<u>Quiz</u>: Last time we established $c_n = Ae^{ikna}$ are the coefficients for a traveling wave LCAO solution. Write out the full wave fn $\Psi(x,t)$.

Act out the wave fn. Each person is a coefficient multiplying an atomic orbital.

When talking about phonons we saw similar traveling waves.

What are the similarities / differences?

- In both cases we are looking for a sequence of numbers

$$x_1, x_2 \cdots x_n$$
$$c_1, c_2 \cdots c_n$$

- Bands of allowed freqs / energies

	The quantity that changes from lattice site to lattice site	Governing eq^n
Phonon	x_n displacement of the n^{th} atom. Has to be real #.	$-m\omega^2 x_n = Kx_{n-1} - 2Kx_n + Kx_{n+1}$
Electron LCAO state	c_n coefficient multiplying the n^{th} atomic orbital. Can be complex #.	$Ec_n = \beta c_{n-1} + \alpha c_n + \beta c_{n+1}$

Question to consider:

The governing eq^{n}s are essentially the same, so why do the dispersion relations have different shapes?

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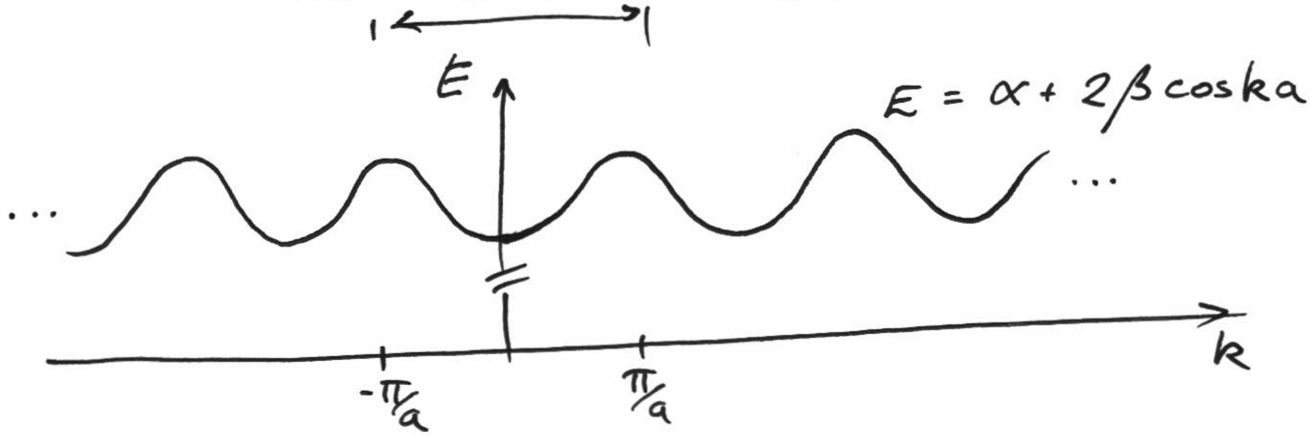

The dispersion relation is well-defined for all k, but all the eigenstates are described with $-\frac{\pi}{a} < k \leq \frac{\pi}{a}$.

What happens when k is outside this range?

Consider a value of k that is inside the 1^{st} B.Z.

$$c_{n,k} = Ae^{ikna}$$

Consider another value, $k' = k + \frac{2\pi}{a}$ (outside the 1^{st} B.Z.)

$$c_{n,k'} = Ae^{ik'na} = Ae^{i(k+\frac{2\pi}{a})na}$$

$$= Ae^{ikna}e^{i2\pi n}$$

$$= Ae^{ikna}$$

The k eigenstate has the same coefficients as the k' eigenstate.

They are the same state!

A strange prediction:

I apply a force to an electron in a periodic potential.

The force leads to a change in momentum.

$$F = \frac{dp}{dt} \quad \text{where } p = \hbar k.$$

The electron moves into states with larger k, but eventually it returns to exactly the same state!

Do you subscribe to the philosophy of Paul Dirac?

"Have faith in the logic of mathematics as a means to physical reasoning."

* Bloch Oscillations do occur in nature, see paper by Dahan et al. Phys. Rev. Lett. 76 4508 (1996)