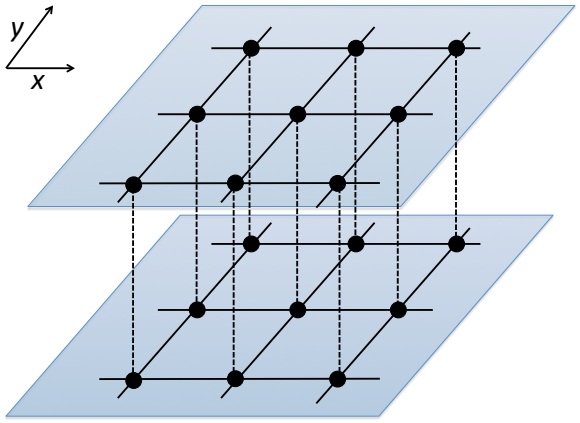
Consider the 2D solid pictured below composed of two atom-thick simple cubic lattices of H atoms placed on top of each other. The distance between two adjacent atoms on a plane is $a = 1$.




1. The electronic structure of such solid can be described by an orthogonal tight-binding model using the $1s$ orbitals of H as basis set. Write the expression for the 2D band structure when the on-site energy is $\epsilon$, the nearest neighbors hopping parameter between H atoms on the same lattice is $t_0$ and the hopping parameter between H atoms sitting on different lattices is $t_1$.

2. By taking the numerical values $\epsilon = 0$, $t_0 = -2$ and $t_1 = -0.1$ plot the band dispersion along the directions:

$$\Gamma \to D \to X \to \Gamma$$

   where $\Gamma = (0, 0)$, $X = (\pi, 0)$ and$D = (\pi, \pi)$.

3. By using the same numerical values for the parameters of section 2) calculate the equation for the Fermi surface when the Fermi energy is placed at $E = -7.8$. Make a draw of the Fermi surface over the two-dimensional Brillouin zone.

4. What is the probability to find an electron on the upper lattice when this occupies the lowest available energy state at $\Gamma = (0, 0)$?

Marking Scheme: A) 6 points, B) 9 points, C) 5 points, D) 5 points.