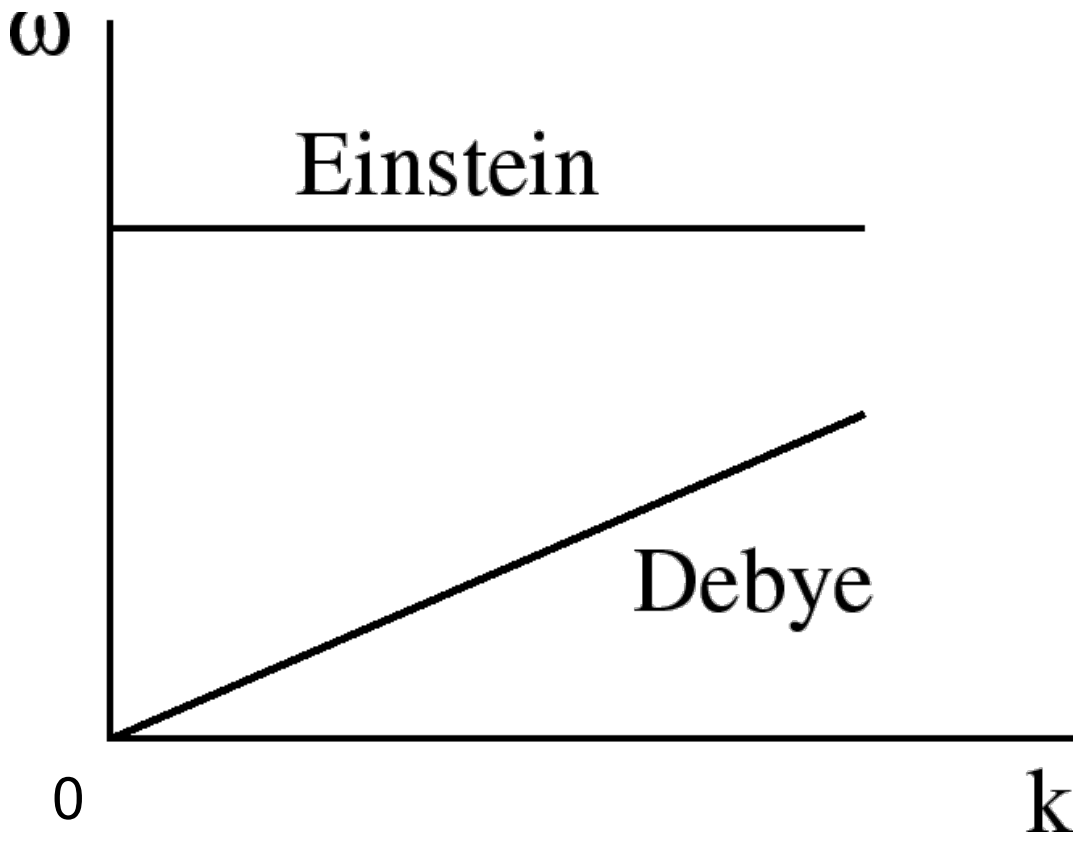
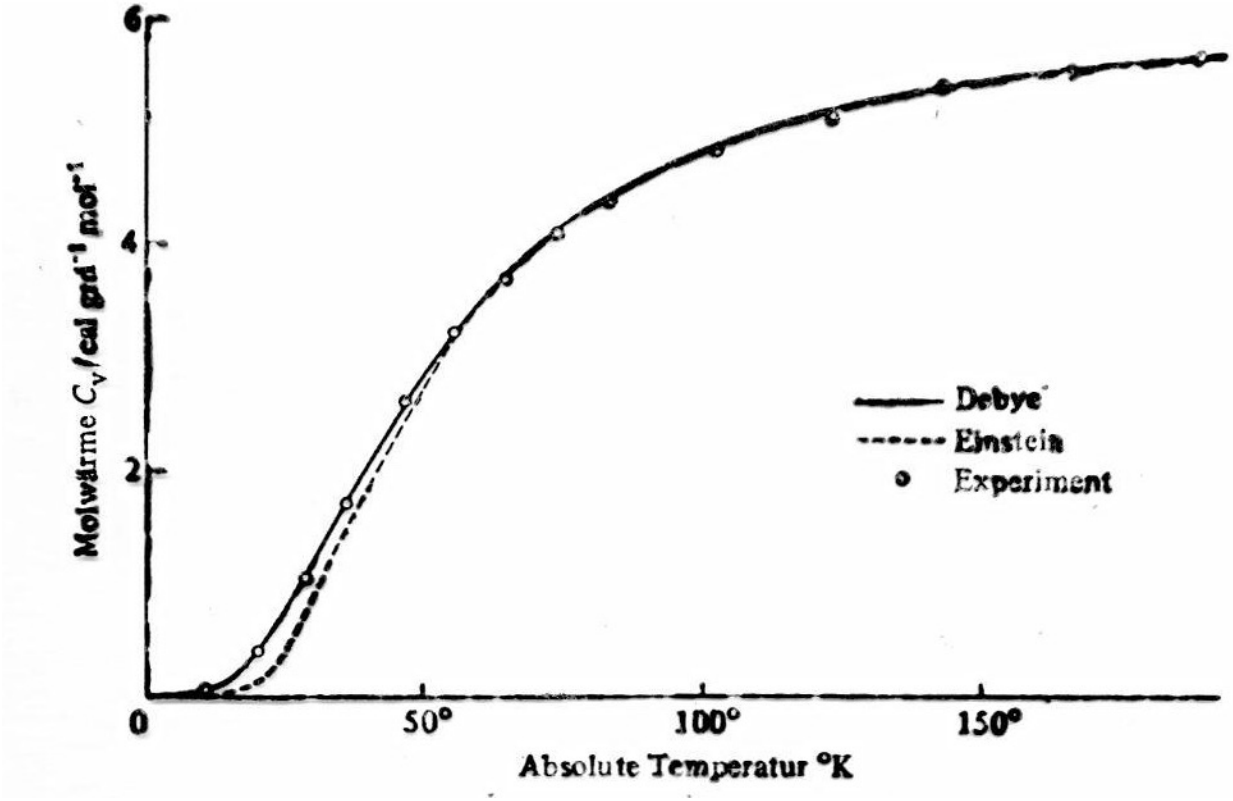
Phononen

1. **Spezifische Wärmekapazität**

Einstein- und Debye-Näherung



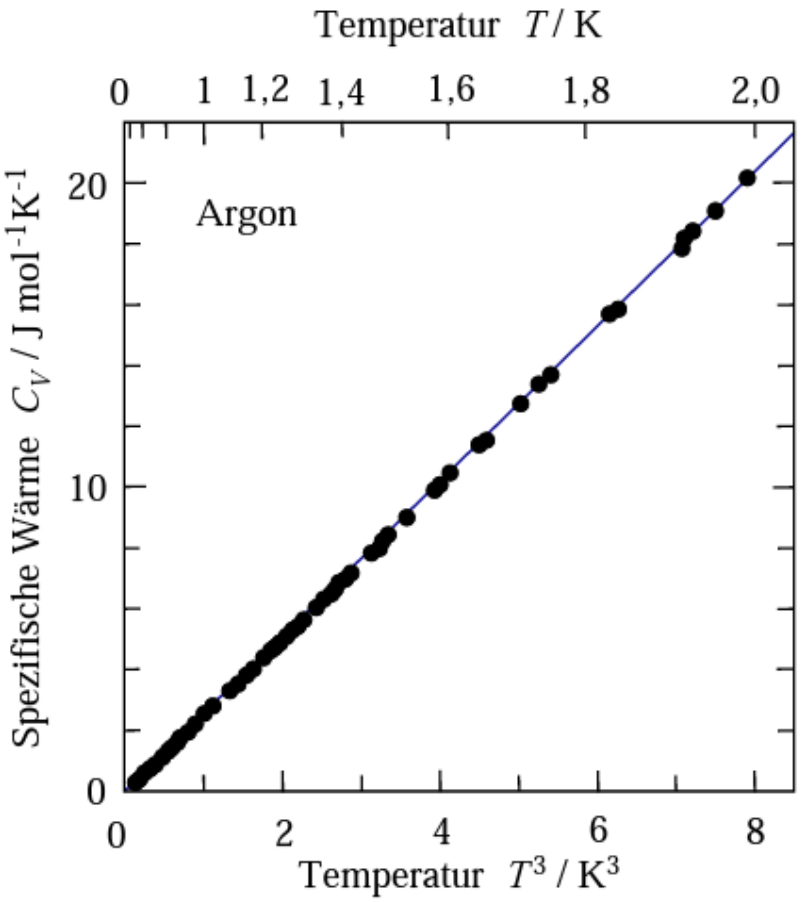
Spezifische Wärme von Silber



θ_D=210 K θ_E=160 K

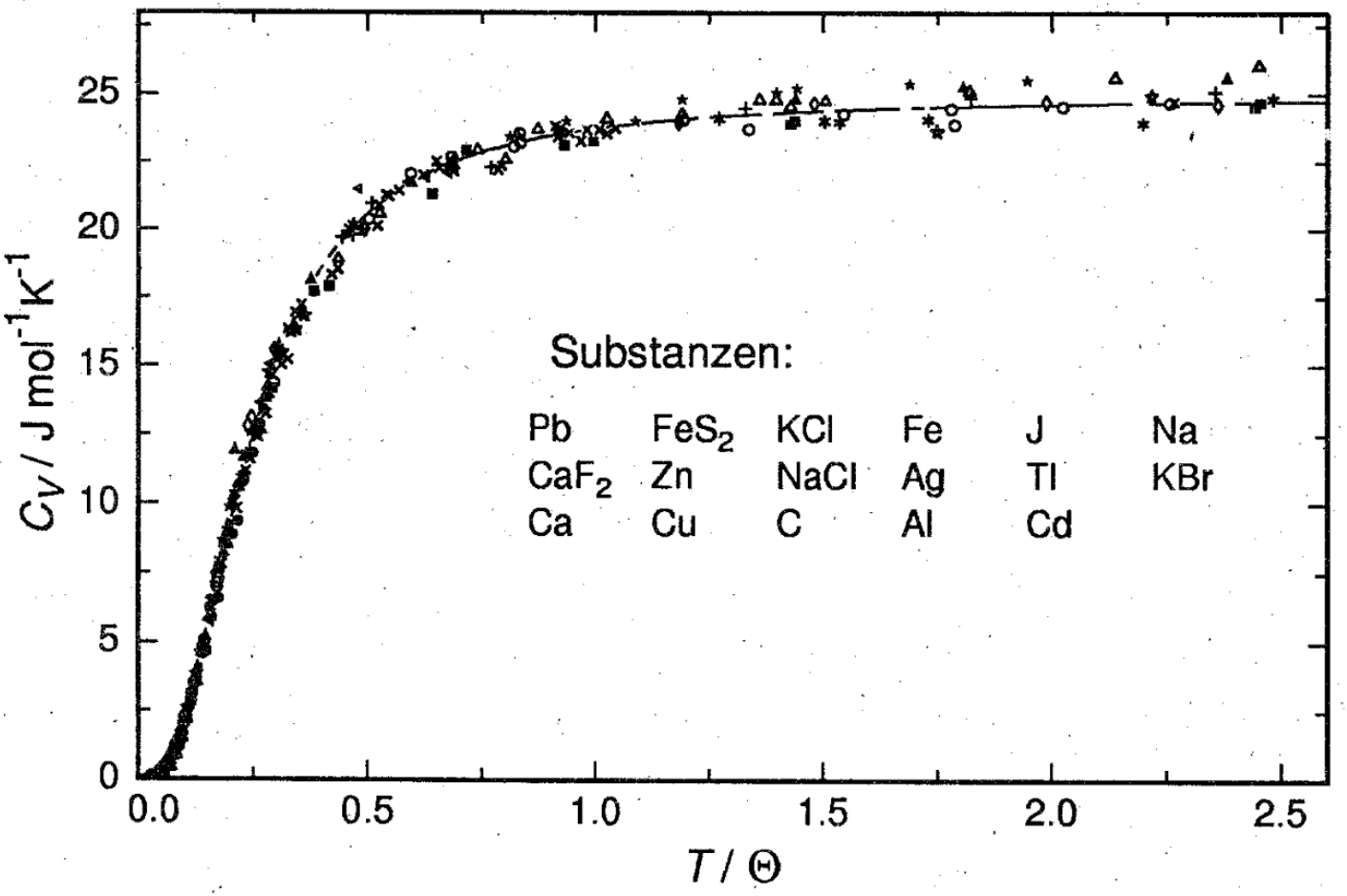
© D. Livesey (1964)

Spezifische Wärme von kristallinem Argon: T^3 Gesetz



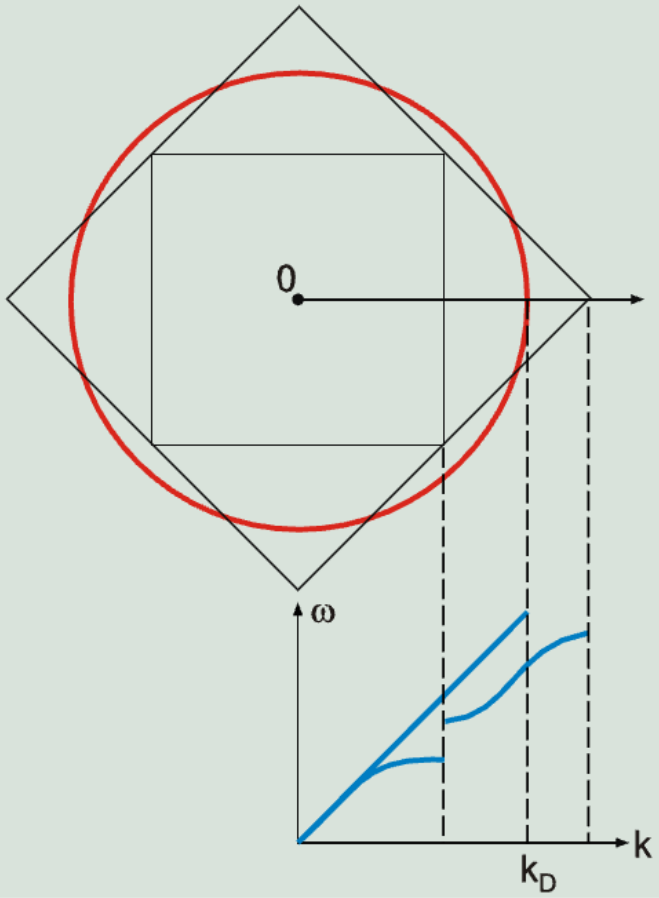
L. Finegold and N. Phillips (1964)

Spezifische Wärme

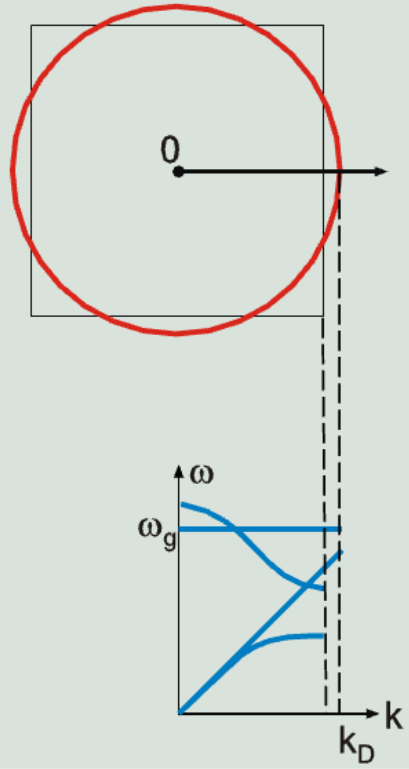


Zwei Nährungen für akustische und optische Moden

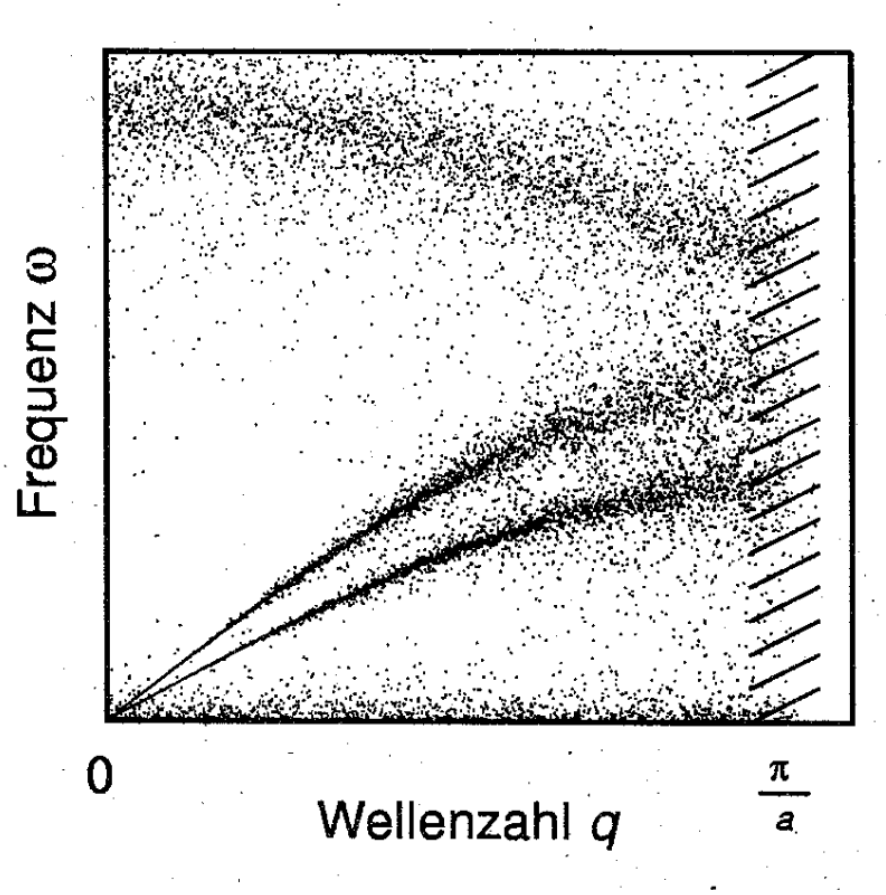
Debye-Modell für alle Moden



Debye-Modell für akustische, Einstein-Modell für optische Moden

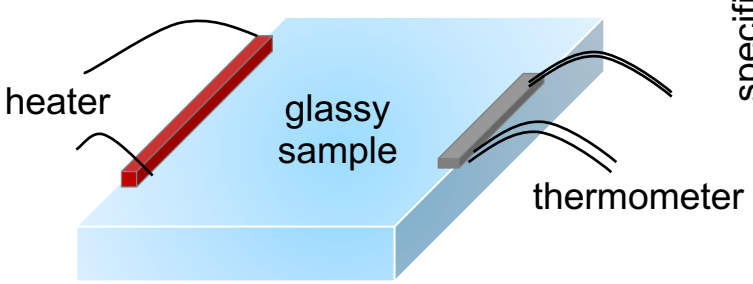


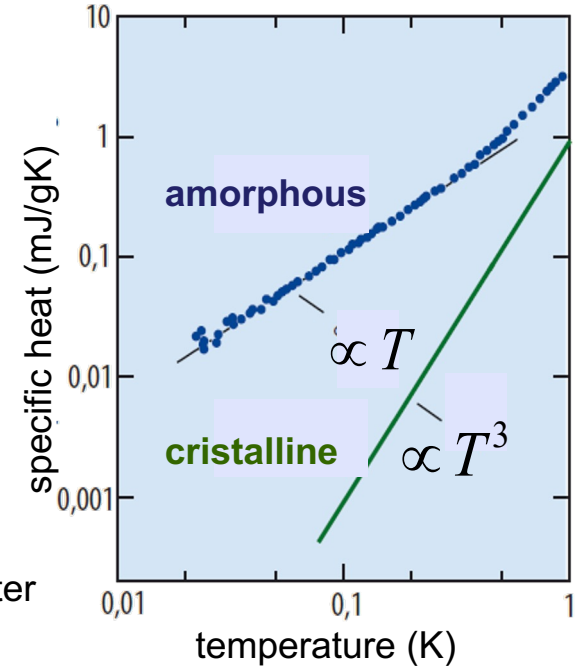
Schwingungspektrum amoprphe Festkörper



Wärmekapazität von Gläsern bei tiefen Temperaturen

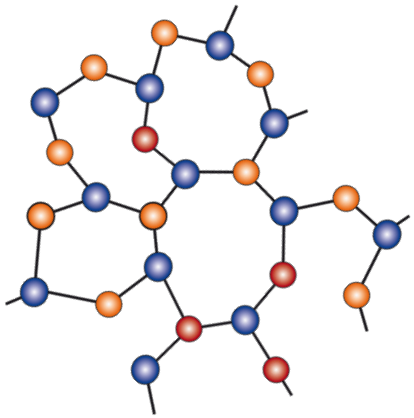
- first evidence of TLS: specific heat anomaly
  (Zeller & Pohl 1971)



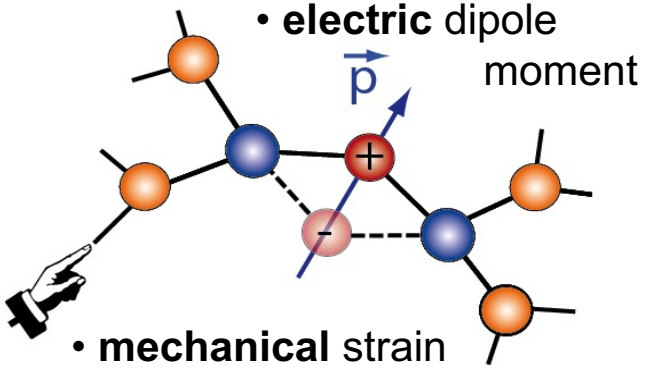


Wärmekapazität von Gläsern bei tiefen Temperaturen

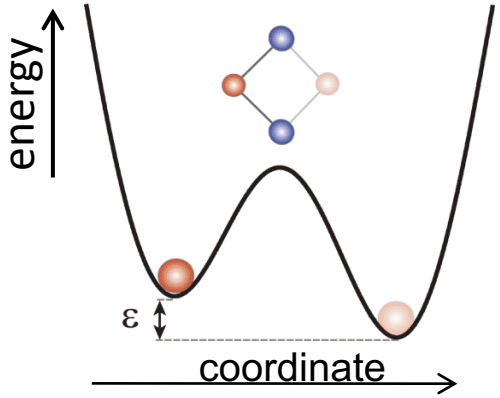
- in amorphous materials, atoms may tunnel between two positions:



- these ”tunneling systems” couple via



- classical



- quantum