Thermal transport

thermal conductivity measurements

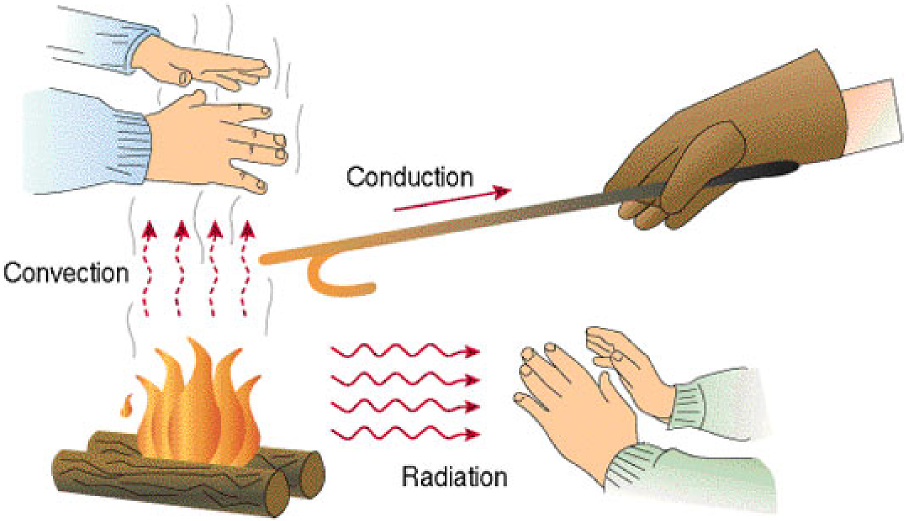
thermal insulation

Joseph Fourier

by Alexander Tsirlin, Leipzig University

Lecture 16: December 6, 2023

Types of heat transfer



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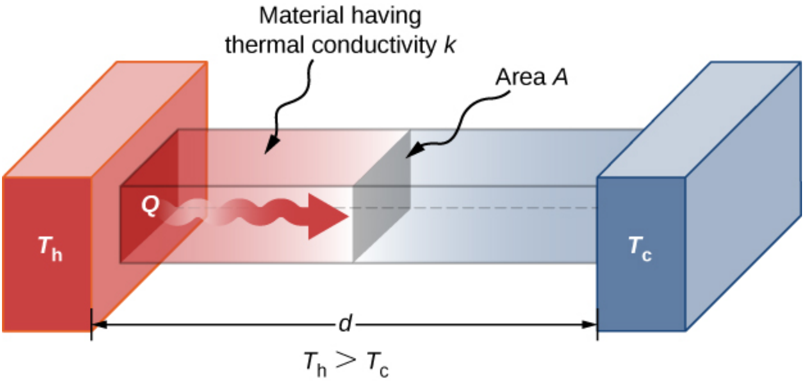

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Person

Joseph Fourier

Joseph Fourier
1768–1830

- early 1790's: advocate of French revolution
- 1795: appointment at École Normale and École Polytechnique
- 1798–1801: Napoleon's Egyptian expedition
- 1801–1816: prefect of the Department of Isére
- early 1820's: The Analytical Theory of Heat

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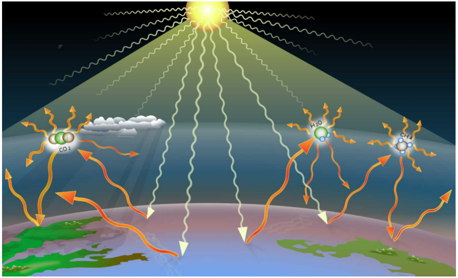
- early 1820's: The Analytical Theory of Heat
- 1824–27: first idea of the greenhouse effect



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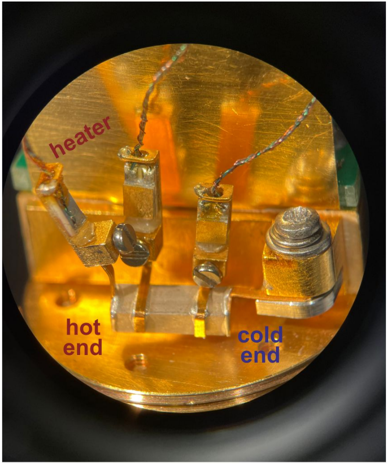
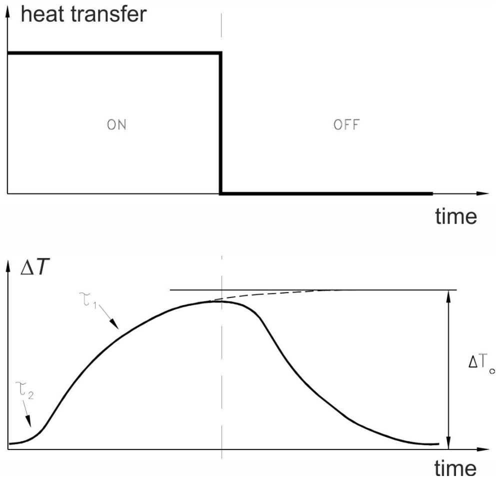
Experimental technique

thermal conductivity measurements





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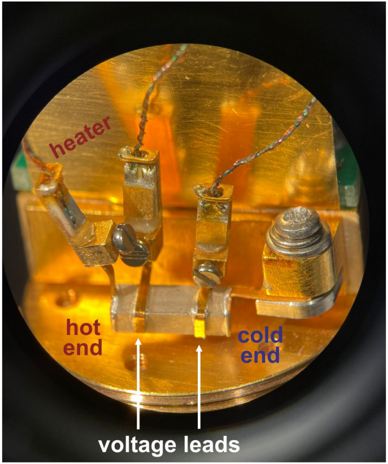
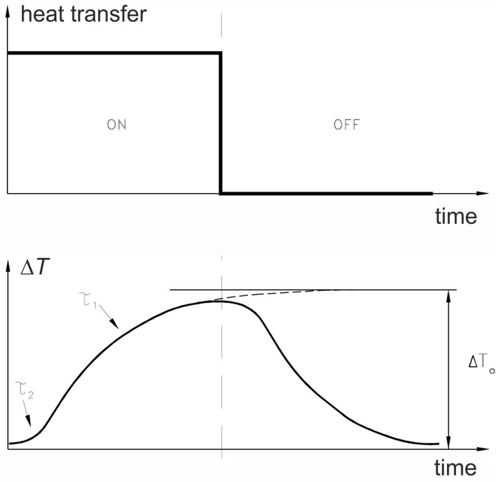


voltage induced by ∇T
(Seebeck effect)



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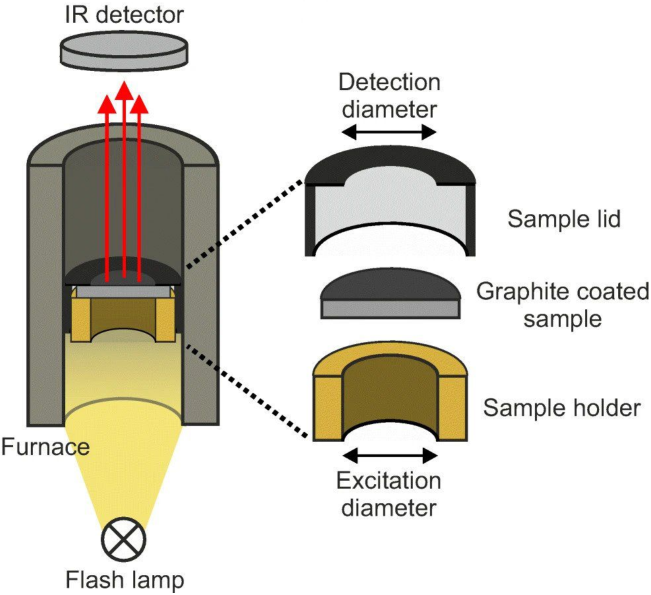
κ/c_V is measured



Heat and Mass Transfer 56, 811 (2020)

High thermal inertia

Low thermal inertia

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7.2. Packing phonons into a Debye sphere (6 P)

Consider a crystal of pyrite, commonly known as "fool's gold" (FeS_2, space group $Pa\bar{3}$).

(a) How many phonon modes does it feature? How many modes should one expect in real gold?

(b) Debye model replaces full phonon spectrum with three acoustic modes that are considered within a sphere of the radius q_D instead of the first Brillouin zone. Determine the value of q_D for pyrite. How many reciprocal lattice points are contained within the Debye sphere?

(c) Speed of sound in pyrite is $v_s = 8.02\,\mathrm{km/s}$. Use this sound velocity in the linear approximation of the Debye model, $\omega = v_s\, q$, to determine the Debye temperature.

(d) Determine the high-temperature (Dulong-Petit) limit of the heat capacity. How much does heat capacity (C_V) of pyrite deviate from the Dulong-Petit limit at 300 K?

(updated on 2.12)

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Career paths in physics

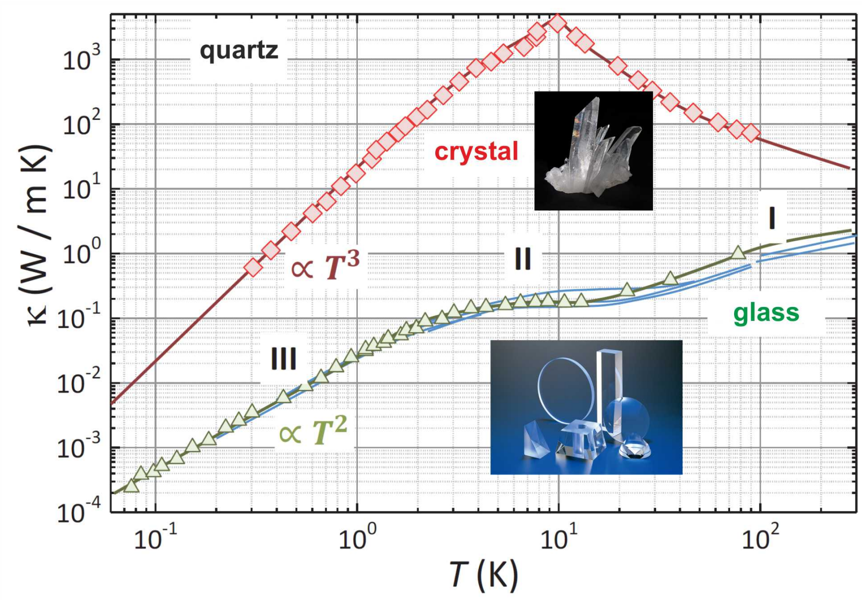
From “how to organize your studies“ to “how do I become a professor in physics“. Meet our new Professor Katja Taute.

All female* physics students are welcome to join the Get-Together as part of the Mentoring Program. Katjawill talk about her career in physics and is happy to chat with you and answer questions.

Monday, Dec. 11, 7 pm (Aula, physics building)

Registration is not required.

(* includes all students defining themselves as female)



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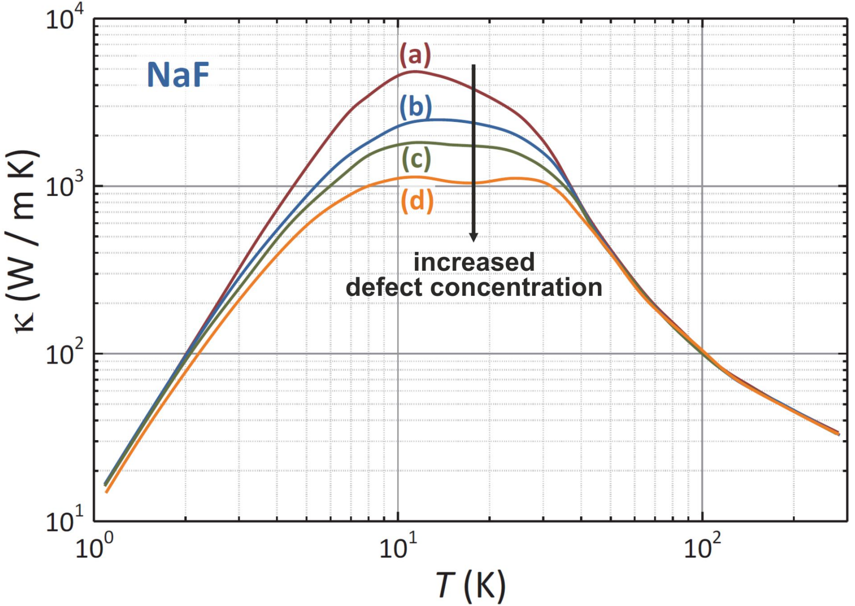

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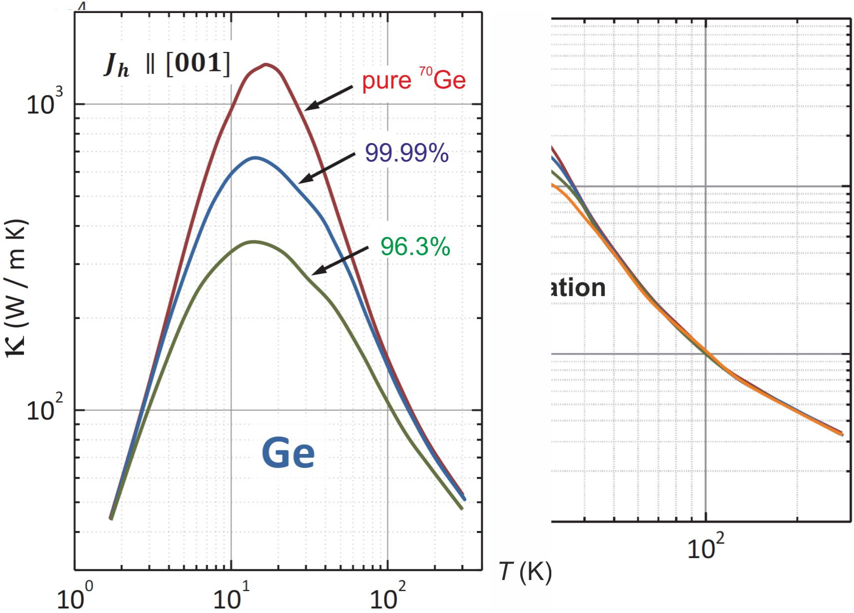

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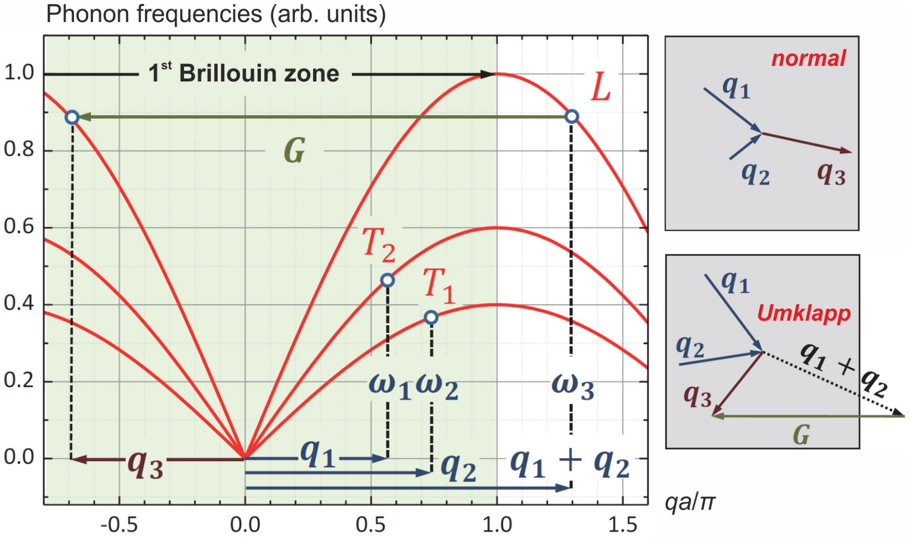

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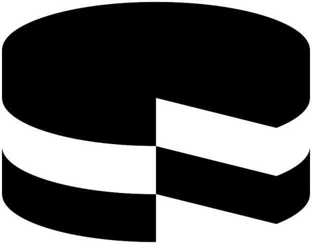

Person

thermal insulators

Substance	Thermal conductivity ($W \cdot m^{-1} \cdot K^{-1}$)	Temperature (°C)
Air[19]	0.026	25
Styrofoam[20]	0.033	25
Water[21]	0.6089	26.85
Concrete[21]	0.92	–
Copper[21]	384.1	18.05
Natural diamond[18]	895–1350	26.85

Quartz crystal	7-9
Glass	1.05
Animal wool	0.05

Source: Wikipedia

Thermal insulators

Image credits: Bernard Spragg, Rob, and Retired Electrician (CC-BY-SA)