

Answer on Question #51571, Physics, Solid State Physics

Explain how a linear monoatomic chain behaves as a low pass filter.

Answer:

The propagation of harmonic waves in a linear chain consisting of equally spaced masses m connected by linear springs of stiffness k has been studied extensively. The chain behaves as a low pass filter so that waves can propagate without attenuation below the frequency $\omega_0 = 2\sqrt{k/m}$. Above this frequency, the amplitude decays exponentially and those waves are called evanescent waves. The $[0, \omega_0]$ frequency range is called a pass-band and in that range the dispersion relation is given by $\omega = \omega_0 \sin(ka/2)$ where $k = 2\pi/\lambda$ is the wave number, λ is the wavelength, and a is the distance between two consecutive masses. In that range, waves with different phase velocities $c = \omega/k$ and group velocities $C_g = d\omega/dk$.

For long waves ($k \rightarrow 0$), the chain behaves as a rod governed by the classical wave equation. Several higher order continuum models are derived from the dispersion relation.