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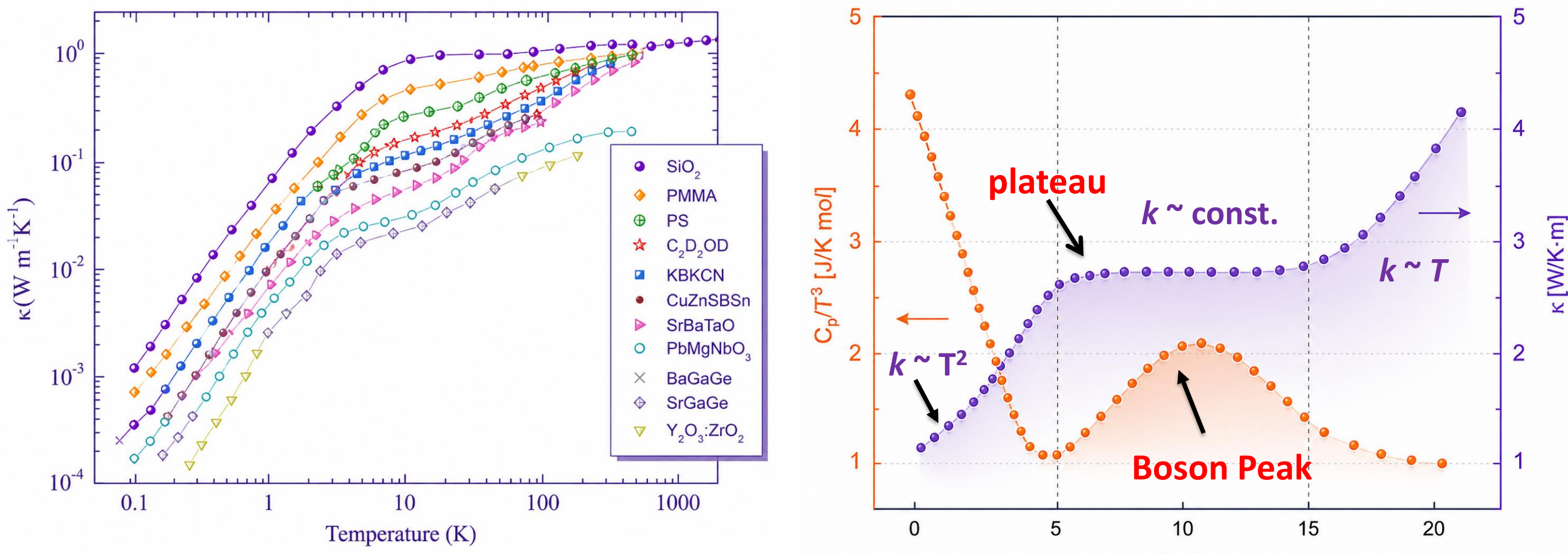
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## MOTIVATION

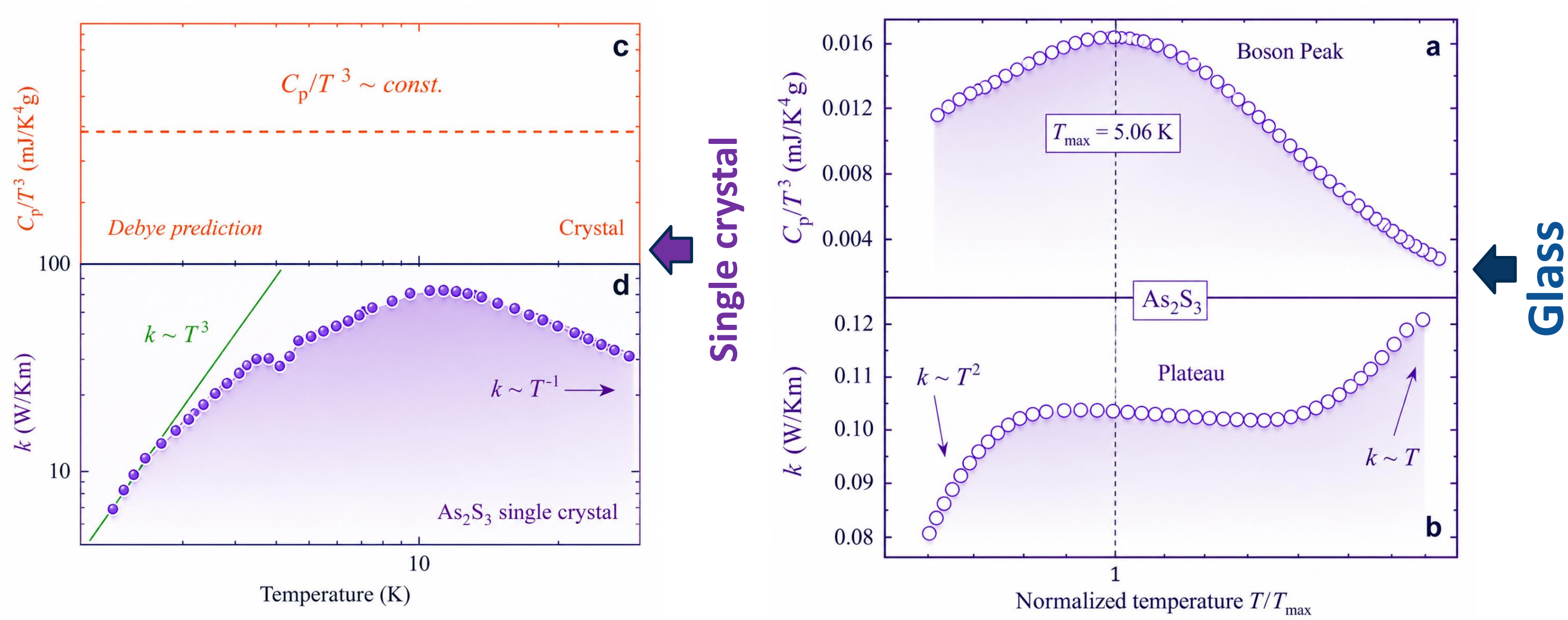
Lattice properties of a **disordered** solid at low temperature



Temperature dependence of thermal conductivity of various crystals and glasses [1]

Universal anomalous behavior of glasses at low temperature

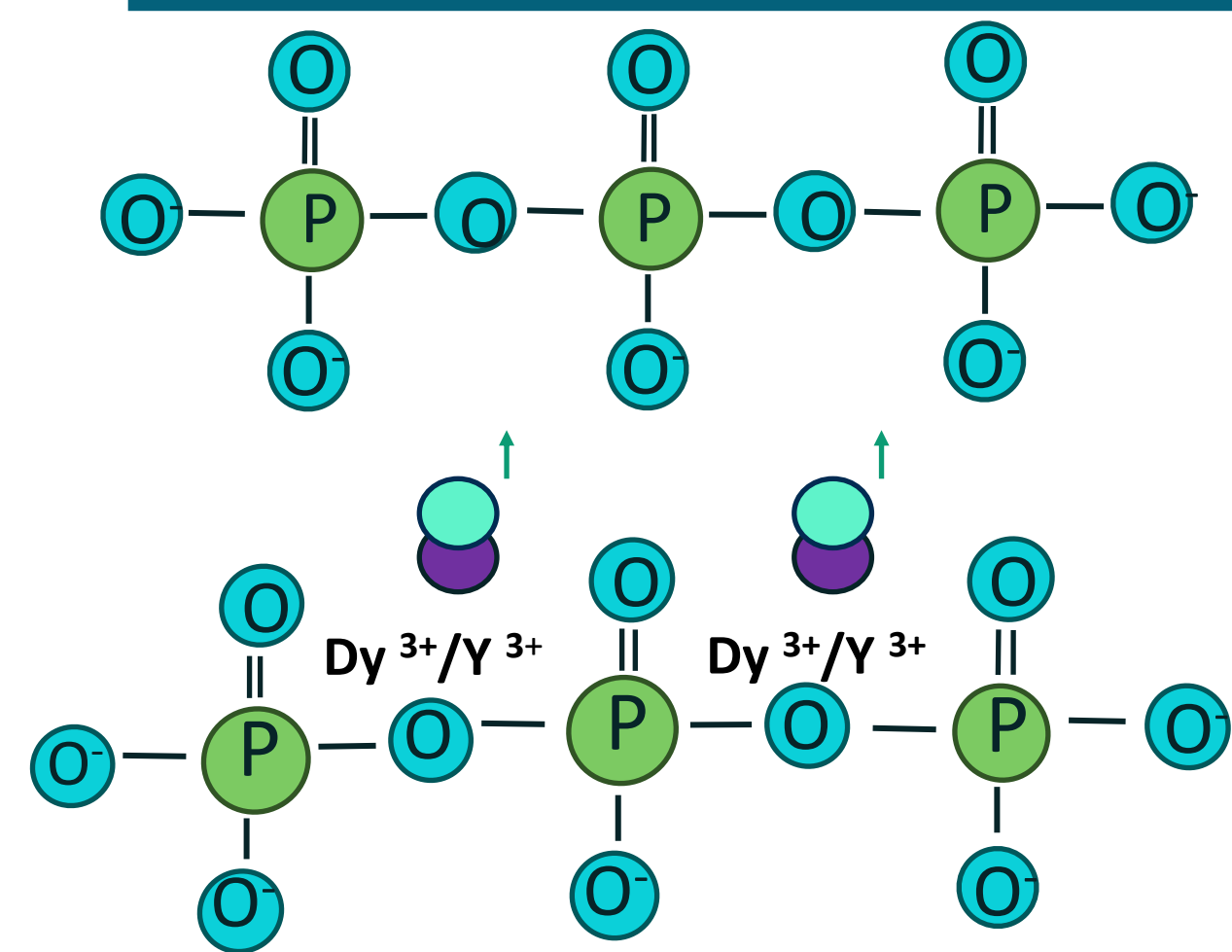
The discrepancy in lattice properties: **Single crystal vs. Glass**



Correlation between boson peak in  $C_p/T^3$  and plateau in  $k(T)$  [2]

Boson peak and plateau are universal low-temperature anomalies in disordered solids

## SAMPLE STRUCTURE



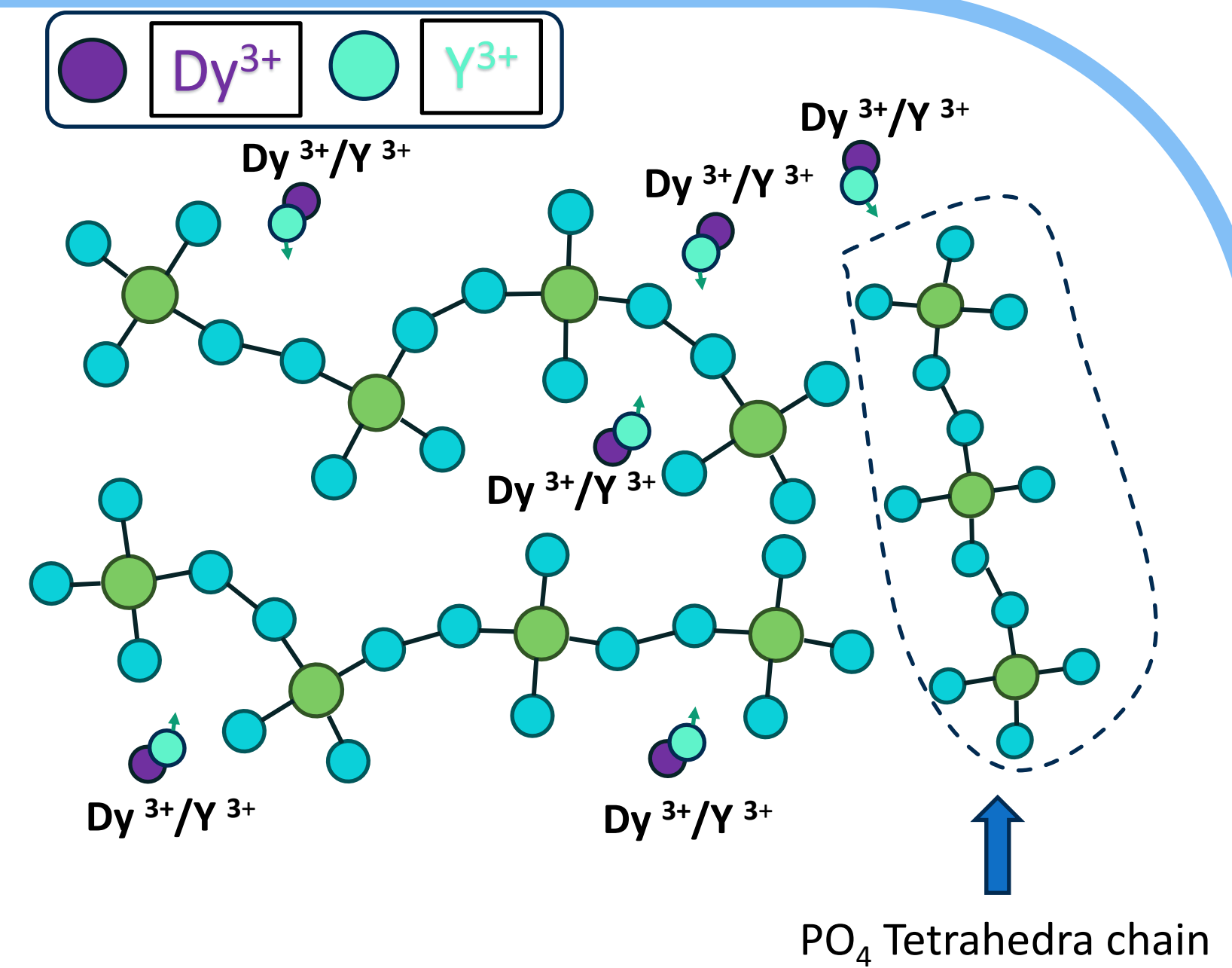
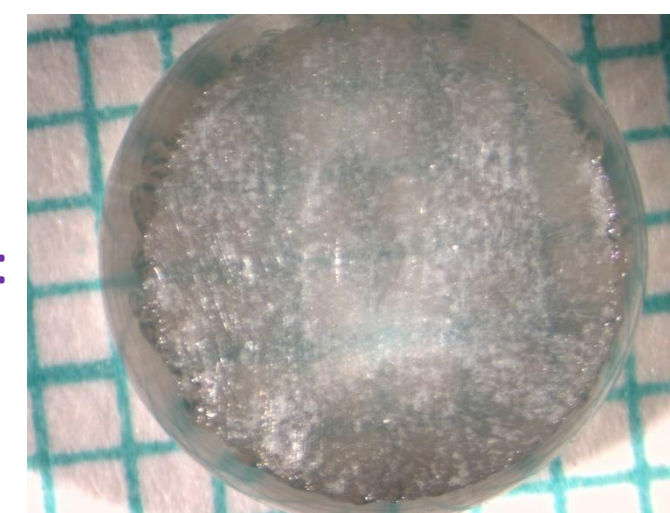
**Crystal lattice:**

- regular arrangement
- uniform spin orientation
- large magnetic moment

**Amorphous lattice:**

- disordered arrangement
- random spin orientation
- average magnetic moment

Photo of glass sample  
Using optical microscope:



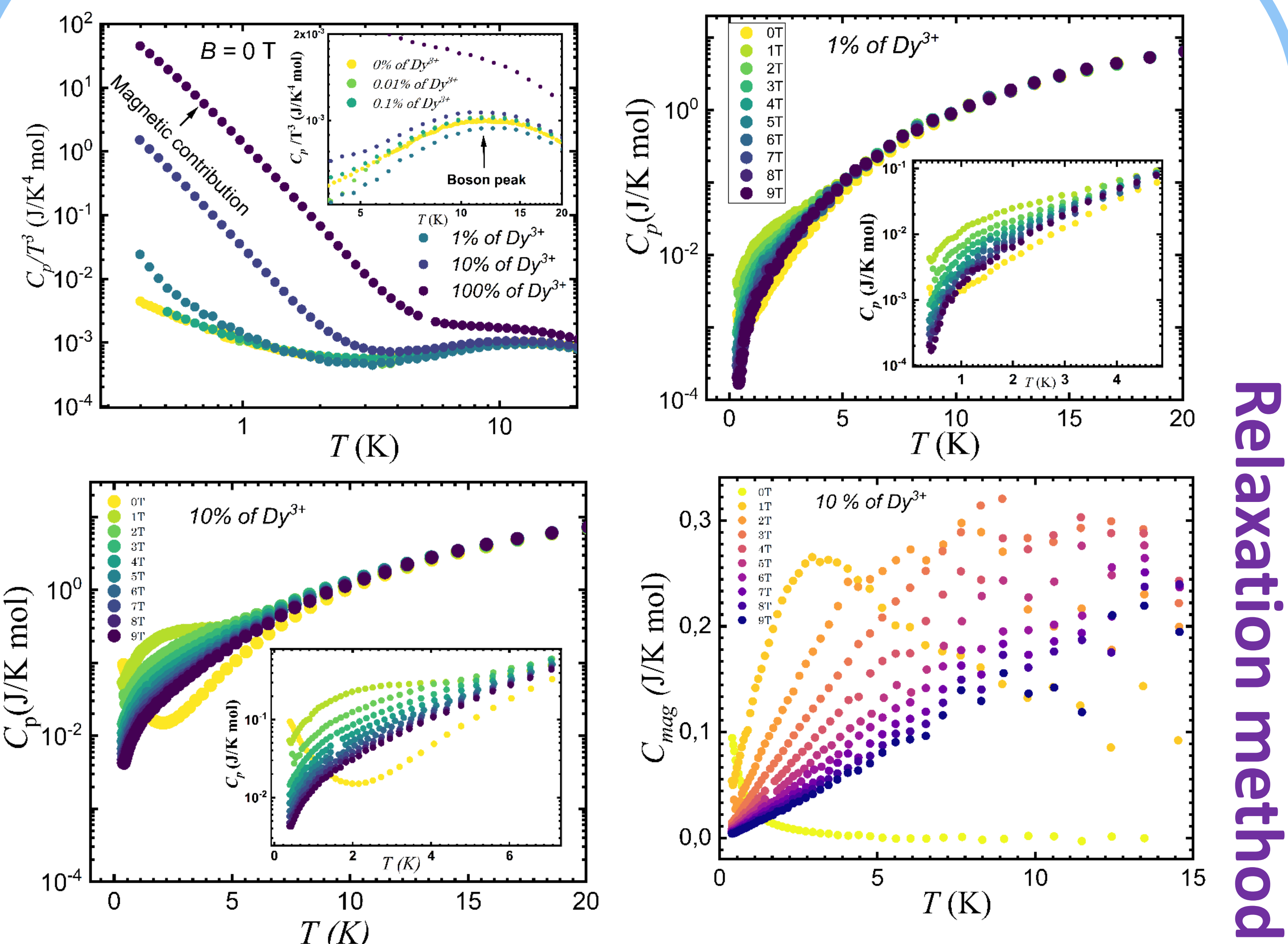
The amorphous phase consists of  $PO_4$  tetrahedra's connected into chains of various length

Dysprosium ions are scattered in-between with random spin orientation

The resulting magnetic moment is an average of individual moments

## RESULTS

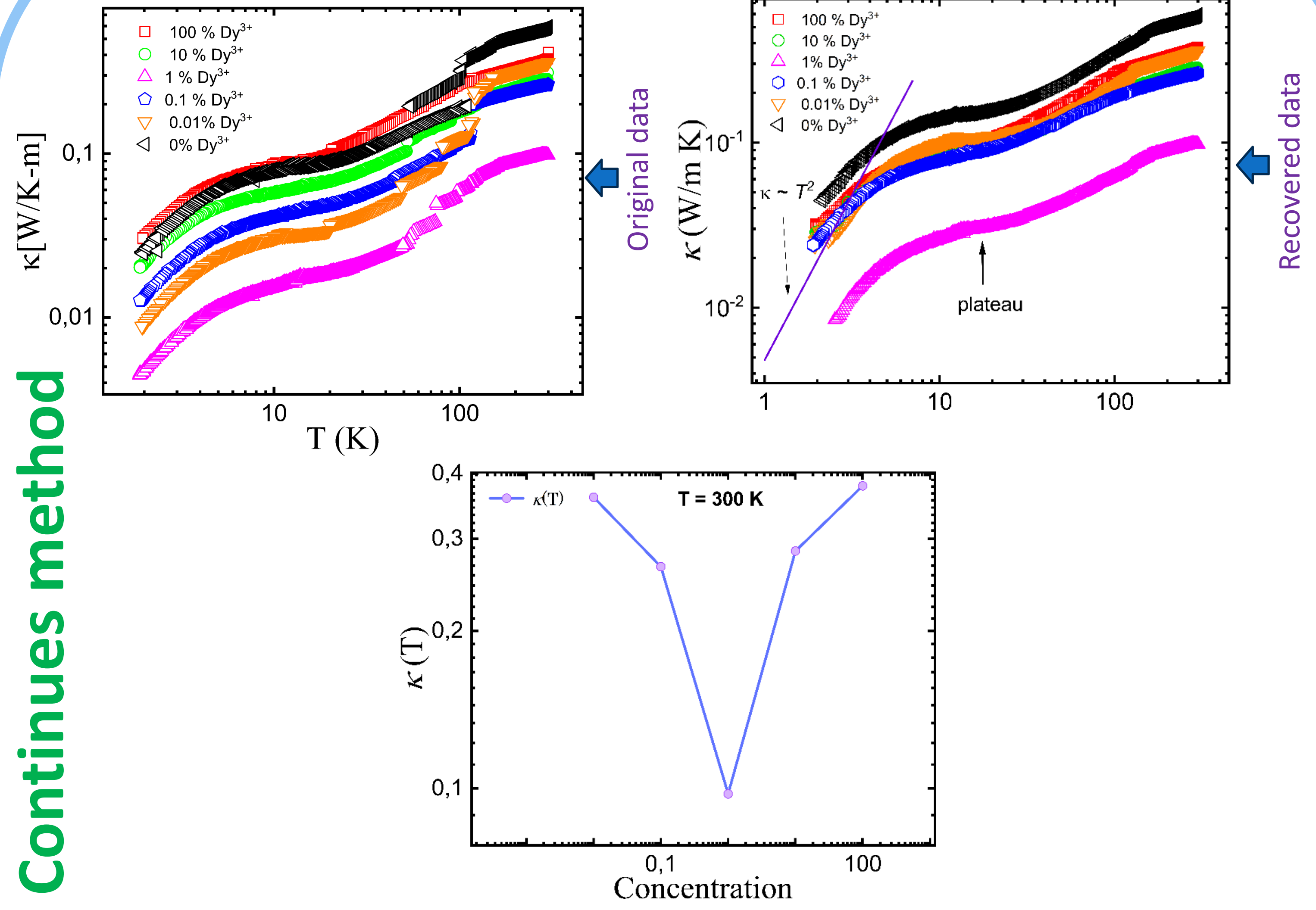
### HEAT CAPACITY



The graphs show a strong influence of  $Dy^{3+}$  ion concentration on the heat capacity:

All samples exhibit glass-like behavior, with a **Boson peak** clearly visible on the  $C_p/T^3$  plot.  $Dy^{3+}$  doping creates a strong magnetic contribution, appearing as a broad **Schottky anomaly** at low temperatures. This peak grows in magnitude and shifts with  $Dy^{3+}$  concentration, enabling tuning of thermal properties.

### Thermal Conductivity



The concentration dependence of thermal conductivity at  $T = 300$  K demonstrates a pronounced **non-monotonic** behaviour.

Thermal conductivity demonstrates a **non-linear** dependence on composition. The highest value is observed for the  $x = 0$  % sample, while the minimal one corresponds to  $x = 1$  %. The results confirm that Dy-doped phosphate glasses display universal low-temperature glassy behaviour.

### Soft Potential Model (SPM)

$$C_{Latt} = TC_{TLS} + T^3 C_D + T^5 C_{SM}$$

$TC_{TLS}$  – Contribution on two level system (TLS)  
 $T^3 C_D$  – Debye Contribution (Phonon)  
 $T^5 C_{SM}$  – Soft Mode Contribution

$$C_p = C_{latt} + C_{mag}$$

$C_{mag}$  → **Schottky maximum** depends on concentration of  $Dy^{3+}$

#### References:

- [1] A. I. Krivchikov and A. Jeżowski, Thermal conductivity of glasses and disordered crystals.  
 [2] P. Baloh, dissertation thesis.

### Conclusion & Acknowledgements

1. The heat capacity exhibits a low-temperature maximum (boson peak, BP) linked to excess low-frequency vibrations. A clear Boson peak appears for  $x = 0\%$  at 12 K, while in  $x \neq 0\%$  samples it overlaps with the Schottky anomaly.
2. Thermal conductivity measurements showed typical glass-like behaviour: a plateau in  $k(T)$  between  $T \approx 5$  and 20 K. Below 5 K is observed onset on  $k(T) \sim T^2$  and a slight increase of  $k(T)$  above  $T = 15$  K. Magnetic  $Dy^{3+}$  ions influence phonon transport due to resonant scattering of phonons on magnetic subsystem.

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