



ENGINEERING PHYSICS

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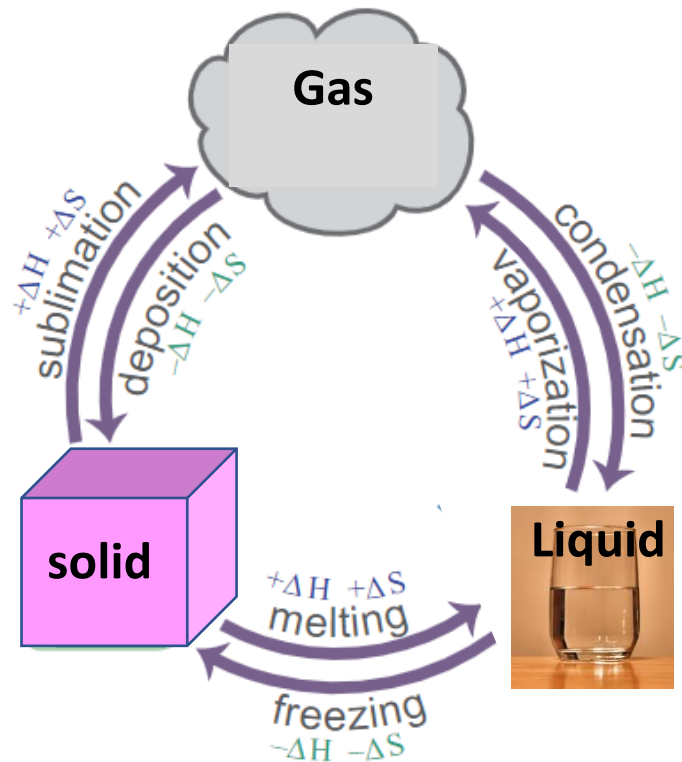
Department of Science and Humanities

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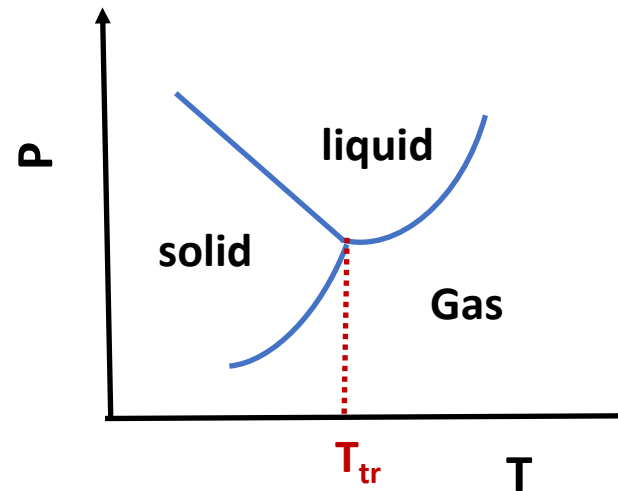
Unit 5 : Quantum mechanical treatment of Magnetic materials and Dielectrics

Phase Transitions

Water



Triple point of water



Metal



Image courtesy: Wikipedia

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- Free energy (G)
- Enthalpy (H)
- Entropy (S)

$$G=H-TS$$

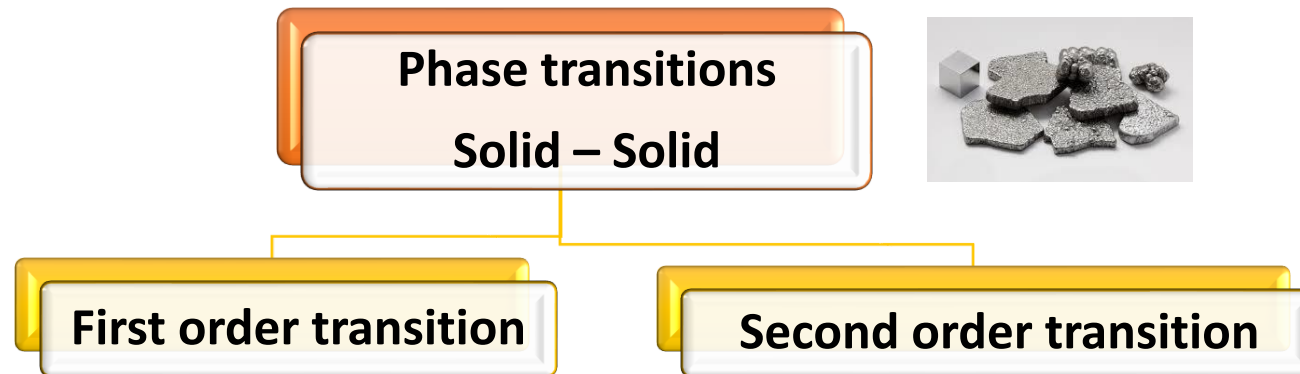
Characteristics

- Phase co-existence
- Critical points
- Symmetry
- Order/disorder

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Ehrenfest Classification



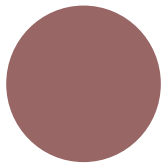
- Discontinuous in first derivative of G
$$\left(\frac{\partial G}{\partial T}\right)_V = S \text{ and } \left(\frac{\partial G}{\partial P}\right)_T = V$$
- Involves latent heat
- Eg: melting of ice
- Continuous in first derivative of G but exhibit discontinuity in second derivative of G
- Eg: Superconductors, Ferromagnetic phase transition

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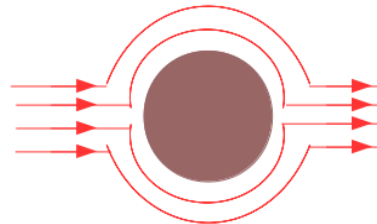
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Superconductor

- Meissner effect
- Perfect diamagnet
- Critical field and temperature



$H = 0, T < T_c$

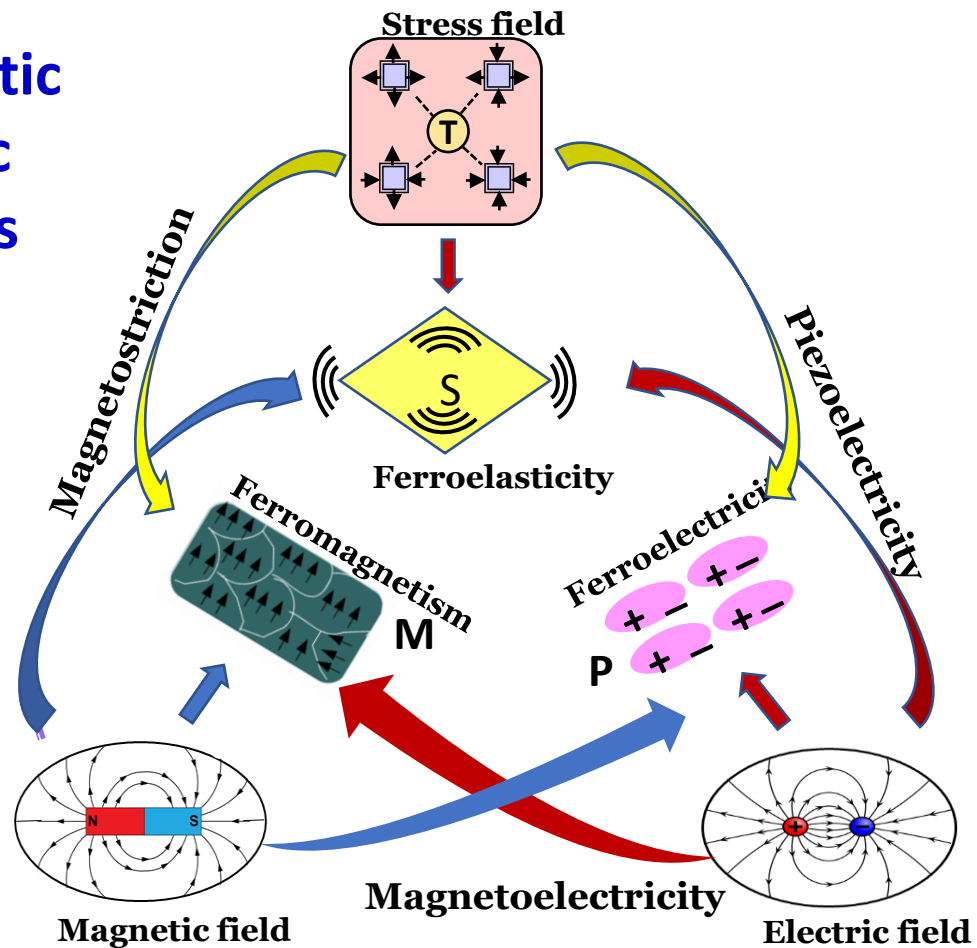


$H \neq 0, T < T_c$

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Ferromagnetic
Ferroelectric
Multiferroics



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PART A

Magnetic materials

- *Magnetization, susceptibility and permeability*
- *Origin of magnetism*
- *Classification of magnetic materials*
- *Diamagnetism*
- *Paramagnetism – Quantum and classical theory*
- *Ferromagnetism*
- *GMR effect & Applications*

PART B

Dielectrics

- *Polarisation mechanisms*
- *Non Linear dielectrics - BaTiO_3*
 - *Piezoelectric materials*
 - *Pyroelectric materials*
 - *Ferroelectric materials*
- *Applications*

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➤ *Suggested Reading*

1. *Quantum Physics of Atoms Nuclei and Molecules, Robert Eisberg, Robert Resnick, Wiley, 2nd edition, Ch 14, 2006.*
2. *The Science and Engineering of Materials by Donald R. Askeland, Pradeep P. Fulay, Wendelin J. Wright, 6th edition, Ch 19 & 20, 2011.*
3. *Learning material prepared by the Department of Physics, PESU*



THANK YOU

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