Topological Mott insulator in the odd-integer filled Anderson lattice model with Hatsugai-Kohmoto interactions

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$$\mathcal{H} = \sum_{\mathbf{k}} \Psi^\dagger_{\mathbf{k}} \begin{pmatrix} (\epsilon_{\mathbf{k}} - \mu)\mathbb{1} & \mathbb{V}_{\mathbf{k}} \\ \mathbb{V}_{\mathbf{k}} & (\epsilon_f - \mu)\mathbb{1} \end{pmatrix} \Psi_{\mathbf{k}} + U_f n^f_{\mathbf{k}\Uparrow} n^f_{\mathbf{k}\Downarrow} + U_{fd}(n^d_{\mathbf{k}\uparrow} + n^d_{\mathbf{k}\downarrow})(n^f_{\mathbf{k}\Downarrow} + n^f_{\mathbf{k}\Uparrow}) + U_d n^d_{\mathbf{k}\uparrow} n^d_{\mathbf{k}\downarrow}$$

$$\mathcal{H} = \sum_{\mathbf{k}} \mathcal{H}_{\mathbf{k}} = \sum_{\mathbf{k}} \sum_n |\hat{\alpha}^n_{\mathbf{k}}\rangle \hat{\mathcal{H}}^n_{\mathbf{k}} \langle \hat{\alpha}^n_{\mathbf{k}}|$$

Mott insulator:

For filling 1: $\forall_{\mathbf{k},n\neq 1} \; E^{(1)}_{\mathbf{k}} < E^{(n)}_{\mathbf{k}}$

For filling 3: $\forall_{\mathbf{k},n\neq 3} \; E^{(3)}_{\mathbf{k}} < E^{(n)}_{\mathbf{k}}$

Topological invariant:

$$(-1)^\nu = \prod_{\mathbf{k}^* \in \{\Gamma, M, X, Y\}} \delta_{\mathbf{k}^*}$$

For filling 1: $\delta_{\mathbf{k}^*} = \mathrm{sgn}(\epsilon_{\mathbf{k}^*} - \epsilon_f)$

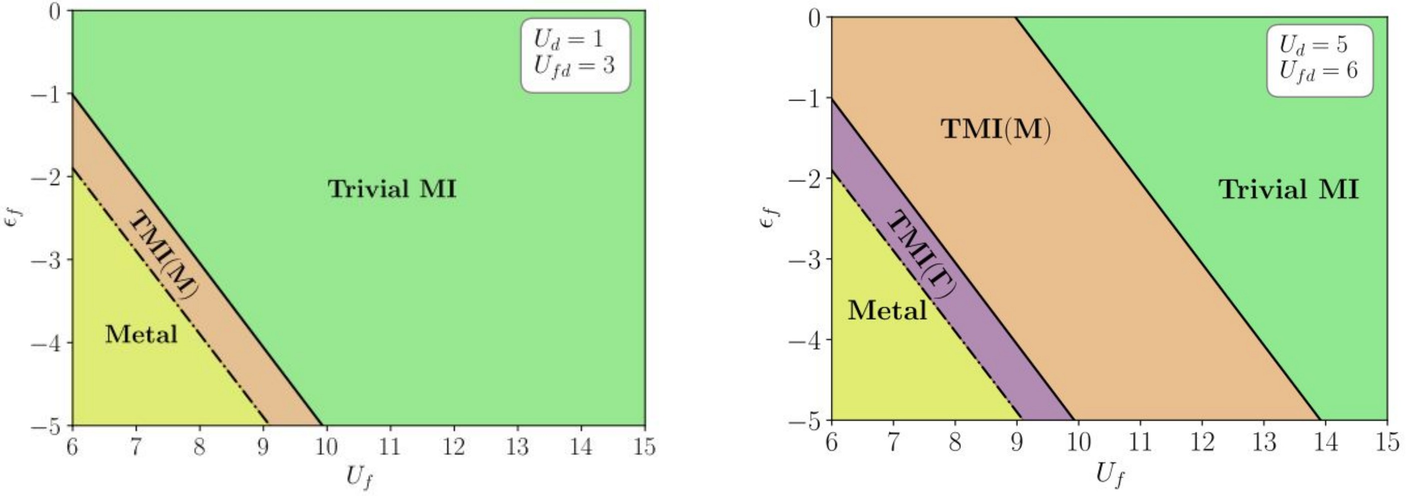
For filling 3: $\delta_{\mathbf{k}^*} = \mathrm{sgn}(\epsilon_{\mathbf{k}^*} - \epsilon_f + U_d - U_f)$

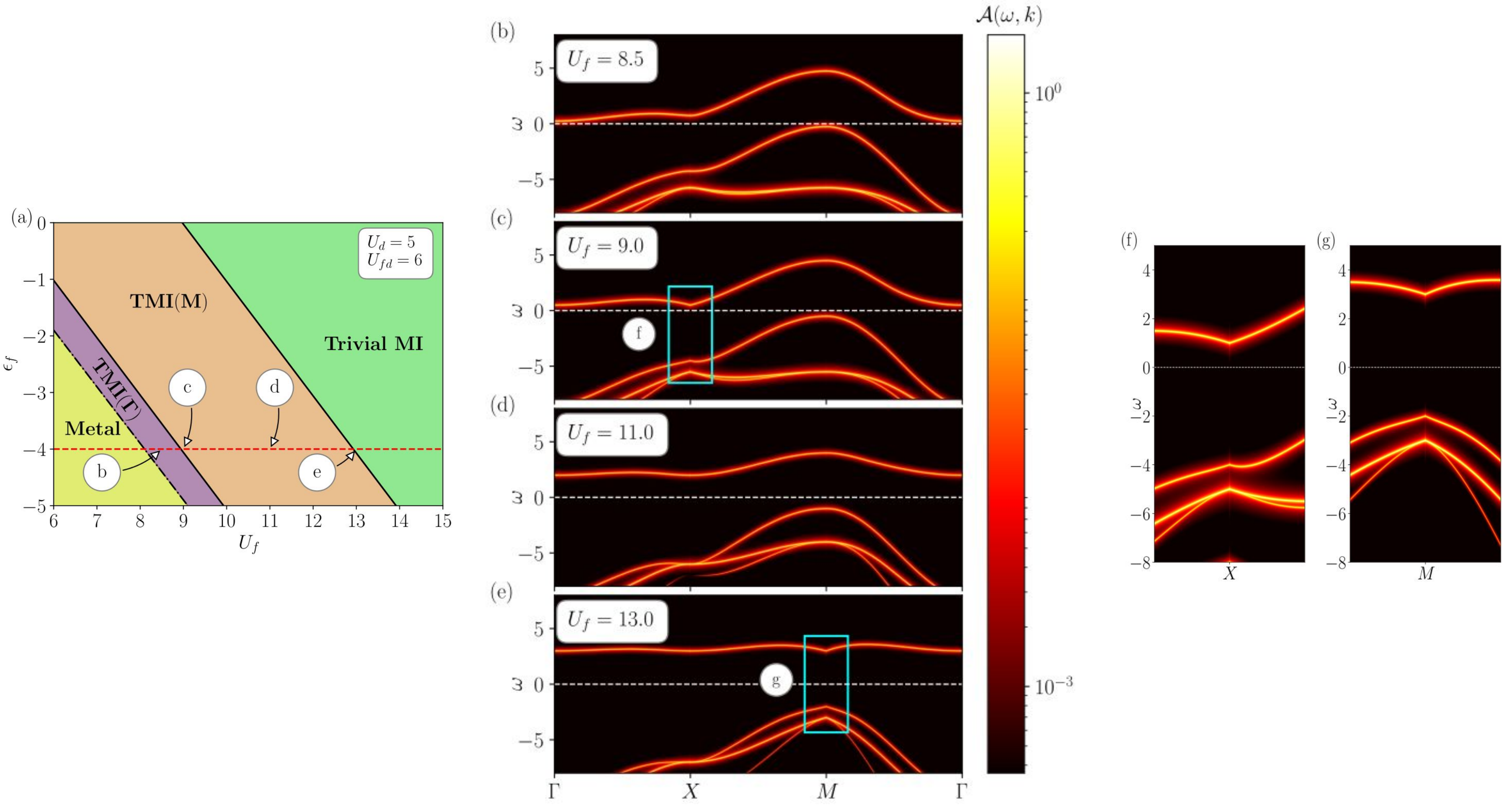
⇓

$\mathrm{TMI(M)} \longrightarrow \delta_{\mathbf{k}^*} = \{-1, 1, -1, -1\}$

$\mathrm{TMI}(\Gamma) \longrightarrow \delta_{\mathbf{k}^*} = \{-1, 1, 1, 1\}$

Phase diagram for filling 3




(a)
$U_d = 5$
$U_{fd} = 6$
TMI(M)
Trivial MI
TMI(Γ)
Metal
ϵ_f
U_f
(b)
$U_f = 8.5$
(c)
$U_f = 9.0$
(d)
$U_f = 11.0$
(e)
$U_f = 13.0$
ω
Γ
X
M
Γ
$\mathcal{A}(\omega, k)$
10^0
10^{-3}
(f)
(g)
X
M

Summary

- The topological Mott insulating phase are realised only if both the intra-f and intra-d and inter-f-d orbital interaction are taken into account
- The topological phase transitions are not associated with a spectral gap closing
- Transitions to different topological phases are signaled by a kink in the spectral function