1 Fractal N = 1

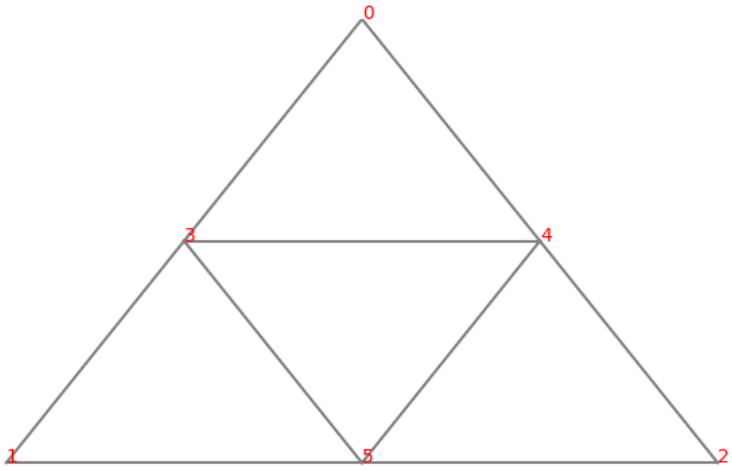

Figure 1: Lattice

1.1 Hamoltionian

$$H = \epsilon \left(\overline{\psi_{0,0}}\psi_{0,0} + \overline{\psi_{1,0}}\psi_{1,0} + \overline{\psi_{2,0}}\psi_{2,0} + \overline{\psi_{3,0}}\psi_{3,0} + \overline{\psi_{4,0}}\psi_{4,0} + \overline{\psi_{5,0}}\psi_{5,0} + \overline{\psi_{6,0}}\psi_{6,0} + \overline{\psi_{7,0}}\psi_{7,0} + \overline{\psi_{8,0}}\psi_{8,0}\right) - t \left(\overline{\psi_{0,0}}\psi_{3,0} + \overline{\psi_{0,0}}\psi_{4,0} + \overline{\psi_{1,0}}\psi_{3,0} + \overline{\psi_{1,0}}\psi_{5,0} + \overline{\psi_{2,0}}\psi_{4,0}$$

1.2 Matrix

$$\begin{bmatrix} \epsilon & 0 & 0 & -t & -t & 0 & 0 & 0 & 0 \\ 0 & \epsilon & 0 & -t & 0 & -t & 0 & 0 & 0 \\ 0 & 0 & \epsilon & 0 & -t & -t & 0 & 0 & 0 \\ -t & -t & 0 & \epsilon & -t & -t & 0 & 0 & 0 \\ -t & 0 & -t & -t & \epsilon & -t & 0 & 0 & 0 \\ 0 & -t & -t & -t & -t & \epsilon & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \epsilon & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \epsilon & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \epsilon \end{bmatrix}$$

1.3 Eigen Values

$$\left\{\epsilon : 3,\ \epsilon - t + \sqrt{5}t : 1,\ \epsilon + \tfrac{t}{2} + \tfrac{\sqrt{5}t}{2} : 2,\ \epsilon - \sqrt{5}t - t : 1,\ \epsilon - \tfrac{\sqrt{5}t}{2} + \tfrac{t}{2} : 2\right\}$$

1.4 Eigen Vectors

$$\left[\left(\epsilon,\ 3,\ \left[\begin{bmatrix}0\\0\\0\\0\\0\\1\\0\\0\end{bmatrix},\ \begin{bmatrix}0\\0\\0\\0\\0\\0\\1\\0\end{bmatrix},\ \begin{bmatrix}0\\0\\0\\0\\0\\0\\0\\1\end{bmatrix}\right]\right),\ \left(\epsilon - t + \sqrt{5}t,\ 1,\ \left[\begin{bmatrix}\frac{\epsilon-2t}{2t} - \frac{\epsilon-t+\sqrt{5}t}{2t}\\ \frac{\epsilon-2t}{2t} - \frac{\epsilon-t+\sqrt{5}t}{2t}\\ \frac{\epsilon-2t}{2t} - \frac{\epsilon-t+\sqrt{5}t}{2t}\\ 1\\1\\1\\0\\0\\0\end{bmatrix}\right]\right),\ \left(\epsilon + \tfrac{t}{2} + \tfrac{\sqrt{5}t}{2},\ 2,\ \left[\begin{bmatrix}0\\ \frac{-\epsilon-t}{t} + \frac{\epsilon+\frac{t}{2}+\frac{\sqrt{5}t}{2}}{t}\\ \frac{\epsilon+t}{t} - \frac{\epsilon+\frac{t}{2}+\frac{\sqrt{5}t}{2}}{t}\\ -1\\1\\0\\0\\0\\0\end{bmatrix},\ \begin{bmatrix}\frac{-\epsilon-t}{t} + \frac{\epsilon+\frac{t}{2}+\frac{\sqrt{5}t}{2}}{t}\\0\\ \frac{\epsilon+t}{t} - \frac{\epsilon+\frac{t}{2}+\frac{\sqrt{5}t}{2}}{t}\\-1\\0\\1\\0\\0\\0\end{bmatrix}\right]\right),\ \left(\epsilon - \sqrt{5}t - t,\right.$$