

# Lattice vibrations and phonons

## Additional reading

- Ashcroft, chapters 23 and 24
- Any book on solid state physics
- The field theoretic aspects are well discussed in chapter 1 of Aetland

Lattice vibrations and phonons

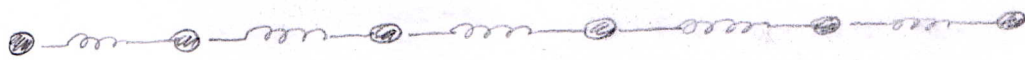
Additional reading

## Phonons in one dimension

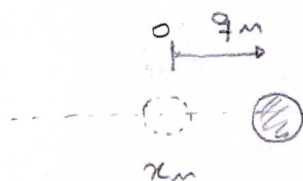
The atoms in a solid are allowed to vibrate slightly around their equilibrium positions. These are mechanical vibrations, which you hear and feel whenever you kick a material. We will learn that these vibrations are actually quantized. A quanta of lattice vibration is called a phonon.

Phonons are an essential part of condensed matter physics. They contribute to most of the specific heat of a solid and most of the thermal conductivity. Moreover, they interact with the electrons and this is the origin of superconductivity and other interesting effects.

To understand phonons we are going to look at the simplest possible model: a 1D chain of particles connected by springs



Let  $x_n = a_n$  denote the equilibrium position of each atom and let  $q_n$  denote the displacement of this atom from equilibrium



$q_n = 0$  if atom  $n$  is at  $x_n$