Higher-order Weyl Semimetals

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where $\gamma_{x,y}$ represent the intra-cell coupling along x, y, $\{\Gamma_\alpha\}$ are direct products of Pauli matrices, σ_i, κ_i, following $\Gamma_0 = \sigma^3\kappa^0$, $\Gamma_i = -\sigma^2\kappa^i$ for $i = 1, 2, 3$, and $\Gamma_4 = \sigma^1\kappa^0$.

$$\Gamma_1\Gamma_3 = \begin{pmatrix} & -1 & & \\ 1 & & & \\ & & & -1 \\ & & 1 & \end{pmatrix}$$

$$\Gamma_1 = \begin{pmatrix} & & & i \\ & & i & \\ & -i & & \\ -i & & & \end{pmatrix} \qquad \Gamma_3 = \begin{pmatrix} & & i & \\ & & & -i \\ -i & & & \\ & i & & \end{pmatrix}$$

$$\Gamma_2 = \begin{pmatrix} & & & 1 \\ & & -1 & \\ & -1 & & \\ 1 & & & \end{pmatrix} \qquad \Gamma_4 = \begin{pmatrix} & & 1 & \\ & & & 1 \\ 1 & & & \\ & 1 & & \end{pmatrix}$$

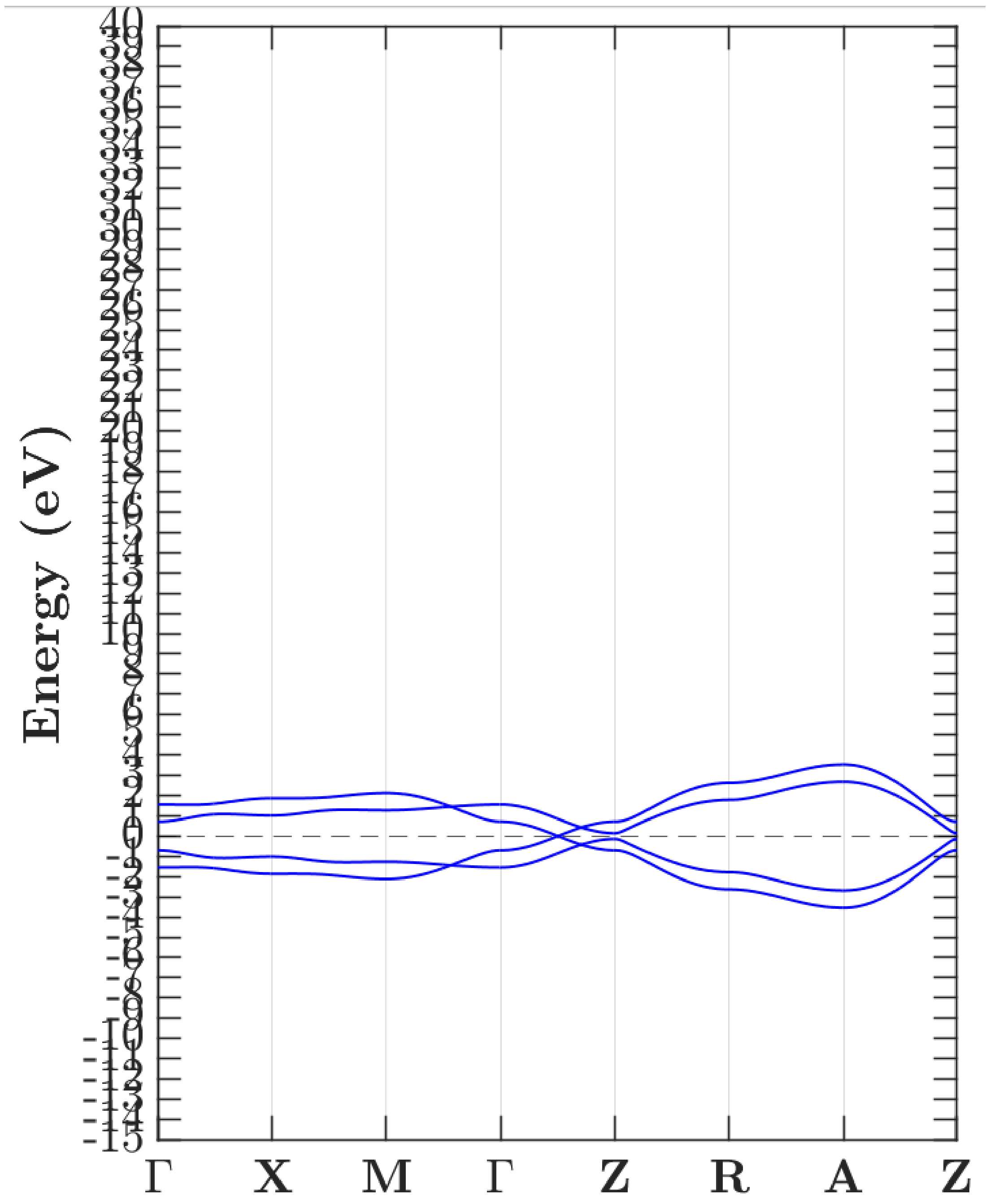
Model and Formalism.– We start with a simple model for HODSMs using spinless fermions from Ref. 38, whose Bloch Hamiltonian can be written as:

$$H_{HODSM}(\mathbf{k}) = \left(\gamma_x + \frac{1}{2}\cos k_z + \cos k_x\right)\Gamma_4 + \sin k_x \Gamma_3 + \left(\gamma_y + \frac{1}{2}\cos k_z + \cos k_y\right)\Gamma_2 + \sin k_y \Gamma_1, \tag{1}$$

shown in Fig. 1(c-e). We first consider $H^1 = H_{HODSM} + m_1 i\Gamma_1\Gamma_3$, which breaks time-reversal symmetry $\mathcal{T}$, $\mathcal{M}_x$,

$\gamma_x = \gamma_y = \gamma$.

$$H = \begin{pmatrix} 0 & -im_1 & \left(\gamma + \frac{1}{2}\cos(k_z) + \cos(k_x)\right) + i * \sin(k_x) & \left(\gamma + \frac{1}{2}\cos(k_z) + \cos(k_y)\right) + i * \sin(k_y) \\ im_1 & 0 & -\left(\gamma + \frac{1}{2}\cos(k_z) + \cos(k_y)\right) + i * \sin(k_y) & \left(\gamma + \frac{1}{2}\cos(k_z) + \cos(k_x)\right) - i * \sin(k_x) \\ \left(\gamma + \frac{1}{2}\cos(k_z) + \cos(k_x)\right) - i * \sin(k_x) & -\left(\gamma + \frac{1}{2}\cos(k_z) + \cos(k_y)\right) - i * \sin(k_y) & 0 & -im_1 \\ \left(\gamma + \frac{1}{2}\cos(k_z) + \cos(k_y)\right) - i * \sin(k_y) & \left(\gamma + \frac{1}{2}\cos(k_z) + \cos(k_x)\right) + i * \sin(k_x) & im_1 & 0 \end{pmatrix}$$

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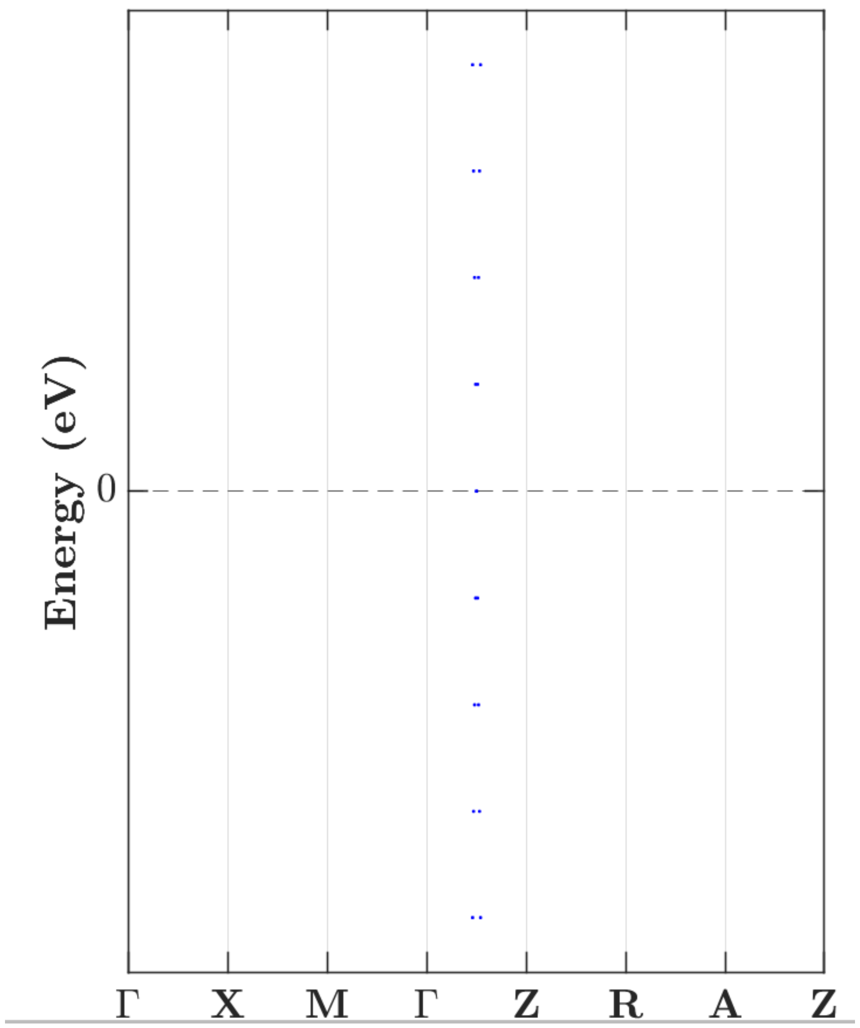
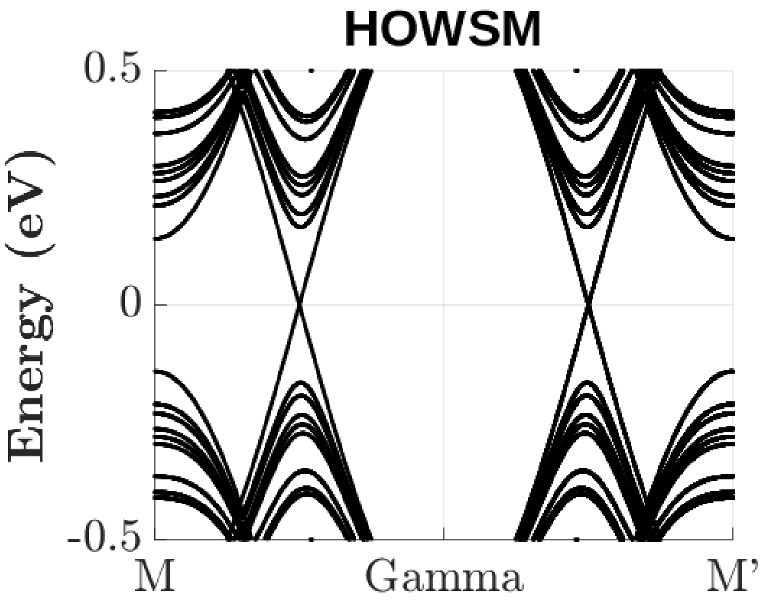
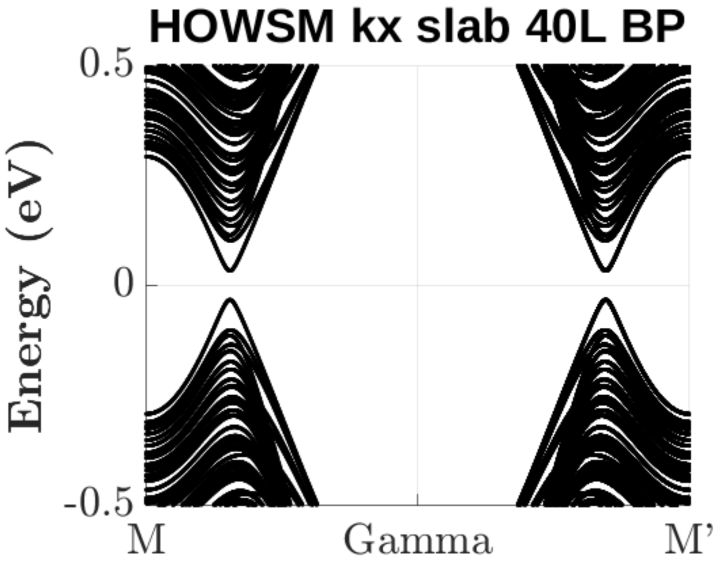
gamma = -0.7;
m1    = 0.6/sqrt(2);
```

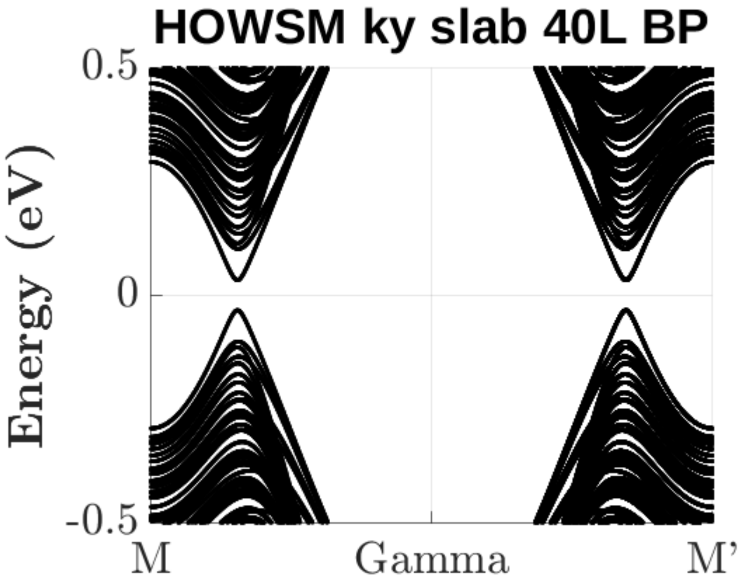


$projection\ to\ k_Z$

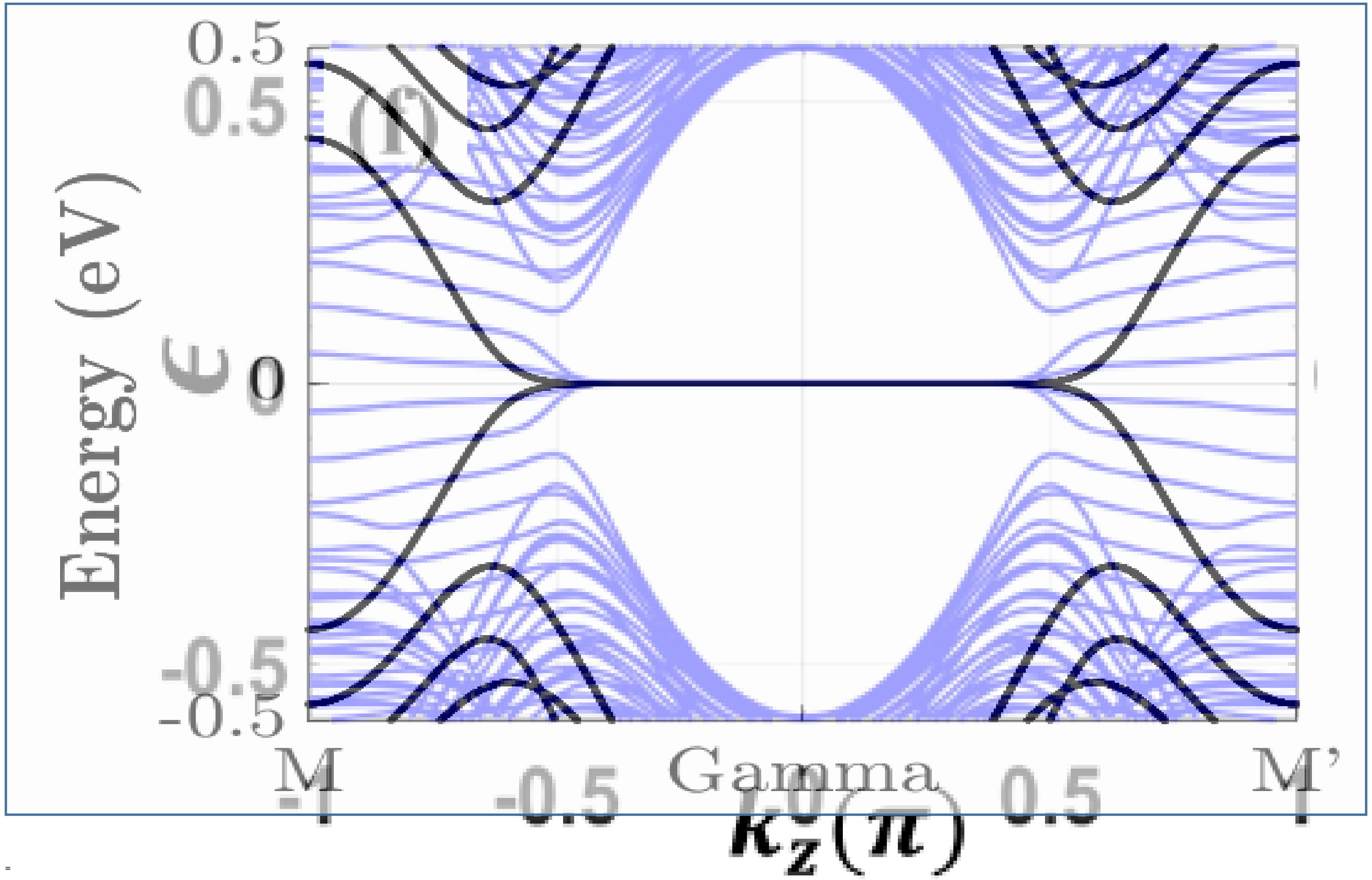
$bulk\ projection\ (3D \Longrightarrow 1D)$







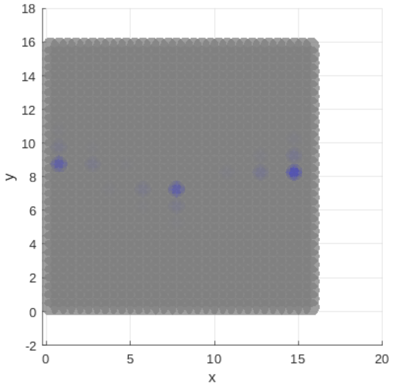
$16L \times 16L$

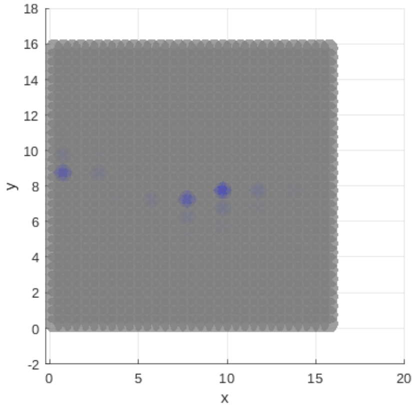


$at\ k_z = 0$

energy =

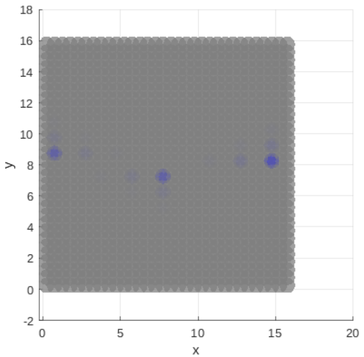
-8.8979e-12





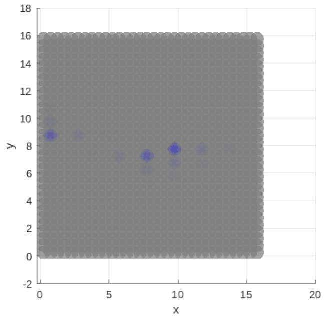
energy =

8.8970e-12

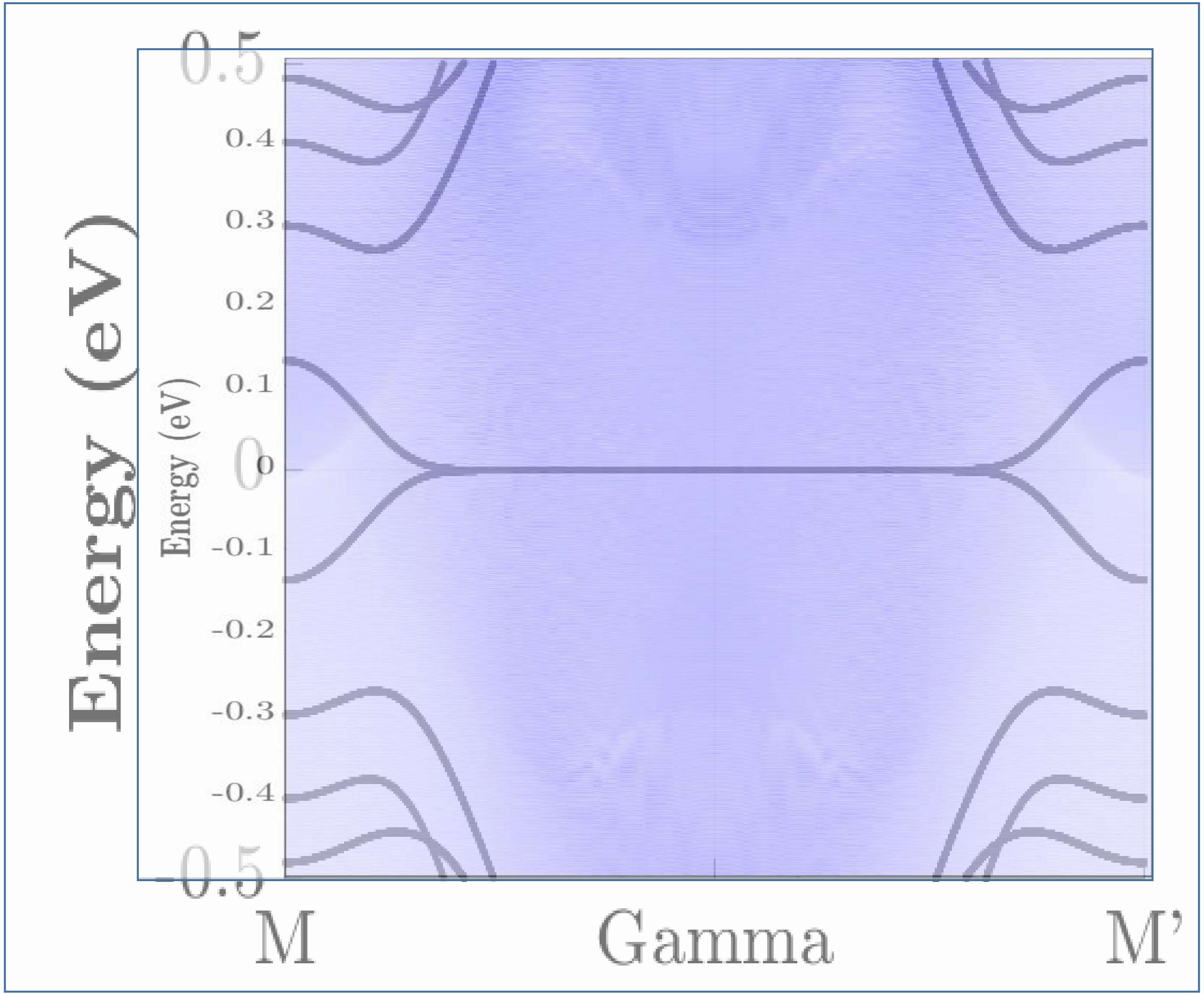


energy =

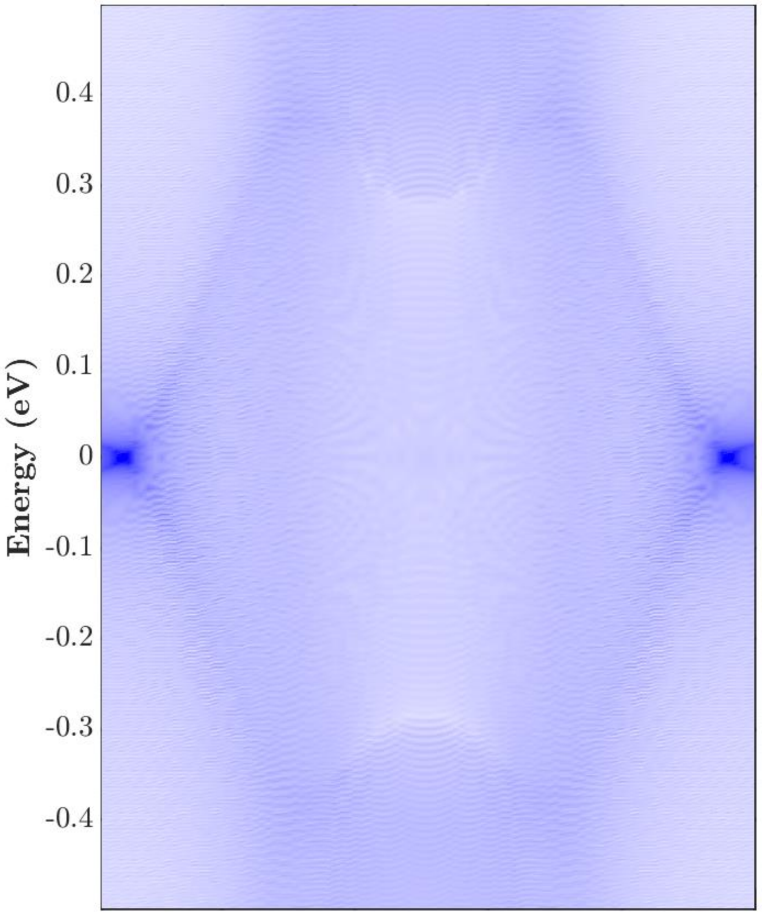
8.8973e-12



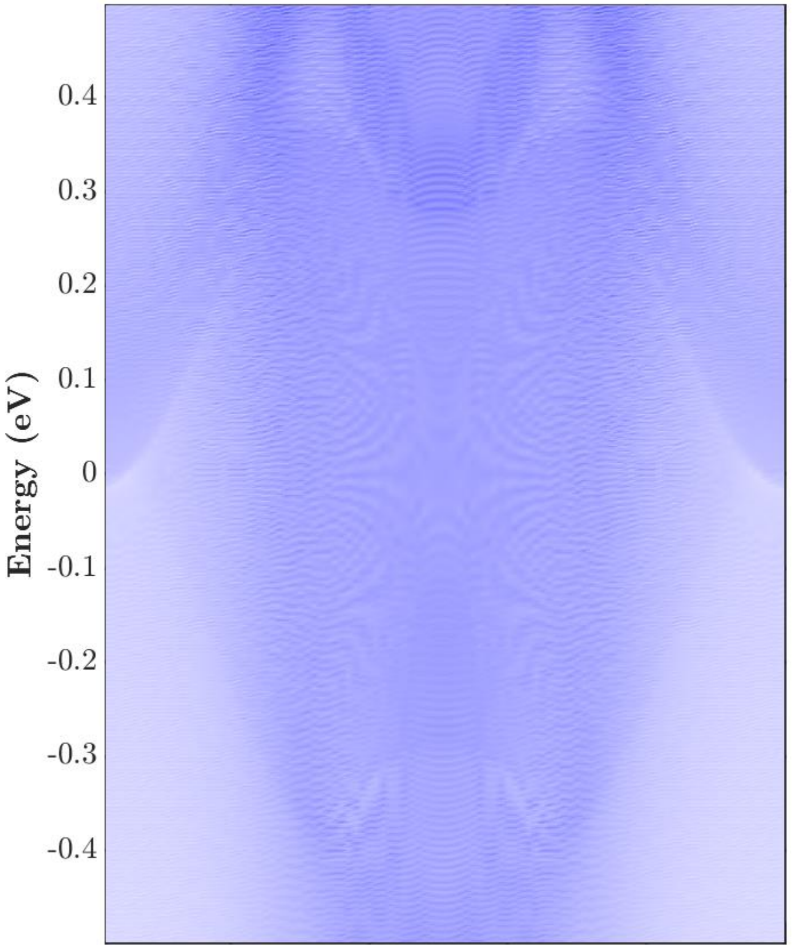
corner



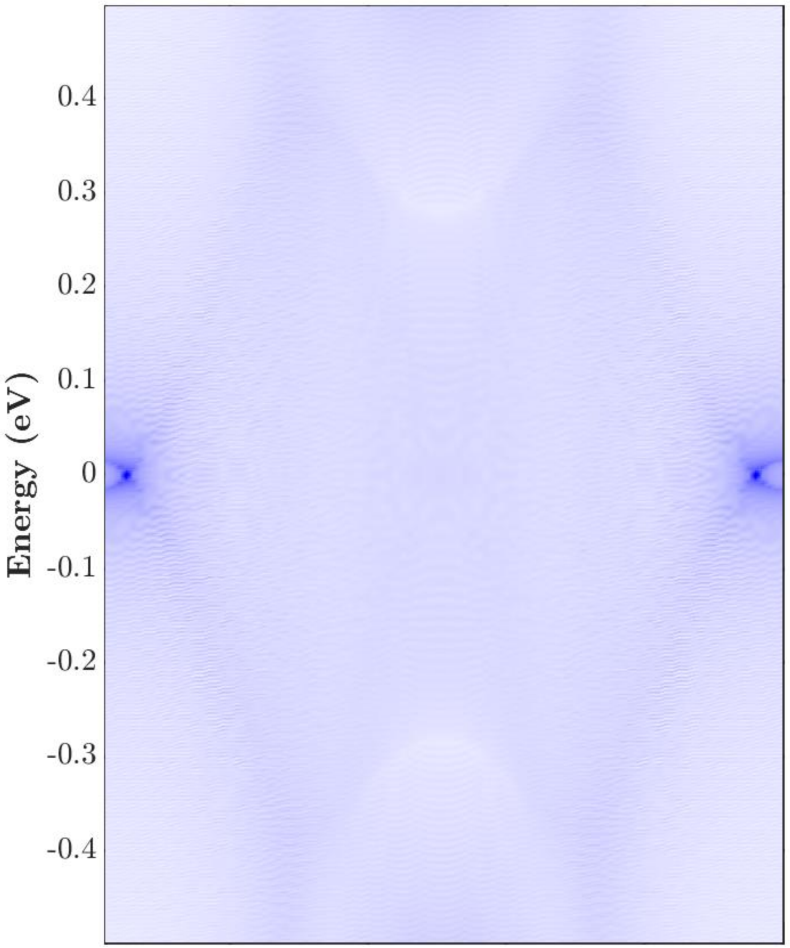
eastS

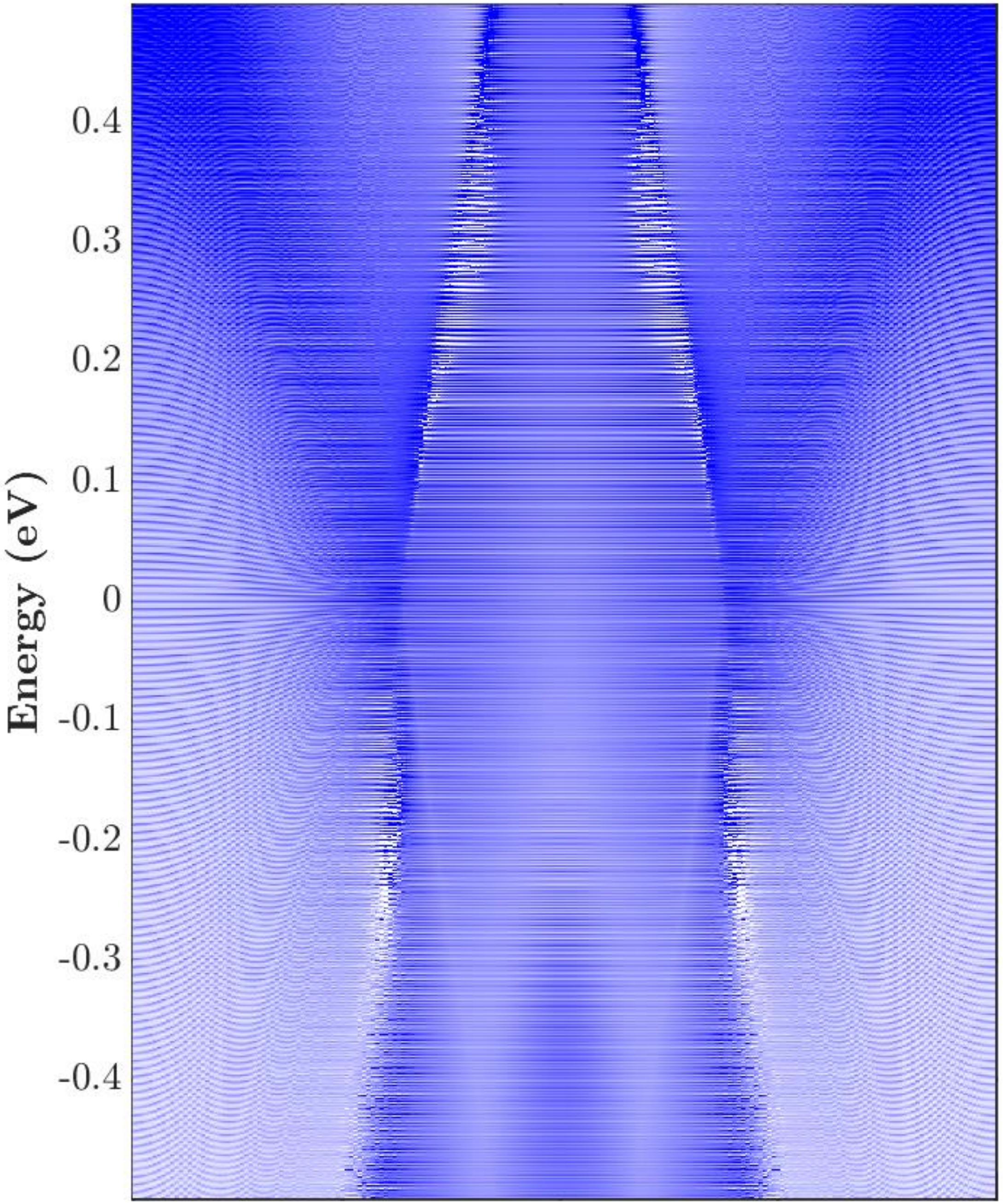


southS



bulk





Energy (eV)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4