FYS3410 - Vår 2016 (Kondenserte fasers fysikk)

http://www.uio.no/studier/emner/matnat/fys/FYS3410/v16/index.html

Pensum: Introduction to Solid State Physics
by Charles Kittel (Chapters 1-9 and 17, 18, 20)

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2016 FYS3410 Lectures (based on C.Kittel's Introduction to SSP, Chapters 1-9, 17,18,20)

Module I – Periodic Structures and Defects (Chapters 1-3, 20)

M18/1: 9-12 am	**Introduction. Crystal bonding. Periodicity and lattices, Brag diffraction and Laue condition, reciprocal space**	**3h**
W20/1 cancelled		
M25/1: 9-12 am	**Ewald construction, interpretation of a diffraction experiment , Brag planes, and Brillouin zones**	**3h**
W27/1 cancelled		
M01/2: 10-12 am	**Elastic strain and structural defects in crystals**	**2h**
W03/2: 9-10 am	**Atomic diffusion in solids**	**1h**
M08/2: 10-12 am	**Summary of Module I**	**2h**

Module II – Phonons (Chapters 4 and 5)

W10/2: 9-10 am	**Vibrations in monoatomic and diatomic chains of atoms**	**1h**
M15/2: 10-12am	**Periodic boundary conditions, phonons and density of states (DOS)**	**2h**
W17/2: 9-10 am	**Planck distribution**	**1h**
M22/2 : 10-12am	**Lattice heat capacity: Dulong-Petit, Einstein, and Debye models**	**2h**
W24/2 cancelled		
M29/2: 9-12am	**Comparison of different models for lattice heat capacity, thermal conductivity with phonons**	**3h**
W02/3: 9-10 am	**Thermal expansion**	**1h**
M07/3: 10-12am	**Summary of Module II.**	**2h**

Module III – Electrons (Chapters 6, 7, 18 - pp.528-530, and Appendix D)

W09/3: 9-10 am	**Free electron gas (FEG) versus free electron Fermi gas (FEFG)**	**1h**
M14/3: 10-12am	**DOS of FEFG in 3D. Effect of temperature – Fermi-Dirac distribution**	**2h**
W16/3: 9-10 am	**Heat capacity of FEFG in 3D**	**1h**
W30/3: 9-10 am	**DOS in 2D - quantum wells**	**1h**
M04/4: 10-12am	**DOS in 1D and 0D, i.e. quantum wires and quantum dots; transport properties of electrons**	**2h**
W06/4: 9-10 am	**Origin of the energy band gap**	
M11/4: 10-12am	**Nearly free electron model. Kronig-Penney model. Empty lattice approximation.**	**2h**
W13/4: 9-10 am	**Number of orbitals in a band**	**1h**
M18/4: 10-12am	**Summary of Module III.**	**2h**

Module IV – Semiconductors and interfaces (Chapters 8, 9-pp 223-231, 17)

W20/4: 9-10 am	**Metals versus semiconductors. Surfaces and interfaces.**	**1h**
M25/4: 9-12 am	**Effective mass method.**	**3h**
W27/4: 9-10 am	**Intrinsic carrier generation – elctrons and holes.**	**1h**
M02/5: 9-12 am	**Localized levels for hydrogen-like impurities – donors and acceptors. Doping.**	**3h**
W04/5: 9-10 am	**Carrier statistics in semiconductors**	**1h**
M09/5: 9-12 am	**p-n junctions**	**3h**
W11/5: 9-10 am	**Optoelectronic semiconductor properties and devices**	**1h**
M18/5: 9-12 am	**Device demonstrations. Summary of Module IV**	**3h**

Repetition

M23/5 9-12 am	**The course in a nutshell**	**2h**

W25/5, M30/5 and W1/6 cancelled

Exam during week 22 (tentatively 30-31/5)

Thermal expansion

In a 1-D lattice where each atom experiences the same potential energy function U(x), we can calculate the average displacement of an atom from its equilibrium position:

$$\langle x \rangle = \frac{\int_{-\infty}^{+\infty} x e^{-U(x)/kT} dx}{\int_{-\infty}^{+\infty} e^{-U(x)/kT} dx}$$

Thermal Expansion in 1-D

Evaluating this for the harmonic potential energy function $U(x) = cx^2$ gives:

$$\langle x \rangle = \frac{\int_{-\infty}^{+\infty} x e^{-cx^2/kT}\, dx}{\int_{-\infty}^{+\infty} e^{-cx^2/kT}\, dx}$$

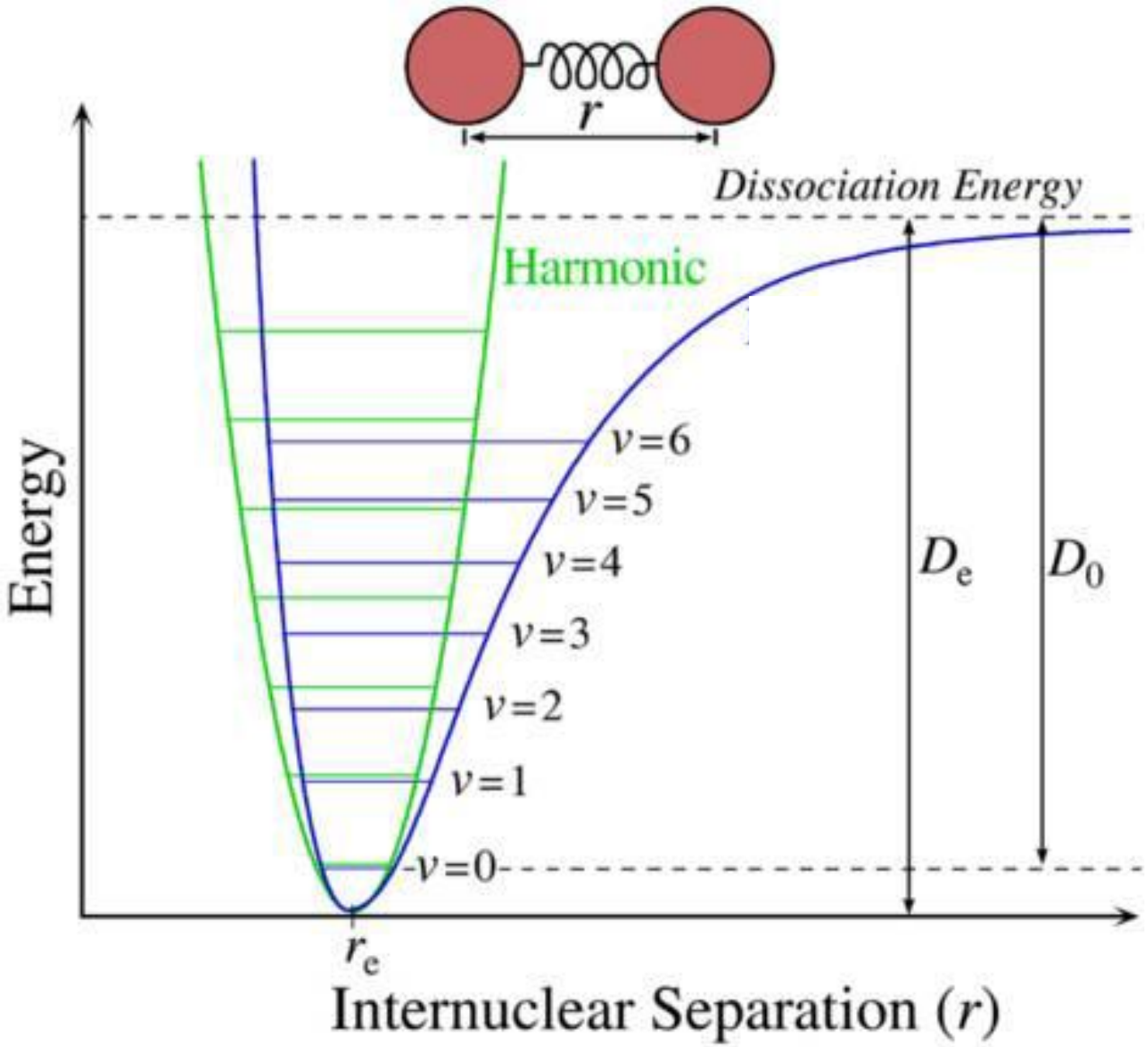
The numerator is zero!

$\langle x \rangle = 0$! independent of T !

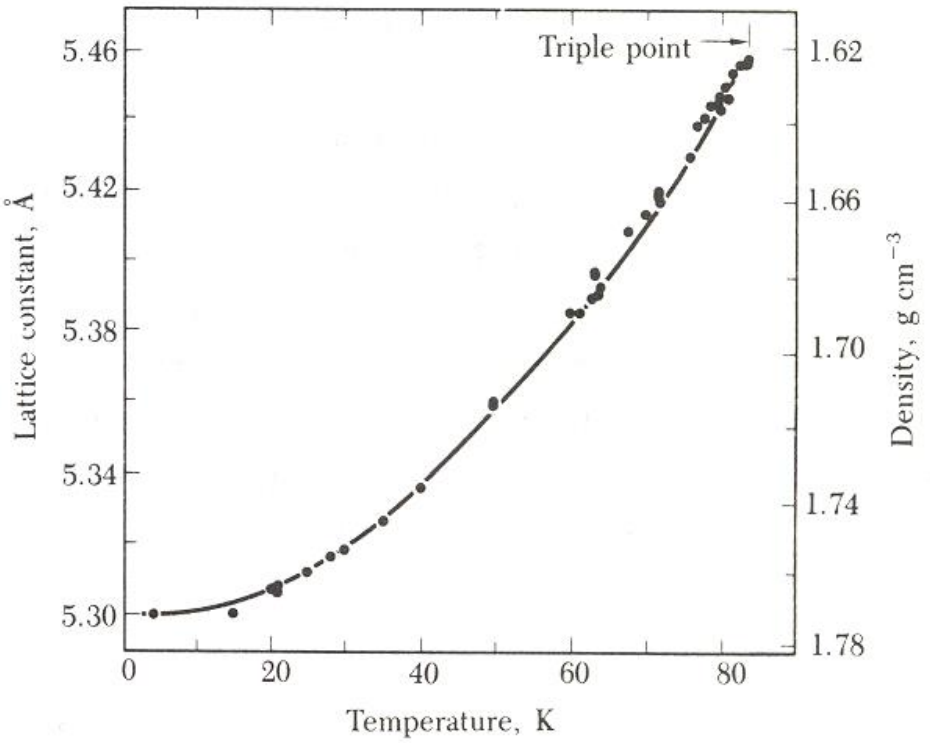
Thus any nonzero <x> must come from terms in U(x) that go beyond x^2. For HW you will evaluate the approximate value of <x> for the model function

$$U(x) = cx^2 - gx^3 - fx^4 \qquad (c, g, f > 0 \quad and \quad gx^3, fx^4 << kT)$$

Why this form? On the next slide you can see that this function is a reasonable model for the kind of U(r) we have discussed for molecules and solids.


r
Dissociation Energy
Harmonic
v=6
v=5
v=4
v=3
v=2
v=1
v=0
D_e
D_0
Energy
r_e
Internuclear Separation (r)

Lattice Constant of Ar Crystal vs. Temperature



Above about 40 K, we see: $a(T) - a(0) \propto \langle x \rangle \propto T$

Usually we write: $L = L_0\left(1 + \alpha\left[T - T_0\right]\right)$ α = thermal expansion coefficient