PHY 491, Fall 2024 - Homework 8

DUE: Friday 10/25/22, 11:59pm

Problem 4.1 Consider electrons on a two dimensional square lattice with lattice constant a in the tight-binding approximation. Using one orbital per site and only nearest neighbor hopping and t=1, the resulting energy is $E(k_x, k_y) = \epsilon_0[2 - cos(ak_x) - cos(ak_y)]$.

4.1.1 What is the value of the energy at the Γ (center), X (middle of side face), and W (corner) high symmetry points of the first Brillouin zone? (3 points)

4.1.2 Sketch a few constant energy curves on the 2D Brillouin zone for k_x, k_y very close to the Γ and W points. (2 points)

4.1.3 Sketch the k_x, k_y curve corresponding to E(k_x, k_y) = $2\epsilon_0$. (4 points)

4.1.4 Sketch E($|k|$) along the Γ-X and W-X lines of the first Brillouin Zone. (4 points)

4.1.5 With one electron per site in this crystal, is this a metal or an insulator? Draw the Fermi surface. What is the Fermi energy? (4 points)

4.1.6 With two electrons per site in this crystal, is this a metal or an insulator? Draw the Fermi surface. What is the Fermi energy? (3 points)