



# ENGINEERING PHYSICS

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**Ambika M R, Ph.D.**

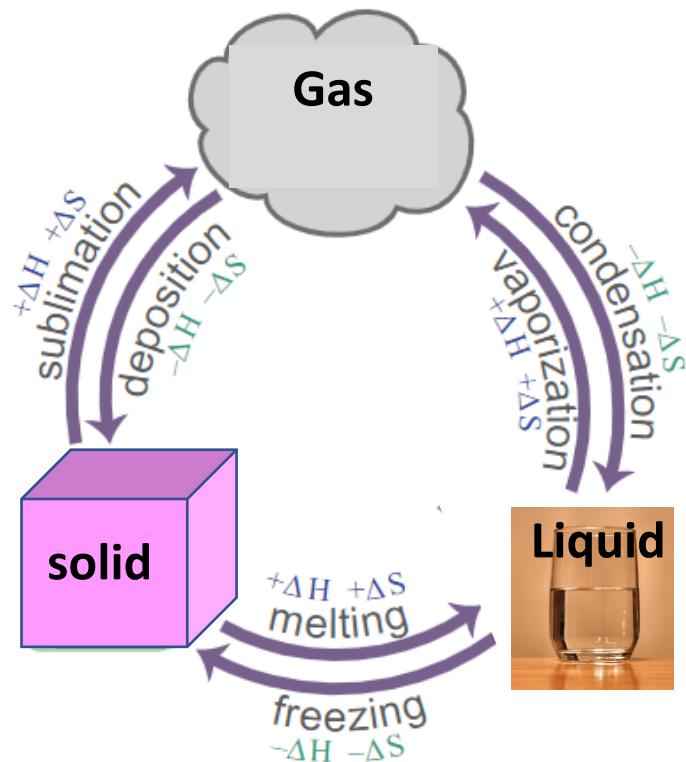
Department of Science and Humanities

# ENGINEERING PHYSICS

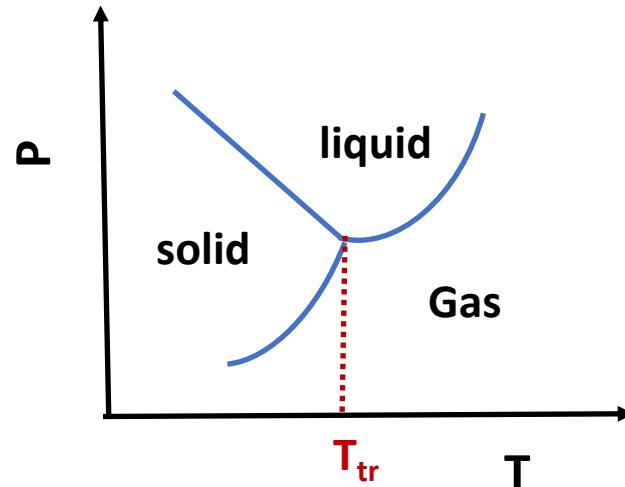
## Unit 5 : Quantum mechanical treatment of Magnetic materials and Dielectrics

### Phase Transitions

Water



### Triple point of water



Metal



Image courtesy: Wikipedia

# ENGINEERING PHYSICS

## Unit 5 : Quantum mechanical treatment of Magnetic materials and Dielectrics

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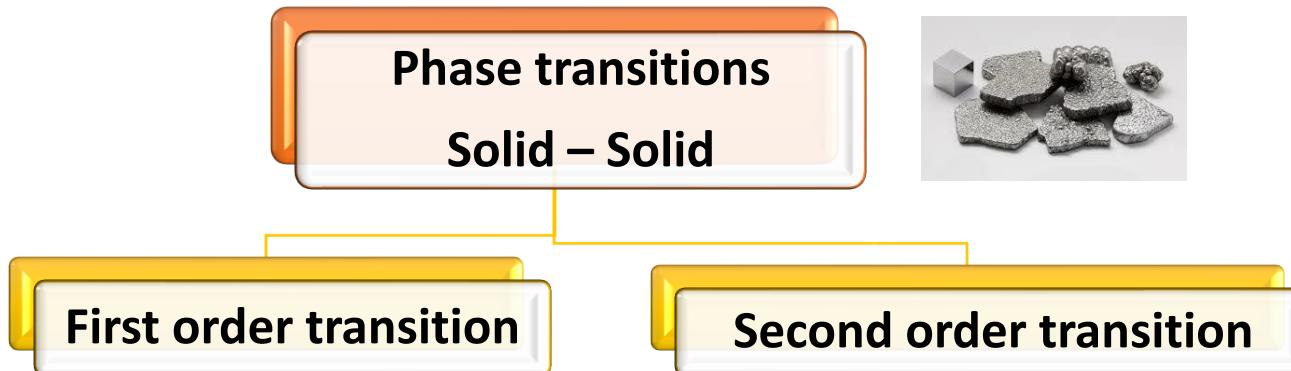
- Free energy ( $G$ )
- Enthalpy ( $H$ )
- Entropy ( $S$ )

$$G=H-TS$$

### Characteristics

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

### Ehrenfest Classification



- Discontinuous in first derivative of  $G$

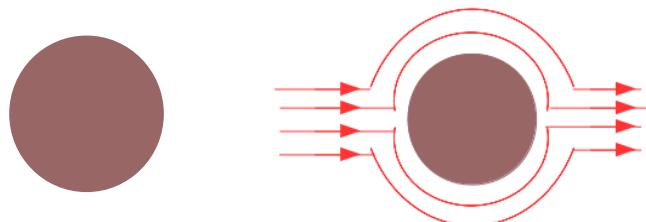
$$\left(\frac{\partial G}{\partial T}\right)_V = S \text{ and } \left(\frac{\partial G}{\partial P}\right)_T = V$$

- 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

### Superconductor

- Meissner effect
- Perfect diamagnet
- Critical field and temperature



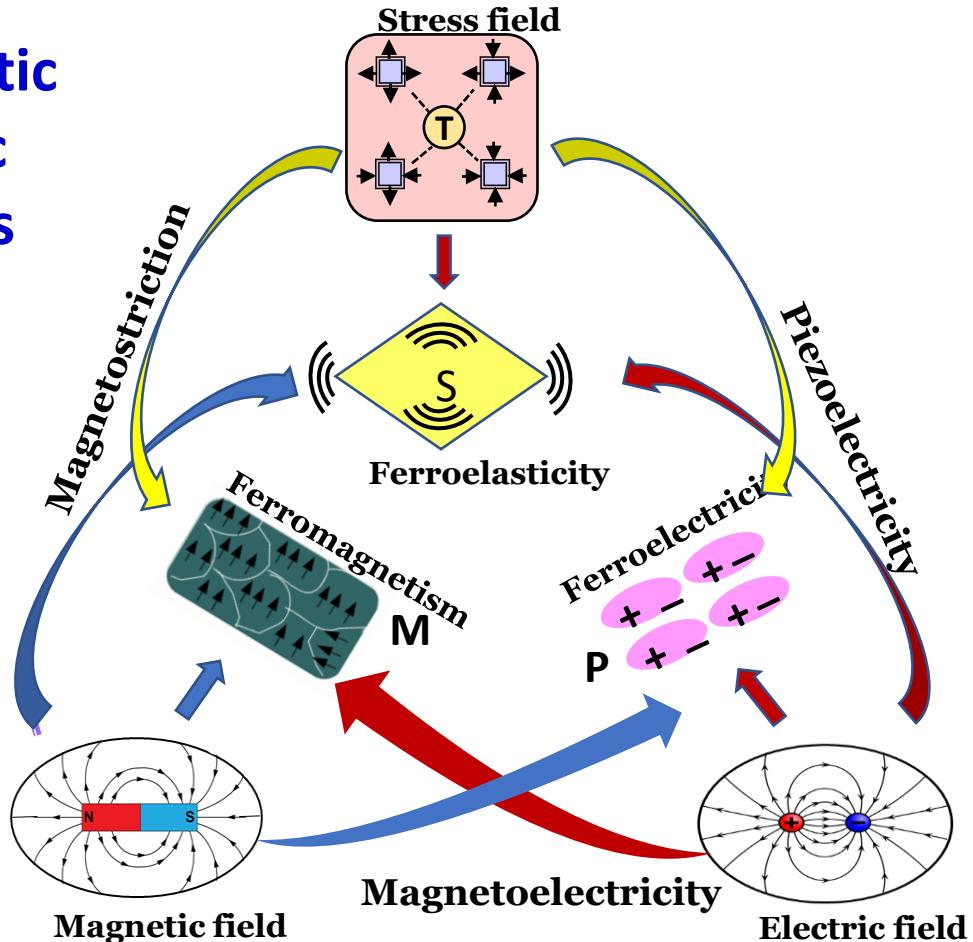
$H = 0, T < T_c$

$H \neq 0, T < T_c$

# ENGINEERING PHYSICS

## Unit 5 : Quantum mechanical treatment of Magnetic materials and Dielectrics

Ferromagnetic  
Ferroelectric  
Multiferroics



# ENGINEERING PHYSICS

## Unit 5 : Quantum mechanical treatment of Magnetic materials and Dielectrics

### 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<sub>3</sub>*
- *Piezoelectric materials*
- *Pyroelectric materials*
- *Ferroelectric materials*
- *Applications*

# ENGINEERING PHYSICS

## Unit 5 : Quantum mechanical treatment of Magnetic materials and Dielectrics

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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, 6<sup>th</sup> edition, Ch 19 & 20, 2011.*
3. *Learning material prepared by the Department of Physics, PESU*



**THANK YOU**

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**Ambika M R, Ph.D.**

Assistant Professor, Department of Science and Humanities

**[ambikamr@pes.edu](mailto:ambikamr@pes.edu)**

+91 80 21722683 Extn 759