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Berry phase oscillations in a one-dimensional Dirac comb

WILLIAM HODGE, NICHOLAS CASSERA, Stevenson University, MATTHEW RAVE, Western Carolina University — In quantum mechanics, the Berry phase is a geometric phase acquired by a wave function over the course of a cycle, when subjected to adiabatic processes. In general, this phase is due to the geometry of the underlying parameter space and thus depends only on the path taken. In any system described by a periodic potential, the torus topology of the Brillouin zone itself can lead to such a phase. In this work, we numerically calculate the Berry phase for a one-dimensional Dirac comb described by N distinct wells per unit cell. As expected, the resulting Berry phase exhibits a rich band-dependence. In the case where $N = 2$, we find that the Berry phase corresponding to the n^{th} energy band oscillates such that $\gamma_n(x) = A_n \sin(\pi x) \cos[(2n-1)\pi x]$, where A_n is a band-dependent constant and $0 < x < 1$ is the relative position of the two wells. This expression, obtained using perturbation theory, gives excellent agreement with exact numerical results, even at low energy levels. The Berry phase exhibits a similar behavior for cases where $N > 2$.

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