Dirac points and band-gap morphing in α-T_3 superlattices

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Electrons in α-T_3 lattices behave as condensed-matter analogies of integer-spin Dirac Fermions[1,2]. The three atoms making up the unit cell bestow the energy spectrum with an additional energy band that is completely flat, providing unique electronic properties[2-4]. The interatomic hopping term, α, is known to strongly affect the electronic spectrum of the 2D lattice, allowing it to continuously morph from graphene-like responses to the behaviour of Fermions in a Dice lattice[1,2]. For pristine lattice structures, the energy bands are gapless, however small deviations in the atomic equivalence of the three sublattices will introduce gaps in the spectrum. It is unknown how these affect transport and electronic properties such as the energy spectrum of superlattice mini-bands. Here we investigate the dependency of these properties on the parameter α accounting for different symmetry-breaking terms and show how it affects band gap formation. Furthermore, we find that superlattices can force band gaps to close and shift in energy (see Figure 1(a)) and new allowed states in the energy spectrum are predicted in regions where previously there were band-gaps (see Figure 1(b)). Our results demonstrate that α-T_3 superlattices provide a versatile material for 2D band gap engineering purposes.

References

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Figures

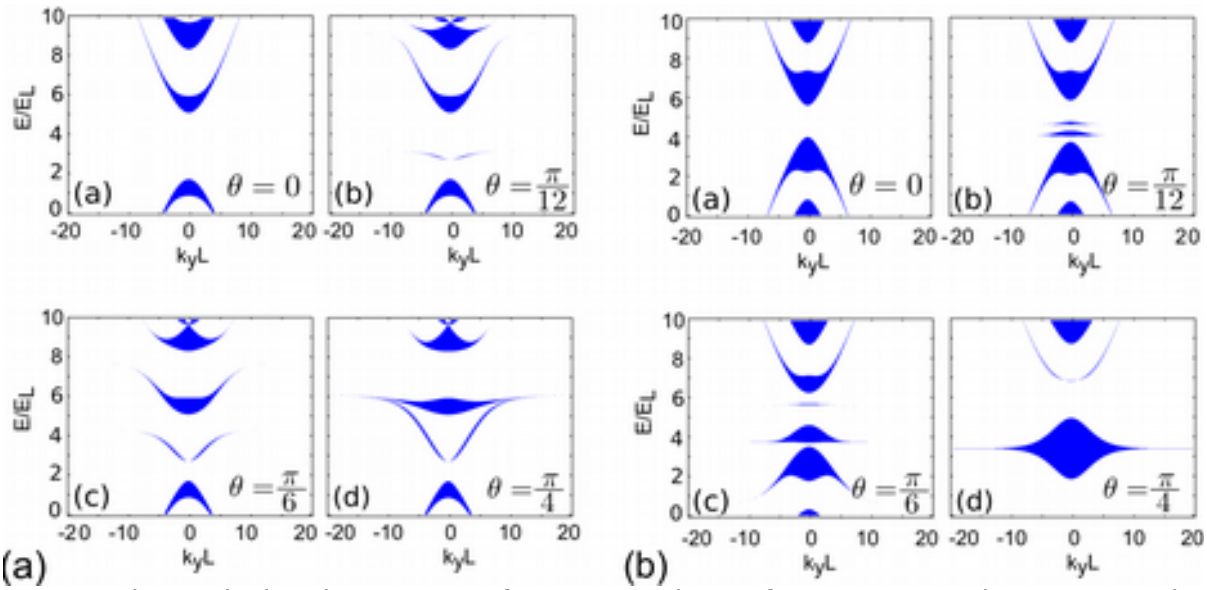

Figure 1: Electronic band structures for some values of α parameter in α-T_3 superlattice assuming the symmetry breaking terms given by the 3 x 3 matrices (a) $U_1 = diag(\Delta,-\Delta,\Delta)$, and (b) $U_2 = diag(\Delta,0,-\Delta)$ where Δ corresponds to the strength of the symmetry breaking.