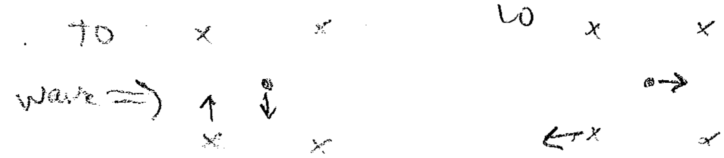
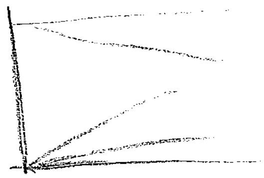
guess at 2D 2 atoms/cell? → 2 acoustic + 2 optical
LA, TA   LO, TO

what does these look like?



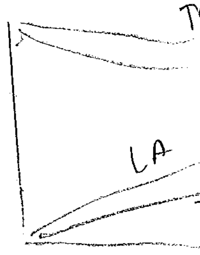
day 15
pg 1



Side topic: effect of finite length
→ coupled eqns
→ N×N matrix
→ N frequencies
Important sidenote before CVM on next page!

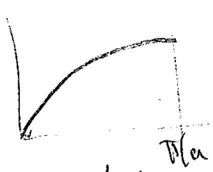
See Fig 8a pg 96

3D, 2 atoms/cell Germanium



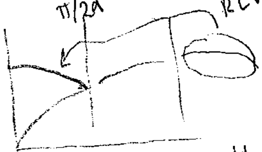
$ { handout w/ Si, GaAs, SnTe } → why GaAs optical split at k→0? see next page

Final note: zone folding



1D, 1 atom/cell

vs



1D 2 atoms/cell for lattice const 2a
→ but same atom!

They are the same!

Si

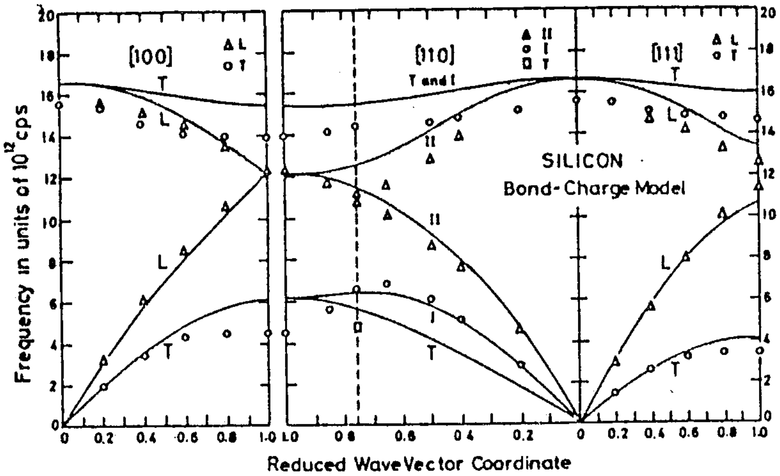
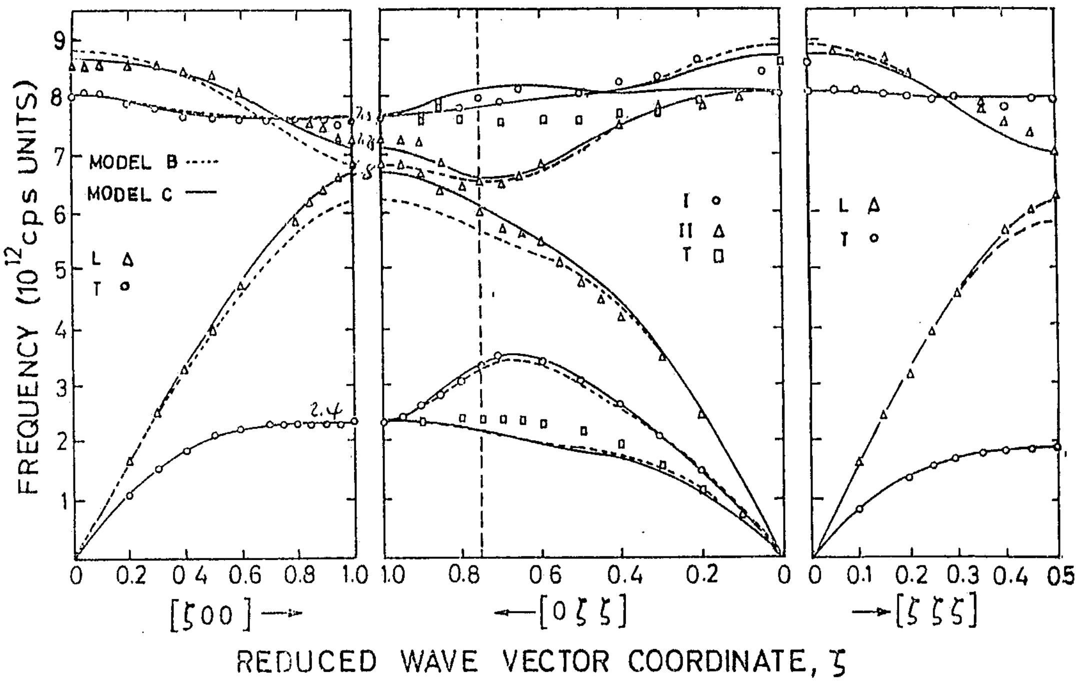


FIGURE 16. Comparison of Martin's bond charge model calculation with the experimental phonon frequencies in Si. (From Martin, R. M., *Phys. Rev.*, 186, 871, 1969. With permission.)

GaAs



SnTe

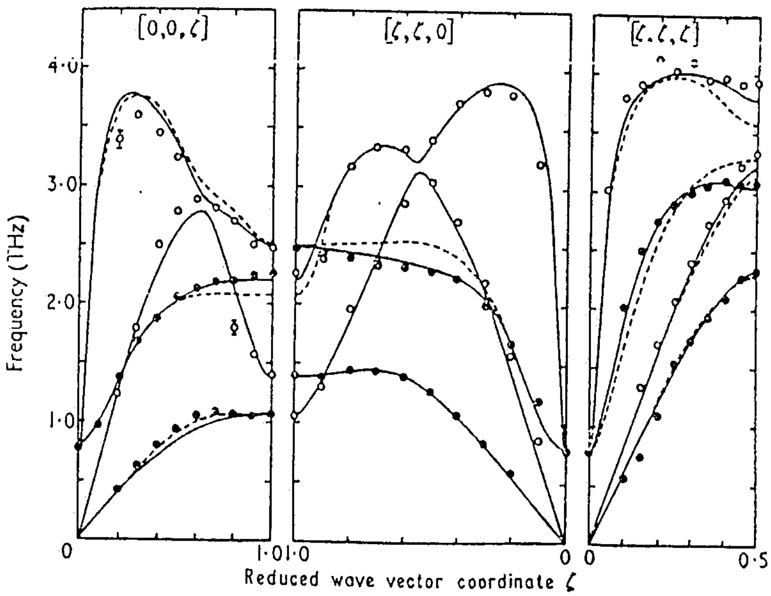
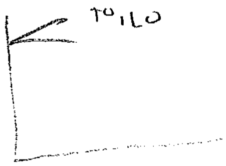


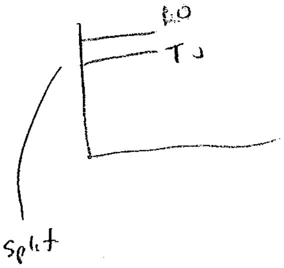
FIGURE 15. Dispersion curves for SnTe along the principal symmetry directions. The solid curve represents a 14-parameter shell model fit (modified to include free carrier screening effects). (From Cowley, E. R., *J. Phys. C. Solid State Phys.*, 2, 1916, 1969. With permission.)

Physical insight:

Si



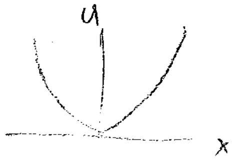
GaAs



For LO, additional contribution to energy from Coulomb

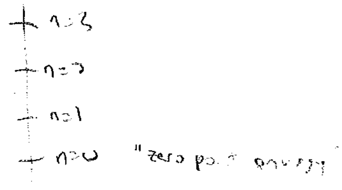
Quantization of Elastic Waves

QM: not all energies are allowed. For spring



allowed energies are
$\left(n+\frac{1}{2}\right)\hbar\omega$

$\hbar = \frac{h}{2\pi}$, $\omega = \sqrt{\frac{k}{m}}$



Actual energy spacing = tiny compared to macroscopic energies

Appendix C: A bunch of masses and springs acts similarly

call these "phonon modes" or just "phonons" for short

n = # phonons that are excited
(a little different than n in SHO problem)

Book analysis

$$u_0 = \sqrt{\frac{4(n+\frac{1}{2})\hbar}{\rho V \omega}}$$

{ Can't get arbitrary amplitude! }

ω ← freq. from dispersion relation (depends on which branch; then ω is set by n, and then dispersion relation gives k)

More on occupation of modes to follow in next chapter

Phonon Momentum

$$\vec{p} = \hbar \vec{k}$$

↳ "crystal momentum"

Example on next pg

Remember: ~~—~~ $\vec{k}$ is only defined modulo $\vec{G}$ = RLV

"crystal momentum" ≠ "actual momentum"