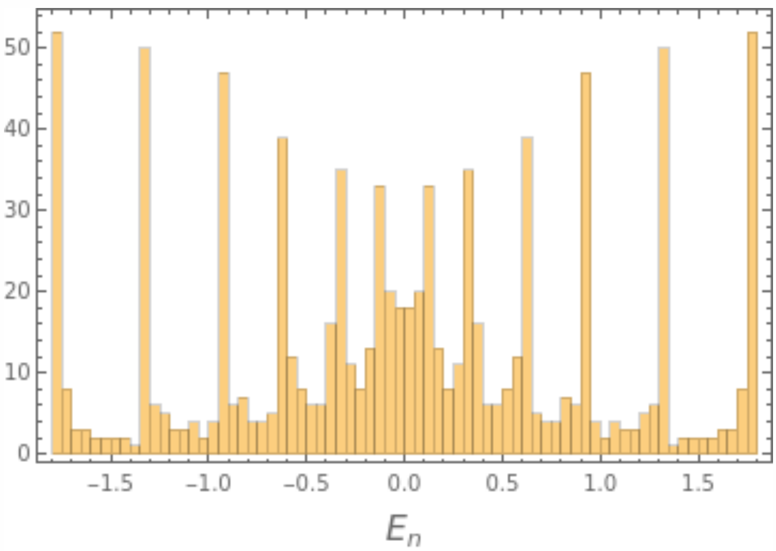
Tight binding on a 2D square lattice with a single orbital per site

$h(k_x, k_y) = cos(k_x) + cos(k_y)$

$B = 0.5$



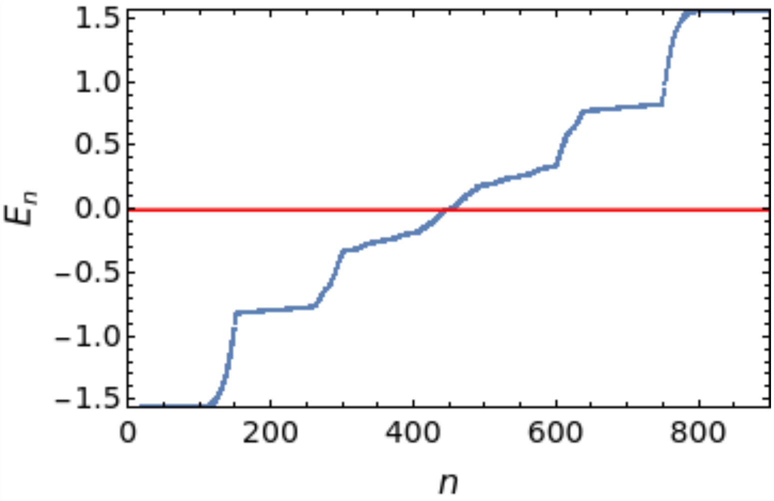
We can plot a histogram to see the density of states.

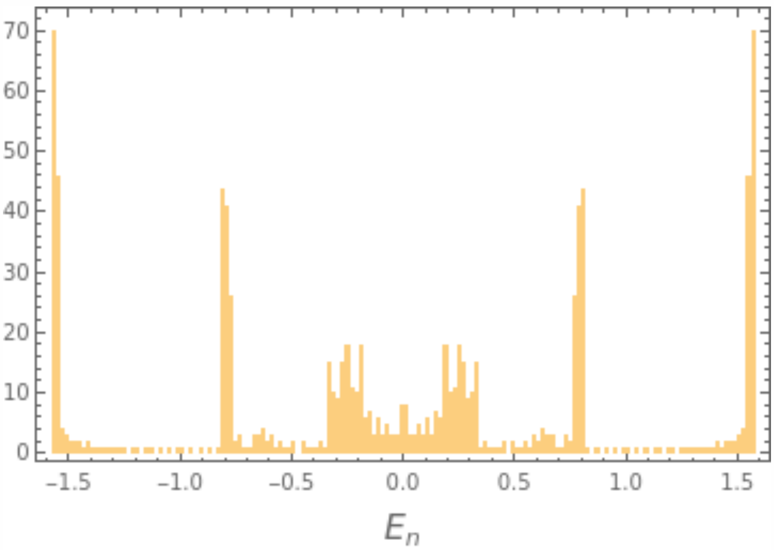


The eigenvalues are same upto 10^{-14} order for both the gauges.

The spacing increases with magnetic field

$B = 1$



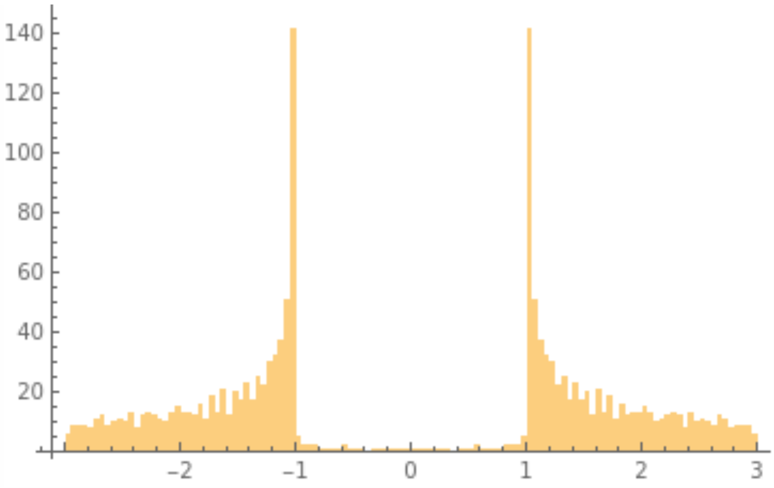


Weyl Semimetals

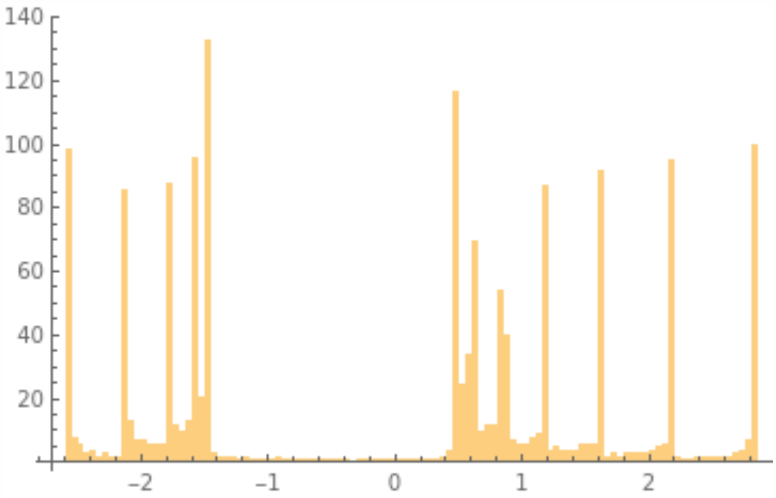
$$h = t \sin k_x \sigma_x + t \sin k_y \sigma_y + \sigma_z (t_1 (\cos k_x + \cos k_y) - m + cos(k_z))$$

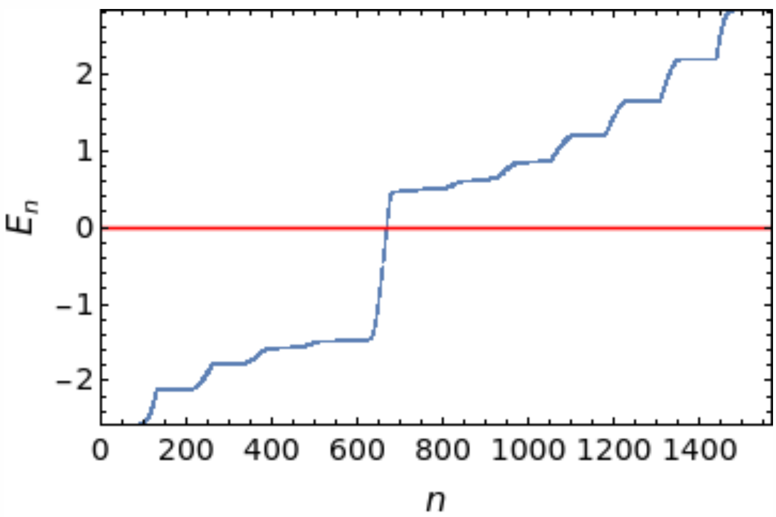
First we fix $k_z = \frac{\pi}{2}$, so that there is no hopping along z (Chern insulator). Also, $t = t_1 = m = 1$.

<u>For *zero magnetic field*</u>

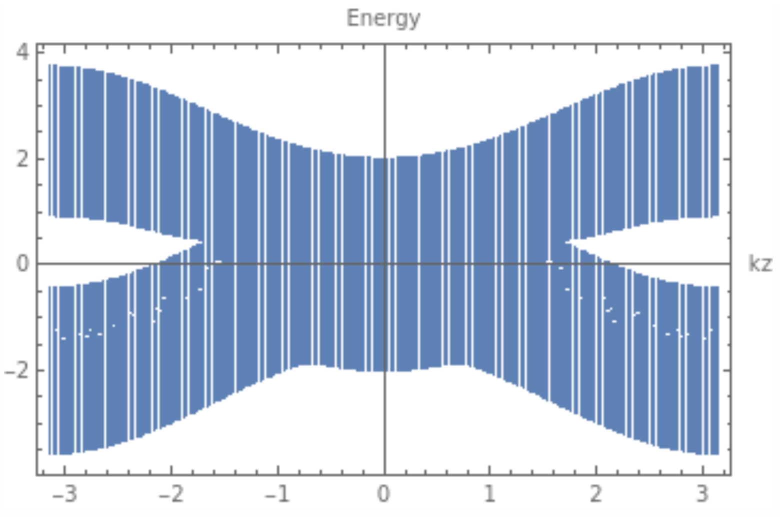


For $B = 1$, the spectrum shifts towards negative energies, and there are Landau levels.





If we plot the energy eigenvalues as function of k_z, we get a plot like the following.



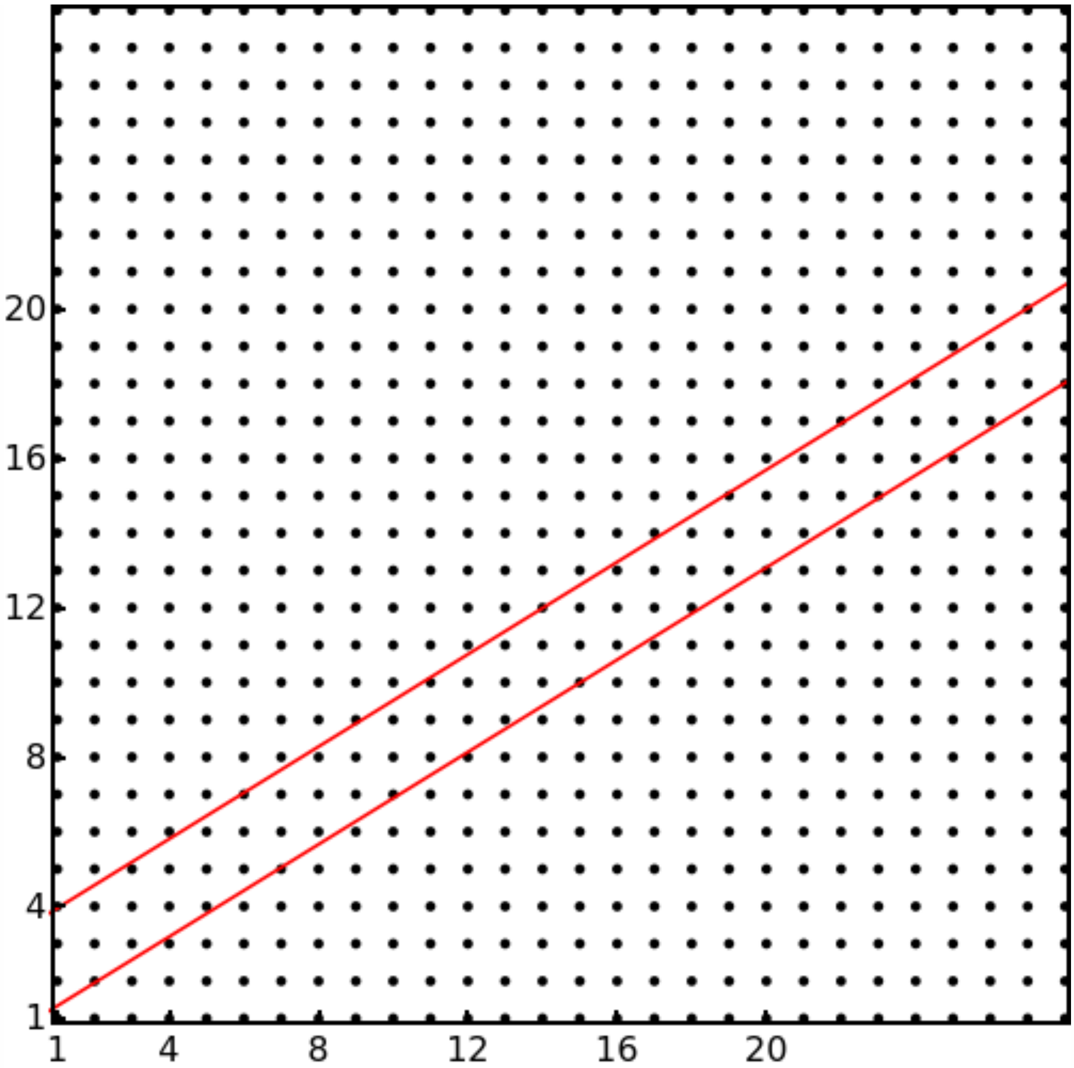
Chern insulator and Quasicrystal

Thin quasicrystal strip

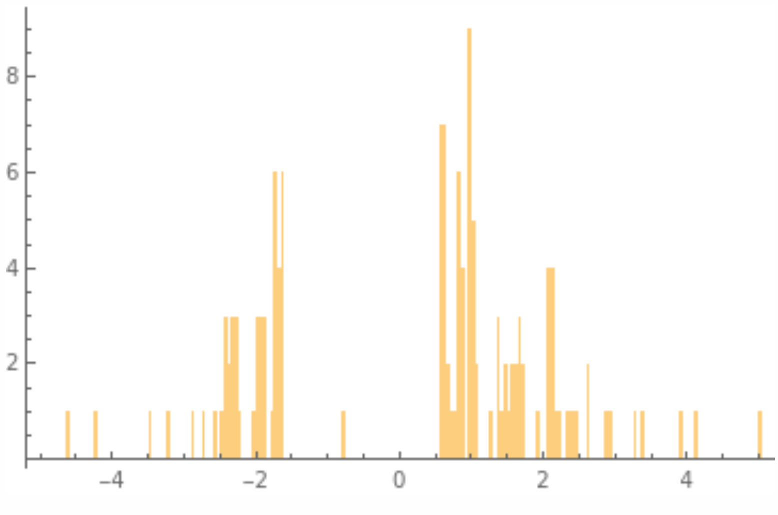
We fix the same parameters as in the previous Hamiltonian, and turn off hopping along z. For a thin quasicrystal strip, the Landau levels are not very prominent.

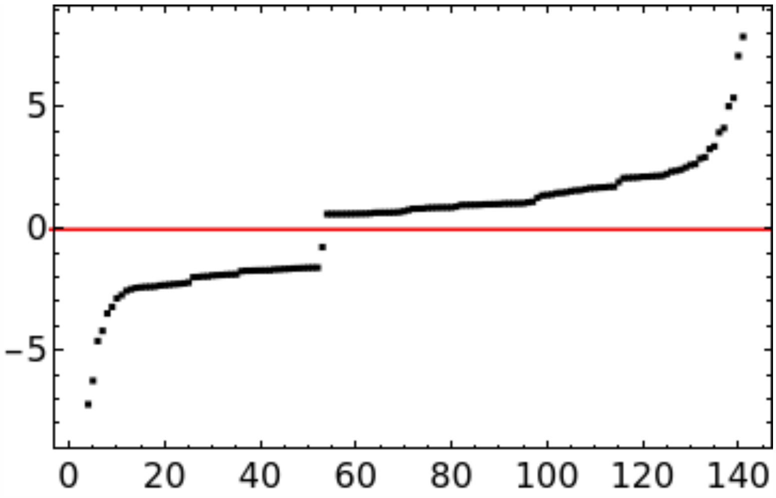
$$y_{up} = \frac{2}{\sqrt{5}+1}(x-1)+4$$

$$y_{down} = \frac{2}{\sqrt{5}+1}(x-2)+2$$



9.2% of sites are inside the quasicrtstal



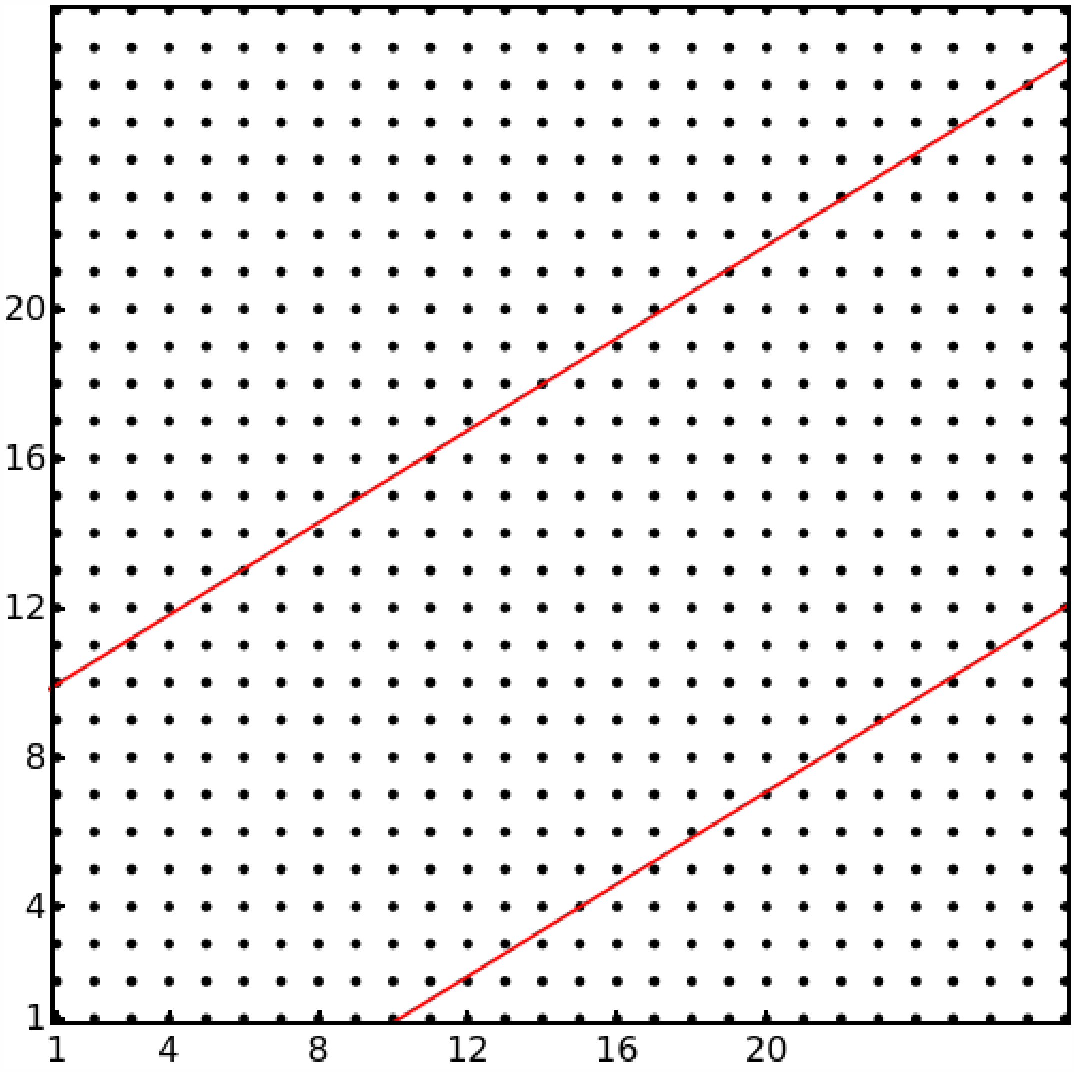


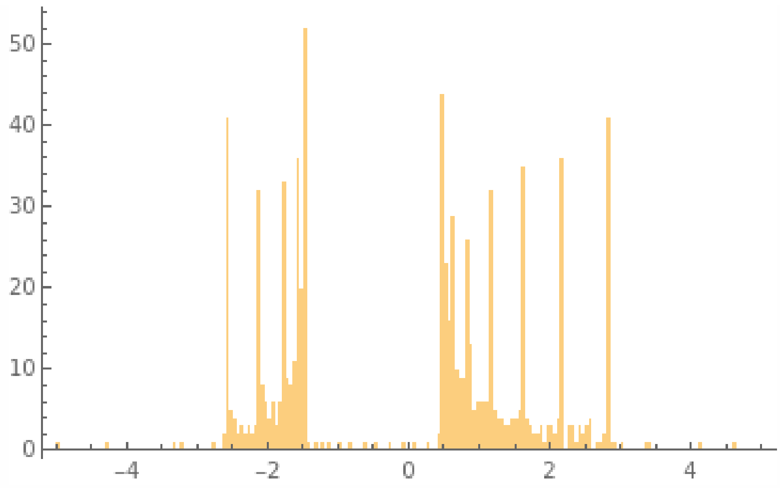
Landau levels are not very prominent

Thick strip

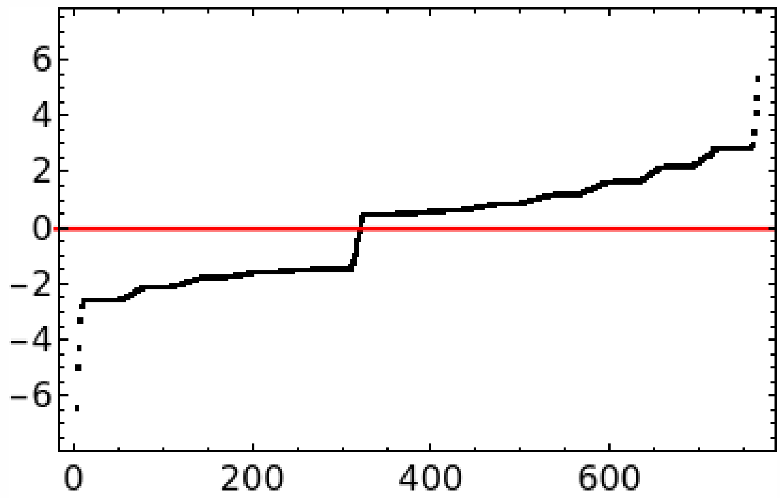
$$y_{up} = \frac{2}{\sqrt{5}+1}(x-1)+10$$

$$y_{down} = \frac{2}{\sqrt{5}+1}(x-2)-4$$





50
40
30
20
10
0
−4
−2
0
2
4



6
4
2
0
−2
−4
−6
0
200
400
600