به نامِ خدا

دانش‌گاهِ صنعتی‌ِ اصفهان ـ دانش‌کده‌ی فیزیک

تصاویرِ فصل ۱۰

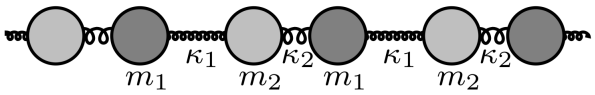

Fig. 10.1 A general diatomic chain with two different types of atoms (i.e., two different masses) and two different types of springs.

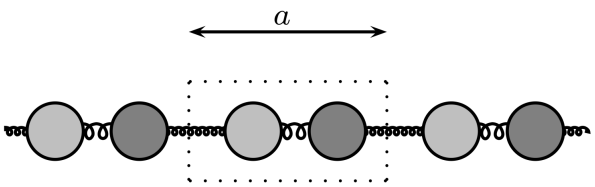

Fig. 10.2 A unit cell for the diatomic chain.

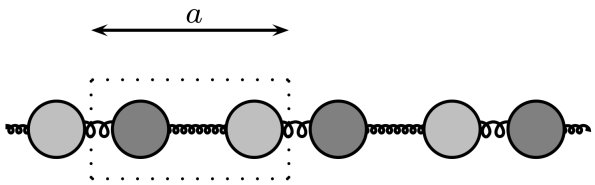

Fig. 10.3 Another possible unit cell for the diatomic chain.

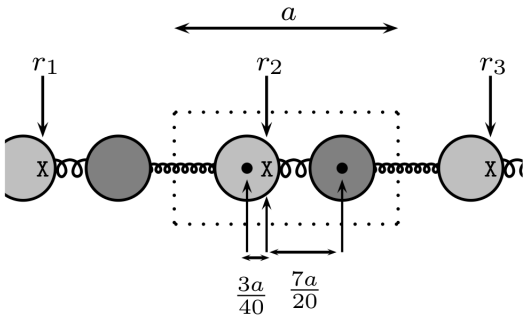

Fig. 10.4 The *basis* describes the objects in the crystal with respect to the positions of the reference lattice points. Here the reference point (at position r_n) is marked with an X.

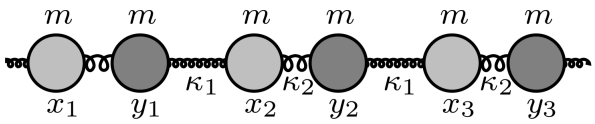

Fig. 10.5 The *alternating chain* has all masses the same but the values of the spring constants alternate.

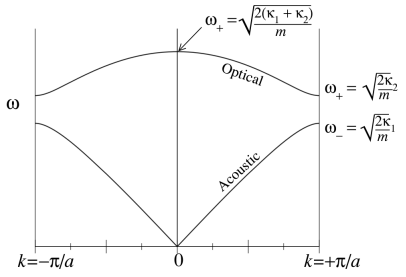

Fig. 10.6 Dispersion relation for vibrations of the one-dimensional diatomic chain. The dispersion is periodic in $k \to k + 2\pi/a$. Here the dispersion is shown for the case of $\kappa_2 = 1.5\kappa_1$. This scheme of plotting dispersions, putting all normal modes within the first Brillouin zone, is the *reduced zone scheme*. Compare this to Fig. 10.8.

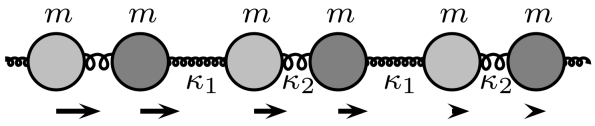

Fig. 10.7 A long wavelength acoustic mode for the alternating chain.

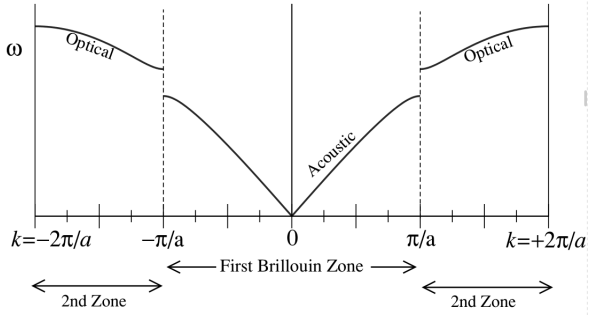

Fig. 10.8 Dispersion relation of vibrations of the one-dimensional diatomic chain in the extended zone scheme (again choosing $\kappa_2 = 1.5\kappa_1$). Compare this to Fig. 10.6. One can think of this as just unfolding the dispersion such that there is only one excitation plotted at each value of k. The first and second Brillouin zones are labeled here

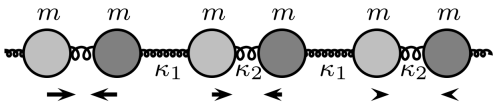

Fig. 10.9 A long-wavelength optical mode for the alternating chain.

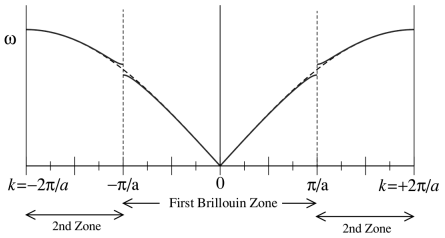

Fig. 10.10 How a diatomic dispersion becomes a monatomic dispersion when the two different atoms become the same. **Solid:** Dispersion relation of vibrations of the one-dimensional diatomic chain in the extended zone scheme with κ_2 not too different from κ_1 ($\kappa_2 = 1.25\kappa_1$ here). **Dashed:** Dispersion relation when $\kappa_2 = \kappa_1$. In this case, the two atoms become exactly the same, and we have a monatomic chain with lattice spacing $a/2$. This single band dispersion precisely matches that calculated in Chapter 9, only with the lattice constant redefined to $a/2$.

- A unit cell is the repeated motif that comprises a crystal.
- The basis is the description of the unit cell with respect to a reference lattice.
- The lattice constant is the size of the unit cell (in 1d).

- If there are M atoms per unit cell we will find M normal modes at each wavevector k (for one-dimensional motion).
- One of these modes is an acoustic mode, meaning that it has linear dispersion at small k, whereas the remaining $M-1$ are optical, meaning they have finite frequency at $k=0$.
- For the acoustic mode, all atoms in the unit cell move in-phase with each other (at $k=0$), whereas for optical modes they move out of phase with each other (at $k=0$).
- If all of the dispersion curves are plotted within the first Brillouin zone $|k| \leqslant \pi/a$ we call this the reduced zone scheme. If we "unfold" the curves such that there is only one excitation plotted per k, but we use more than one Brillouin zone, we call this the extended zone scheme.
- For a diatomic chain, if the two atoms in the unit cell become identical, the new unit cell is half the size of the old unit cell. It is convenient to describe this limit in the extended zone scheme.
