

# Wannier representation of $Z_2$ topological insulators

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We consider the problem of constructing Wannier functions for  $Z_2$  topological insulators in two dimensions. It is well known that there is a topological obstruction to the construction of Wannier functions for Chern insulators (IQHE insulators), but it has been unclear whether this is also true for the  $Z_2$  case. We consider the Kane-Mele tight-binding model, which exhibits both normal and topological insulating phases as a function of the model parameters. We do find a topological obstruction in the  $Z_2$  odd phase, but only if one insists on choosing a gauge that respects the time-reversal symmetry, corresponding to Wannier functions that come in time-reversal pairs. If instead we are willing to violate this gauge condition, a Wannier representation becomes possible. We present an explicit construction of Wannier functions for the topological phase of the Kane-Mele model and confirm that these Wannier functions correctly represent the electric polarization and other electronic properties of the insulator. The choice of a smooth gauge of the Bloch states for the general case of  $Z_2$  insulator is also discussed.