Heat Transfer: Radiation

Radiation of real Objects

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HEATQUIZ

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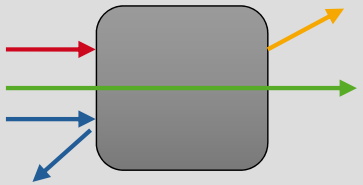
Learning goals

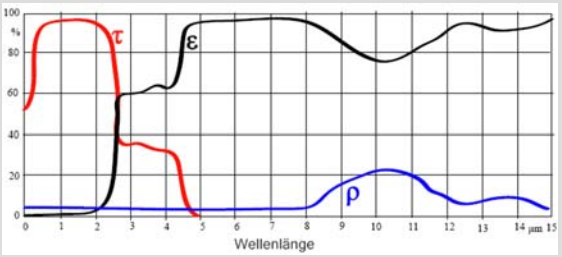
Interaction between Radiation and Body:

- Definition and interpretation of Emissivity, Absorptivity, Transmissivity and Reflectivity



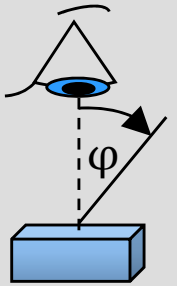
Spectral Intensity Distribution of real bodies:

- Behaviour of real bodies compared to ideal bodies



Angle dependent radiation properties:

- Angular dependence of the radiation properties of real bodies



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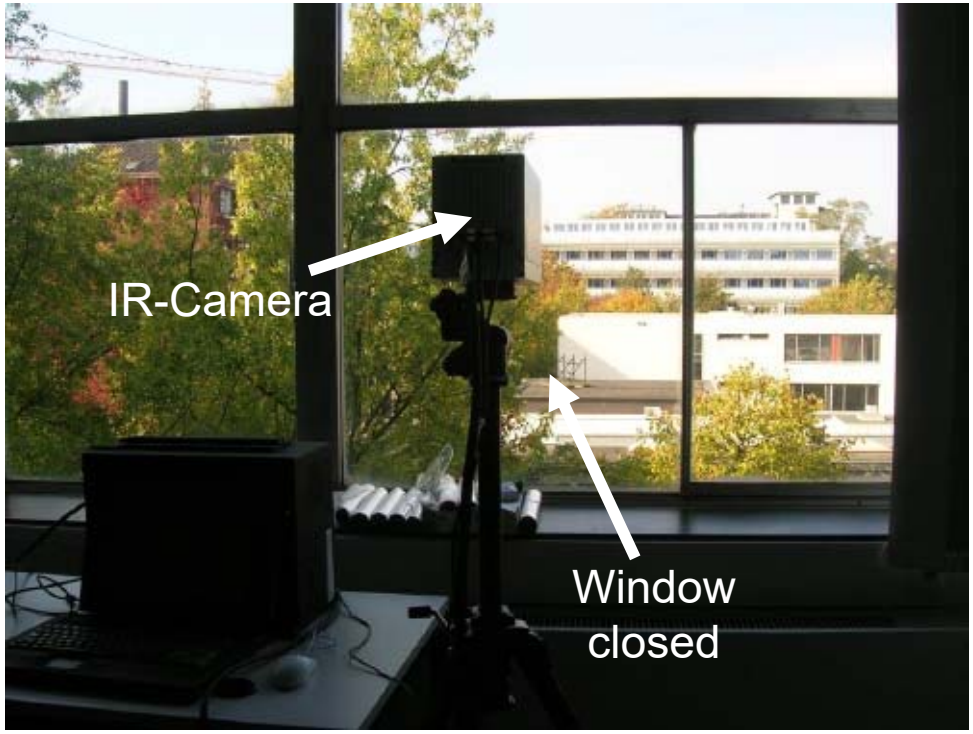
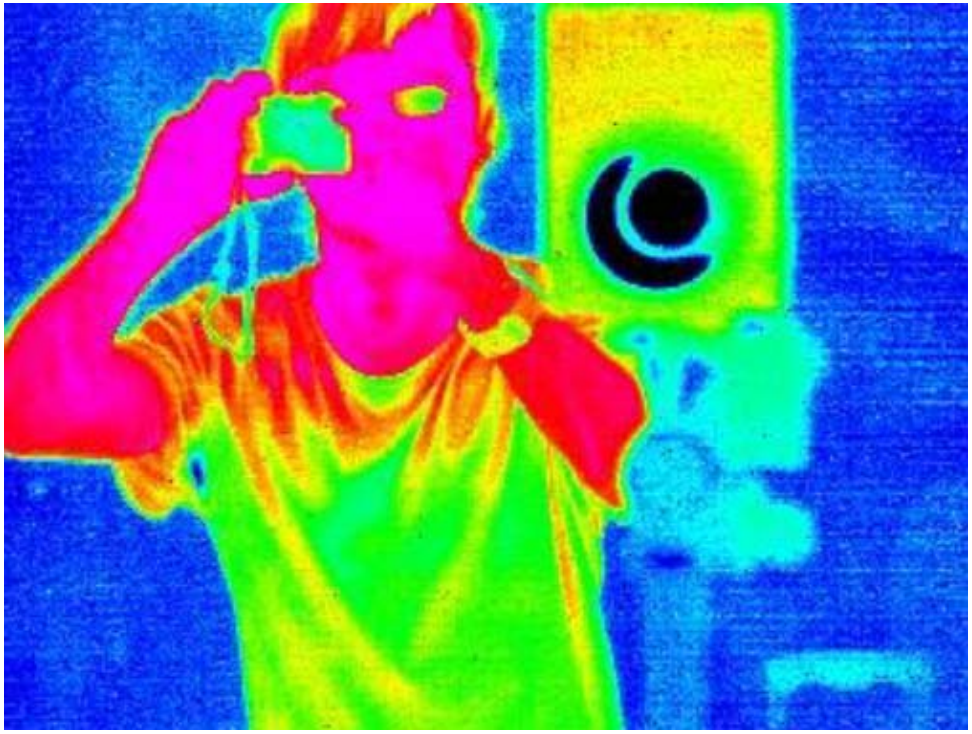
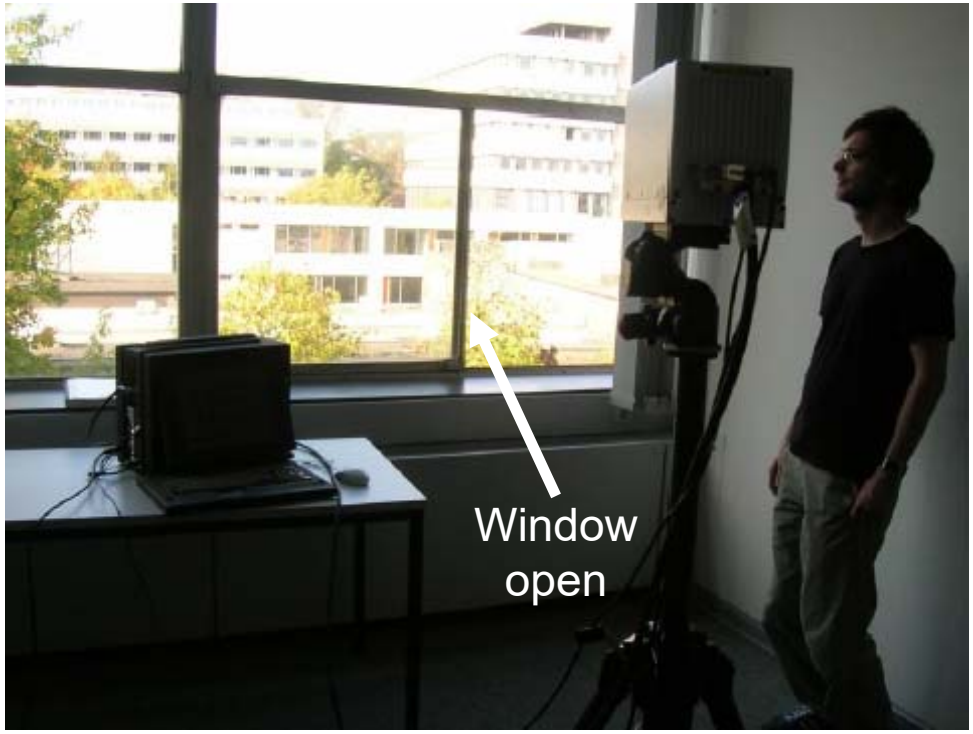
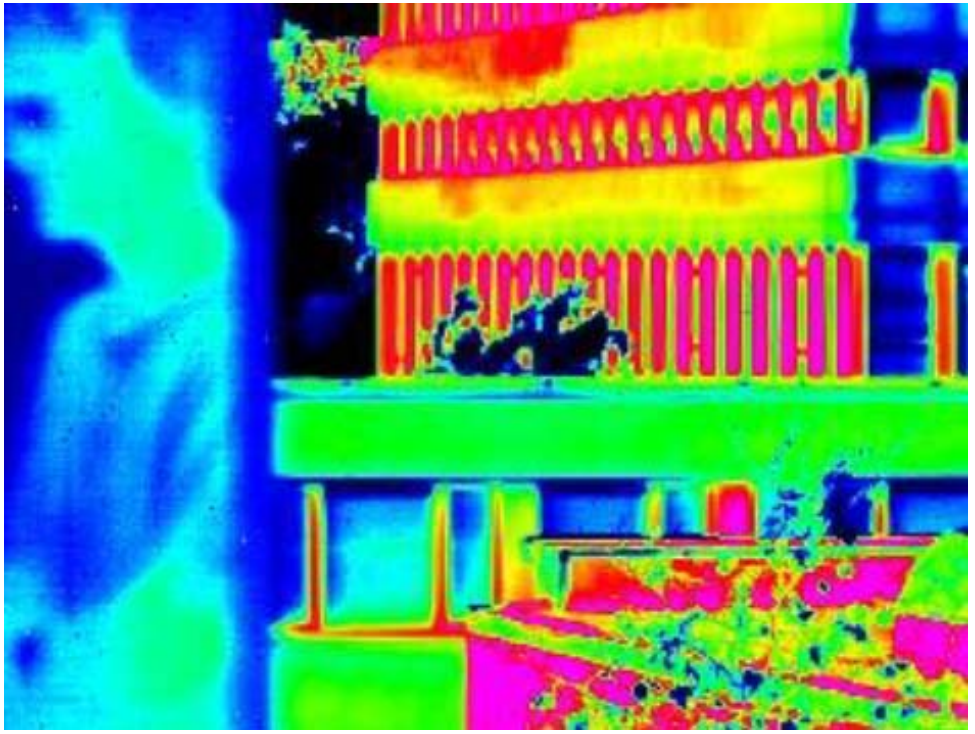
Wavelength dependence of radiation properties



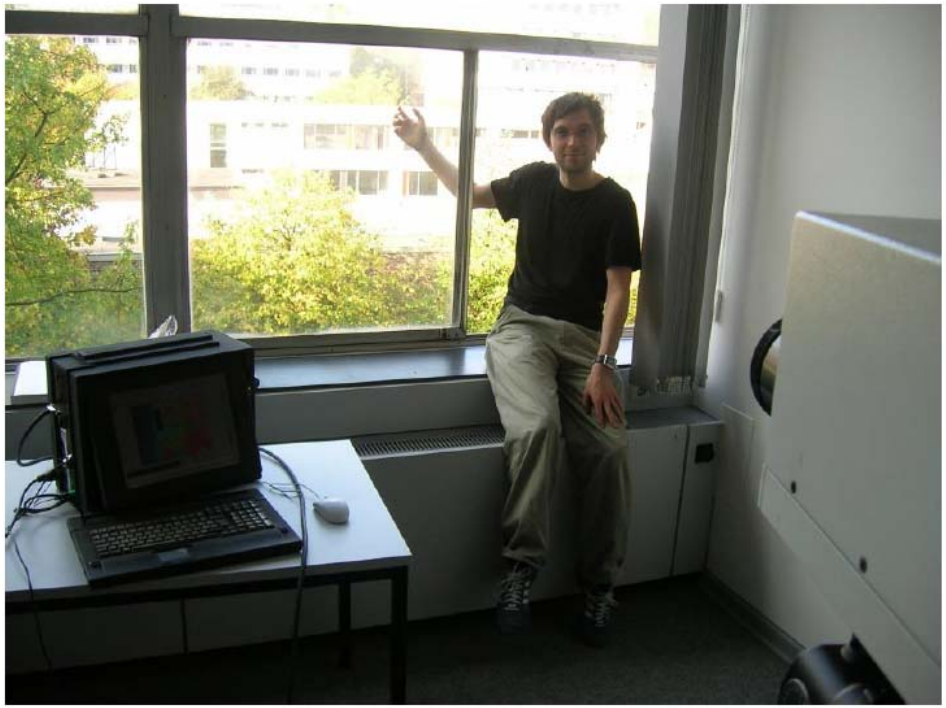


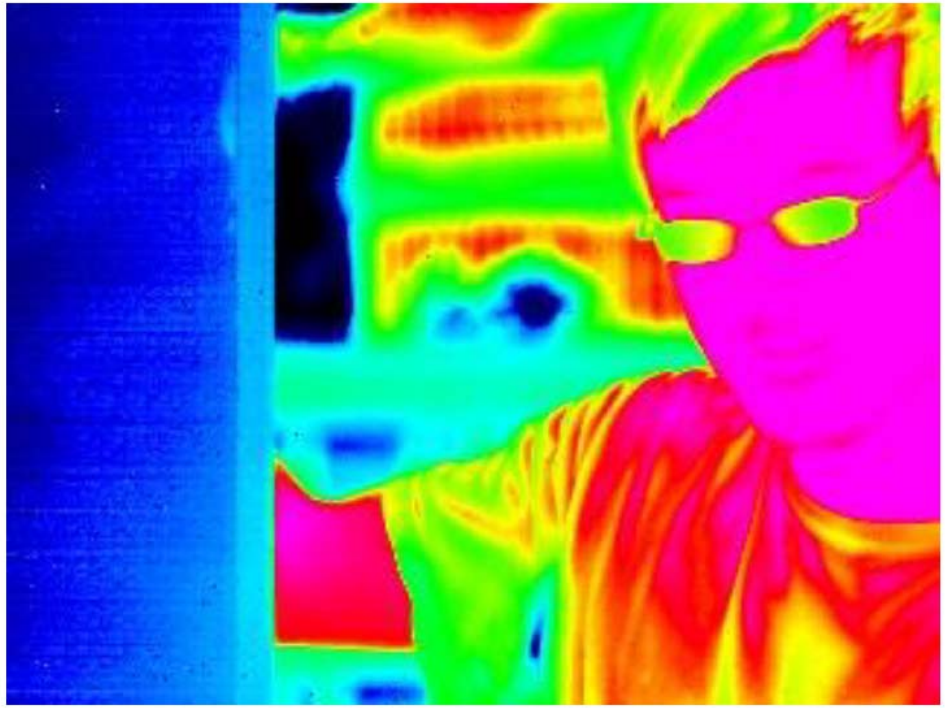
Wavelength dependence of radiation properties



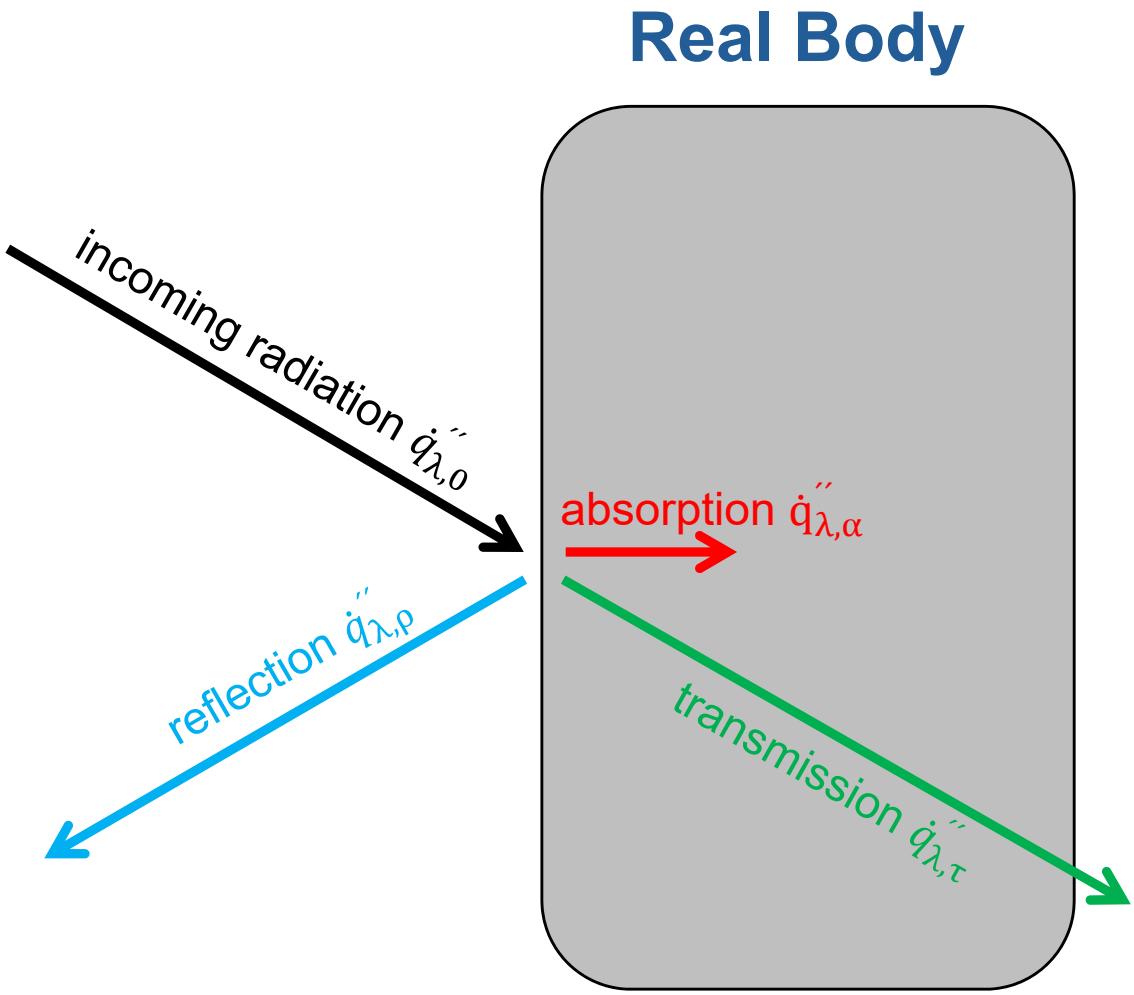


Wavelength dependence of radiation properties





Radiation distribution in real bodies



Distribution of the radiation:

$$\dot{q}''_{\lambda,0} = \dot{q}''_{\lambda,\rho} + \dot{q}''_{\lambda,\alpha} + \dot{q}''_{\lambda,\tau}$$

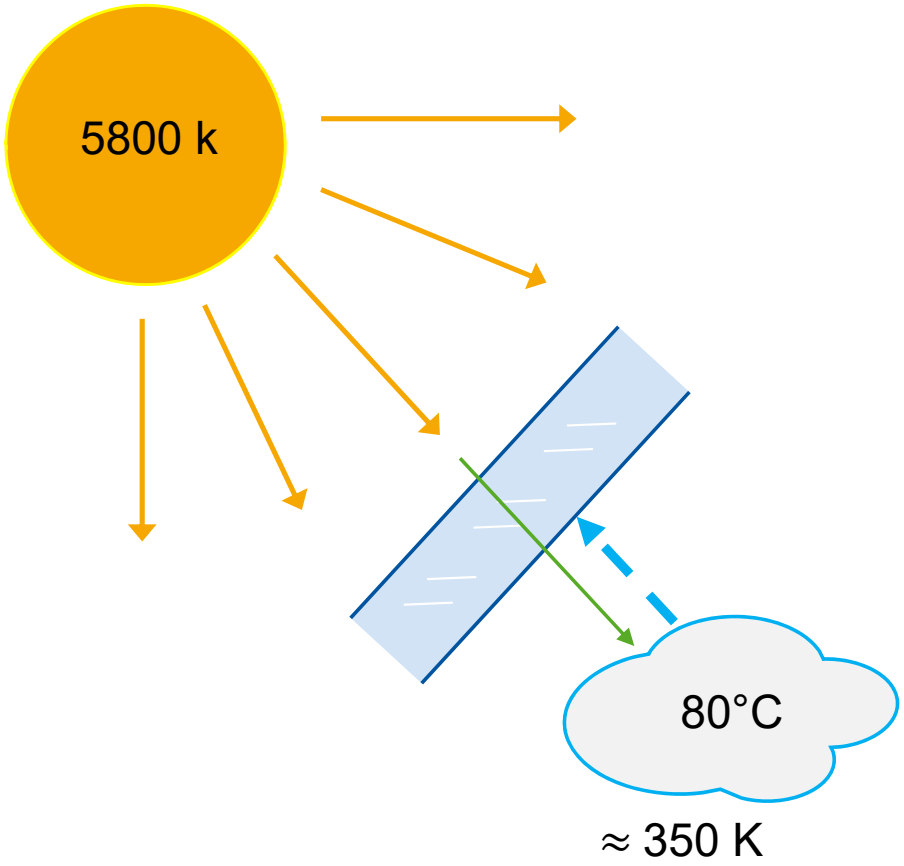
$$1 = \frac{\dot{q}''_{\lambda,\rho}}{\dot{q}''_{\lambda,0}} + \frac{\dot{q}''_{\lambda,\alpha}}{\dot{q}''_{\lambda,0}} + \frac{\dot{q}''_{\lambda,\tau}}{\dot{q}''_{\lambda,0}}$$

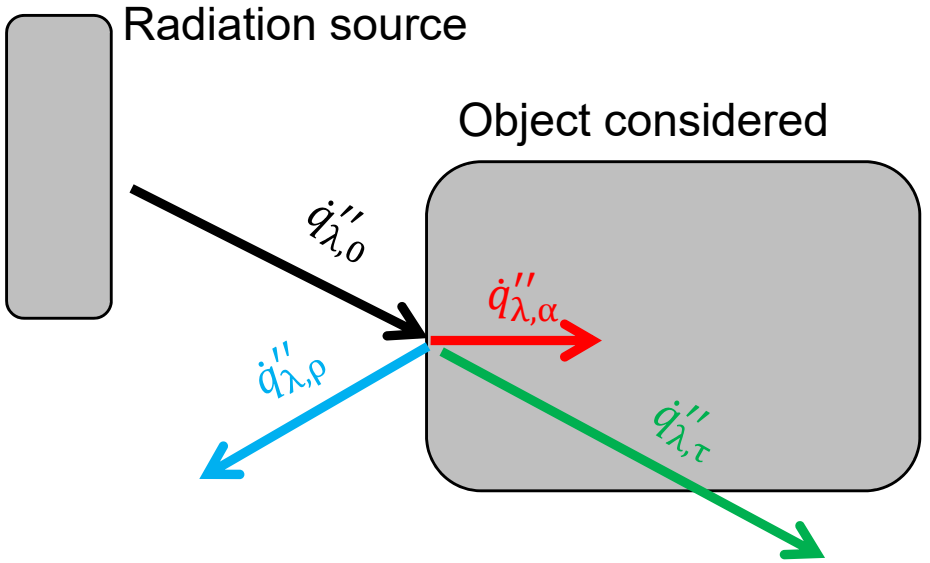
$$1 = \rho(\lambda) + \alpha(\lambda) + \tau(\lambda)$$

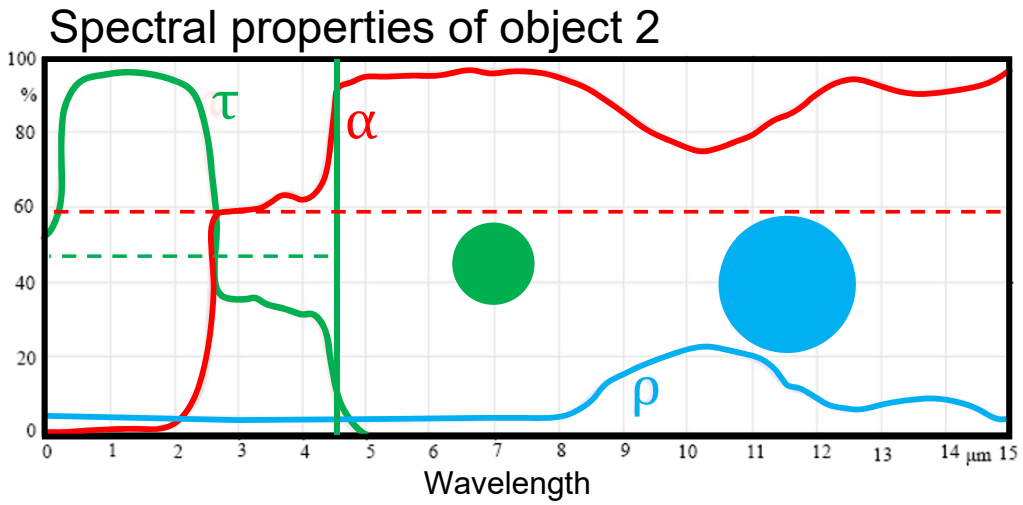
Body properties:

- Reflectivity $\rho(\lambda)$
- Absorptivity $\alpha(\lambda)$
- Transmissivity $\tau(\lambda)$

Wavelength dependent properties (e.g. glass window)







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Wavelength dependent properties (e.g. glass window)

Distribution of the radiation:

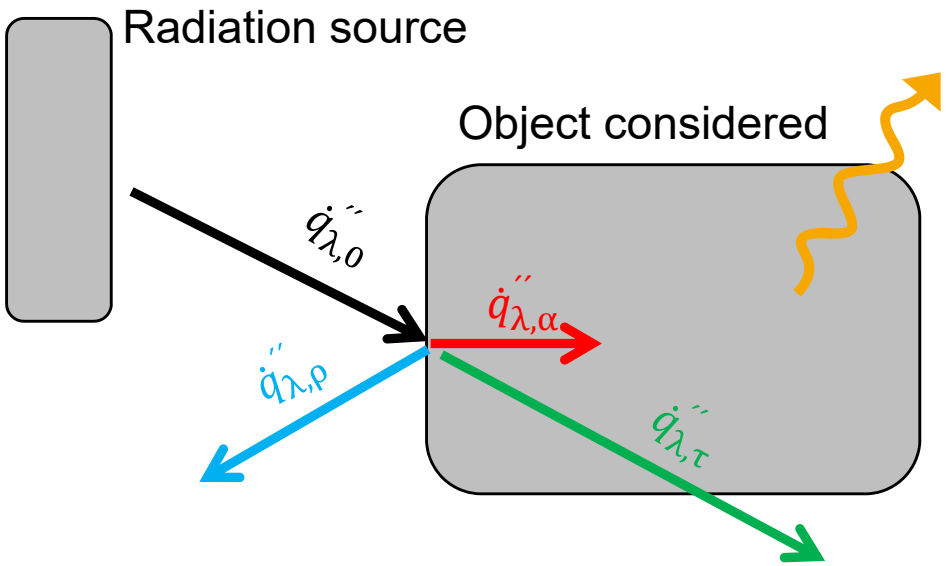
$$\bar{\rho} = \rho = \frac{\dot{q}''_\rho}{\dot{q}''_0} = \frac{\int_0^\infty \rho(\lambda)\,\dot{q}''_{\lambda,0}\,d\lambda}{\int_0^\infty \dot{q}''_{\lambda,0}\,d\lambda}$$

$$\alpha = \frac{\dot{q}''_\alpha}{\dot{q}''_0} = \frac{\int_0^\infty \alpha(\lambda)\,\dot{q}''_{\lambda,0}\,d\lambda}{\int_0^\infty \dot{q}''_{\lambda,0}\,d\lambda}$$

$$\tau = \frac{\dot{q}''_\tau}{\dot{q}''_0} = \frac{\int_0^\infty \tau(\lambda)\,\dot{q}''_{\lambda,0}\,d\lambda}{\int_0^\infty \dot{q}''_{\lambda,0}\,d\lambda}$$

$$1 = \rho + \alpha + \tau$$

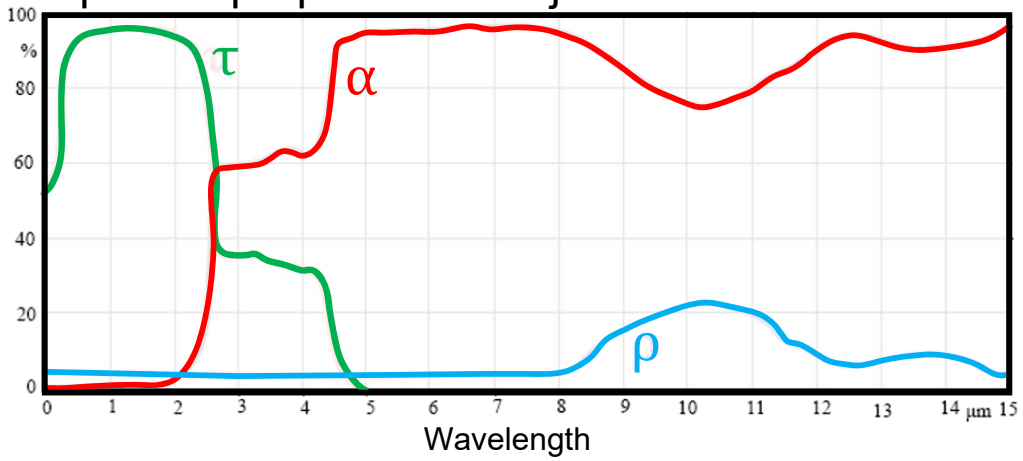
f (body)



In the interaction of radiation from a source with an object:

- Properties of source and object influence the result.

Spectral properties of object 2



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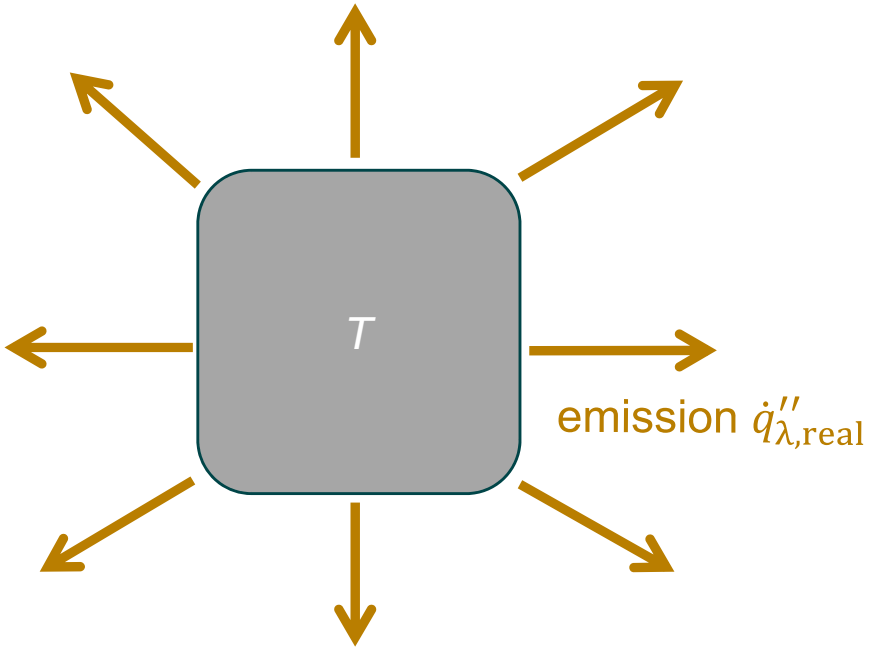
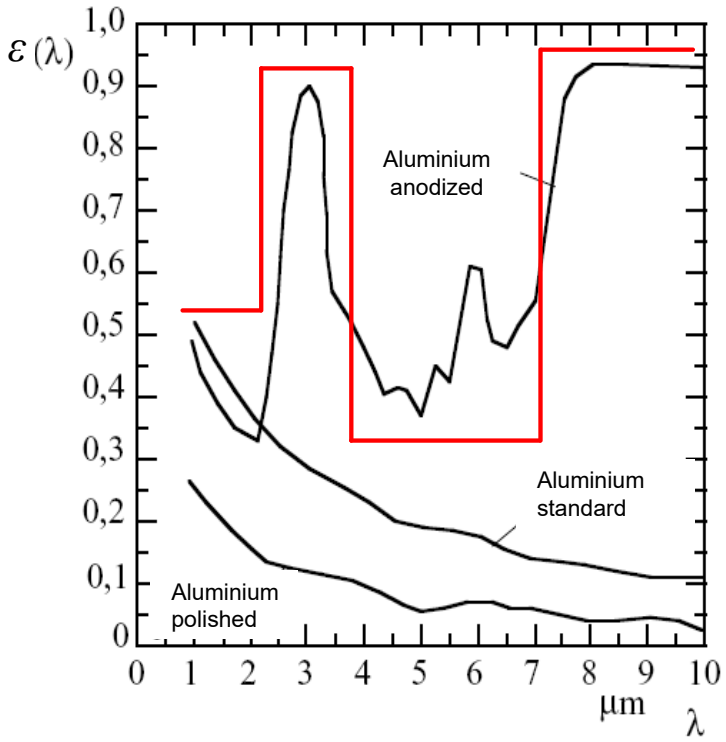
Spectral Emission of Real Objects/Bodies





Heat radiation:

Every body with $T > 0\ K$ emits heat radiation

- The **emissivity** ε of a body indicates how much radiation it emits in comparison with a **black body**.

Heat radiation:

$$\varepsilon(\lambda) = \frac{\dot{q}''_{\lambda,\mathrm{real}}(T)}{\dot{q}''_{\lambda,\mathrm{schwarz}}(T)}_{T};\ 0 \le \varepsilon \le 1$$

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Spectral Emission of Real Bodies

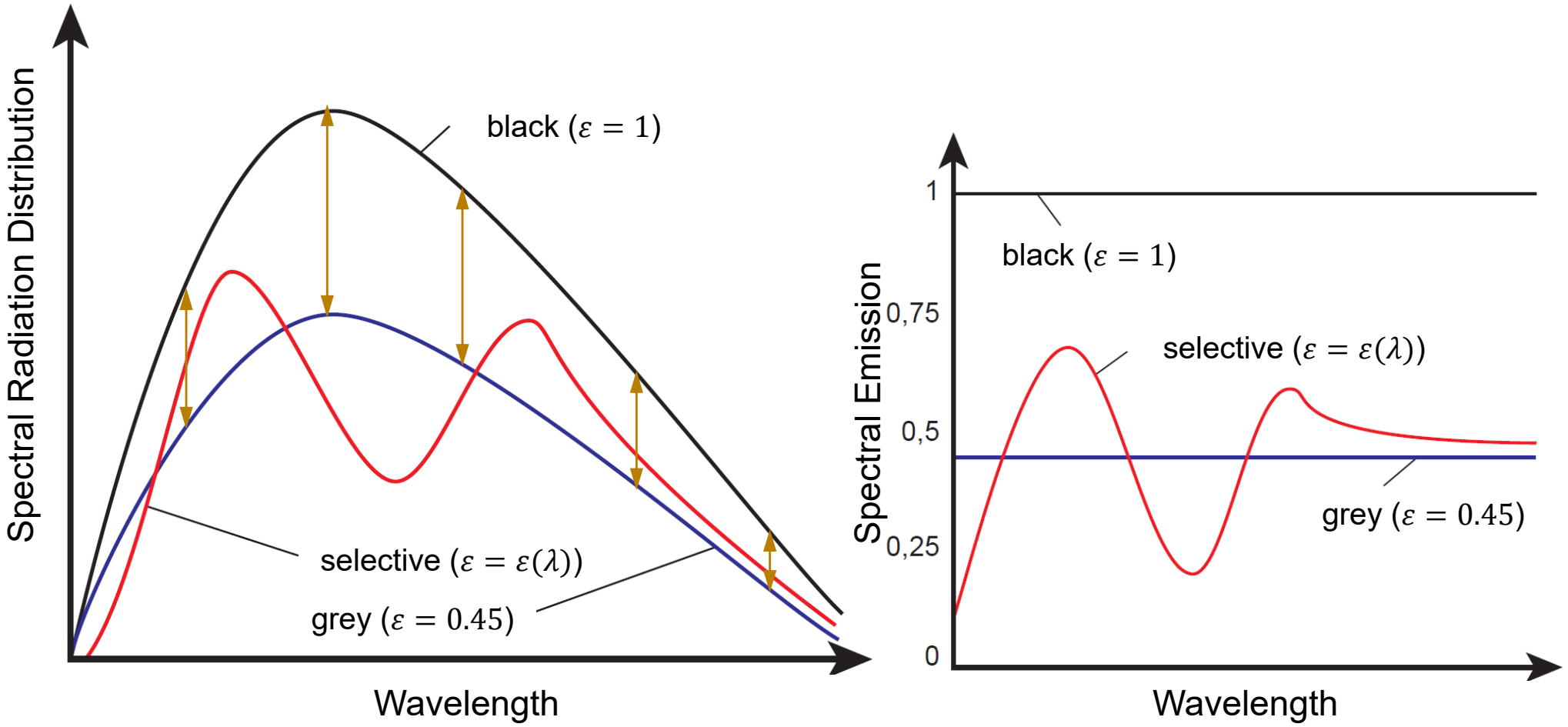
Physik: Einführung in die Wärmelehre, Matthias Kohl

Spectral Emission of Real Bodies

What does the video show:

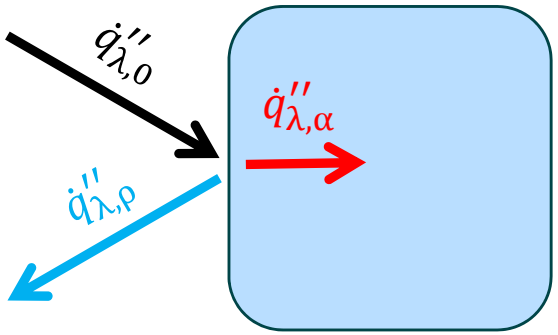
- Radiation emission = f(surface properties and temperature)
- IR Camera detects radiation intensity, no temperatures
- Correlation of picture content and temperature ➡ software
- Thermographic images with different objects ➡ temperature correlation usually not correct

Black, Grey and real Bodies

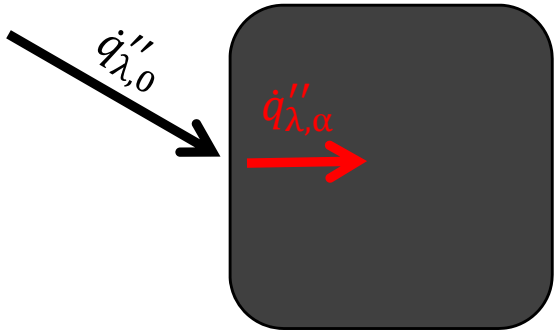


Special Cases

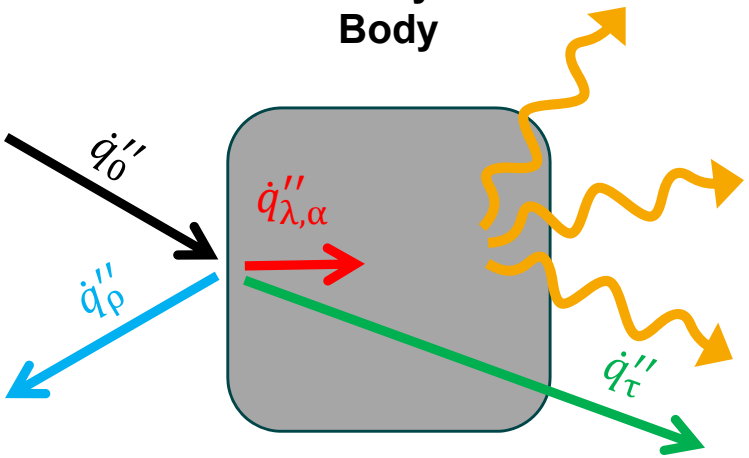
Solid Body
(Opaque to Radiation)



Black Body



Grey Body



Properties:

- No Transmission
  - $\tau(\lambda) = 0$

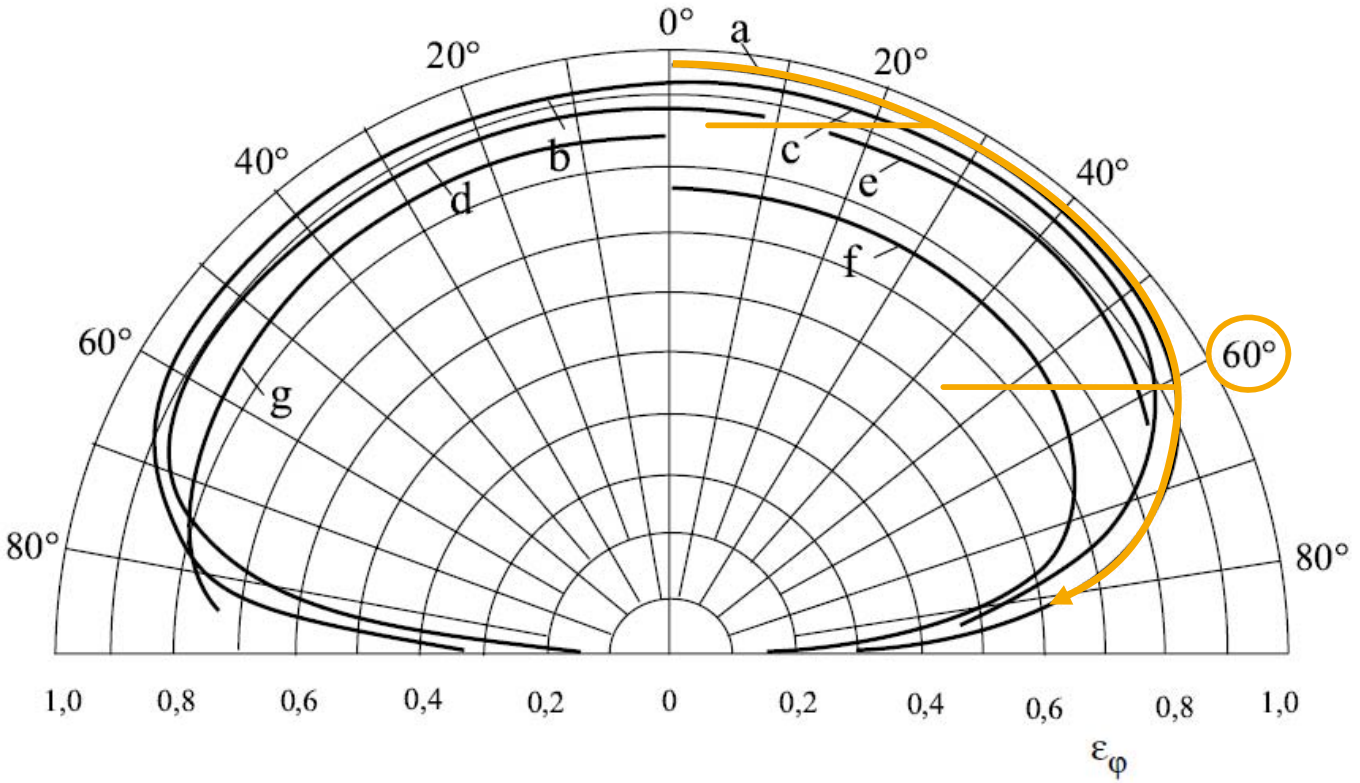
Properties:

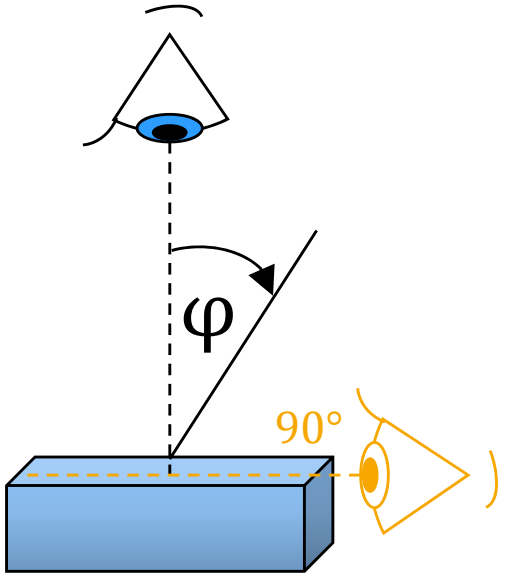
- Absorption of all incoming Radiation
  - $\rho(\lambda) = \rho = 0$
  - $\alpha(\lambda) = \alpha = 1$
  - $\tau(\lambda) = \tau = 0$

What does the video show:

- Wavelength-independent Properties
  - $\rho(\lambda) = \rho$
  - $\alpha(\lambda) = \alpha$
  - $\tau(\lambda) = \tau$

Angle dependent radiation properties: non-conductive materials





Non-conductive at room temperature:

- *(a)* wet ice, *(b)* wood, *(c)* glass, *(d)* paper, *(e)* chalk, *(f)* copper oxide, *(g)* aluminium oxide

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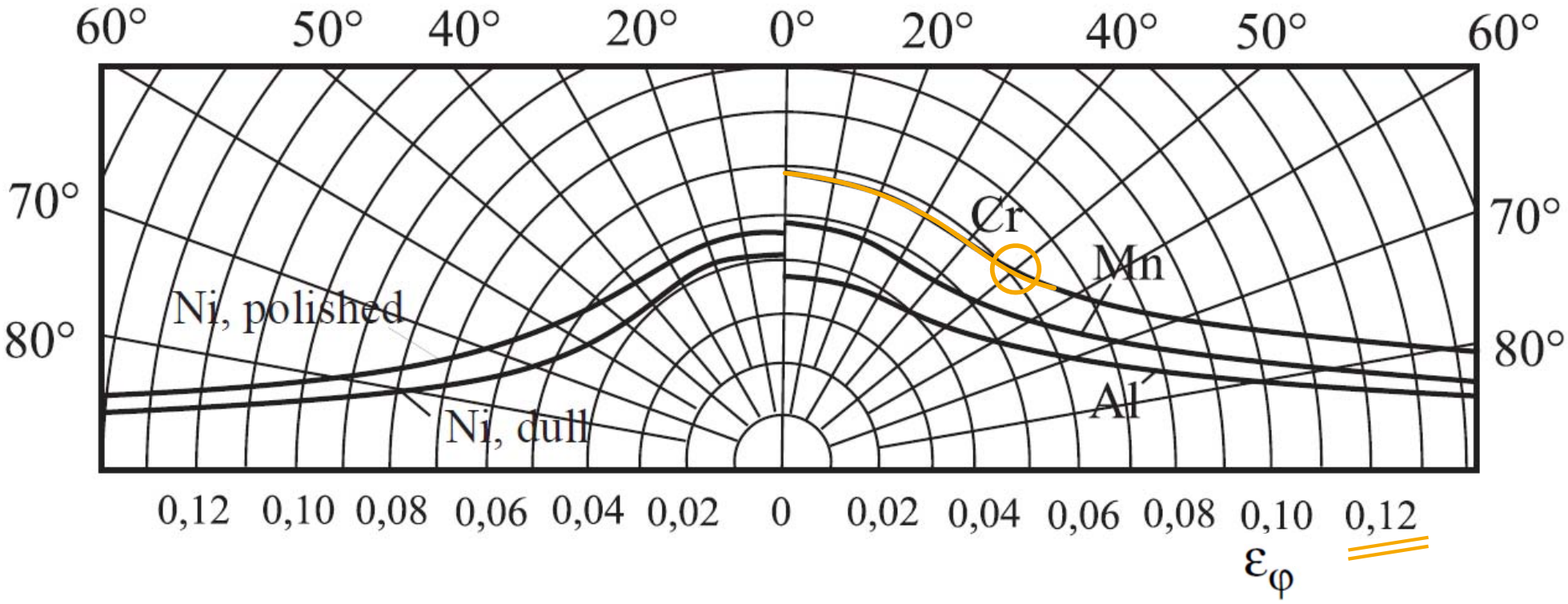
Angle dependent radiation properties: non-conductive materials



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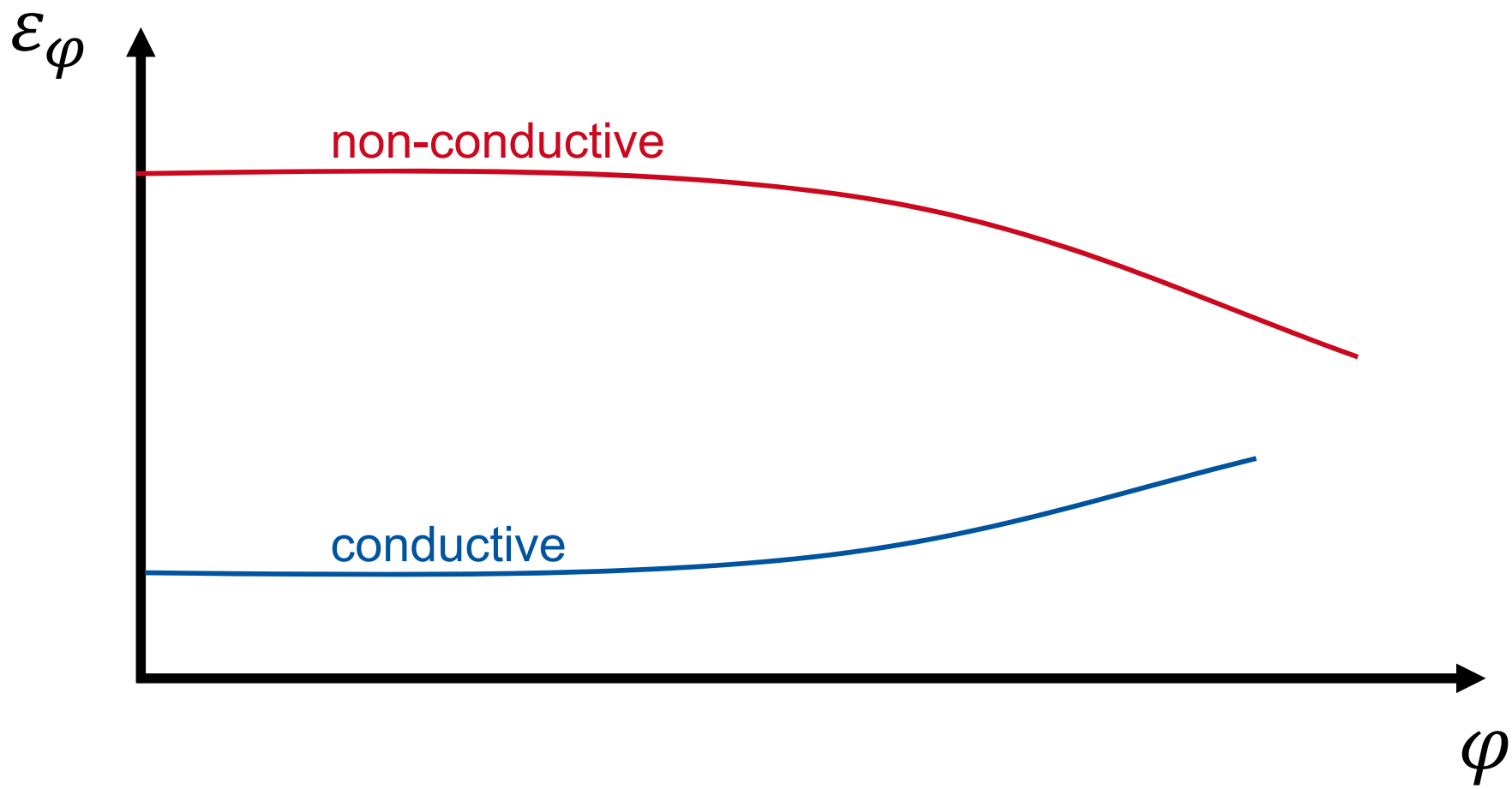
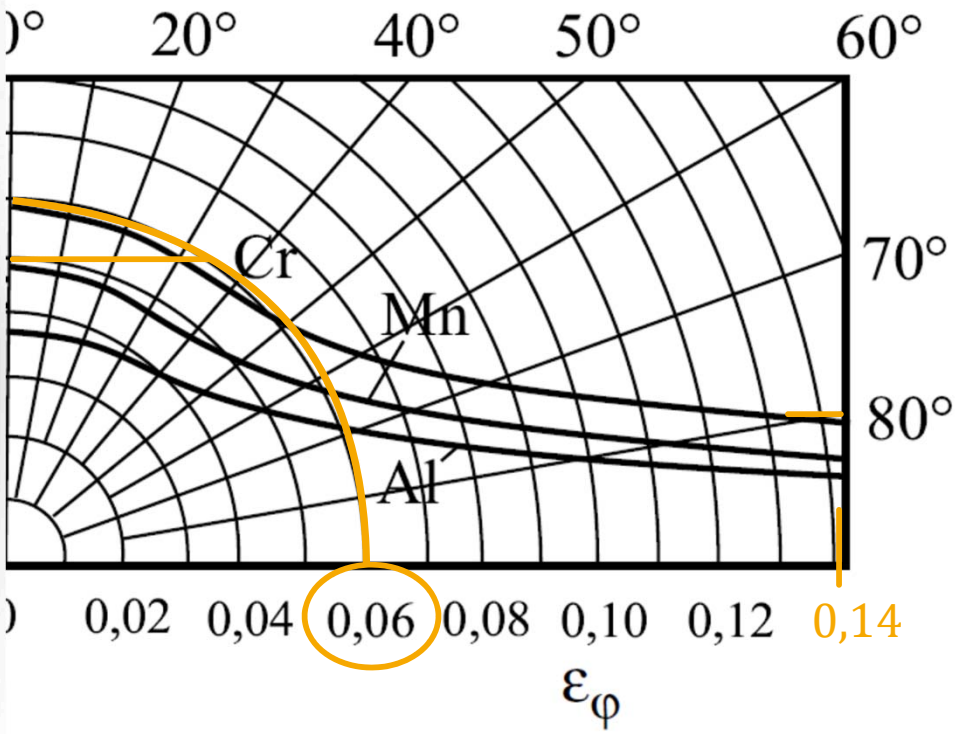
Angle depedency



Angle dependent Radiation Properties: Example



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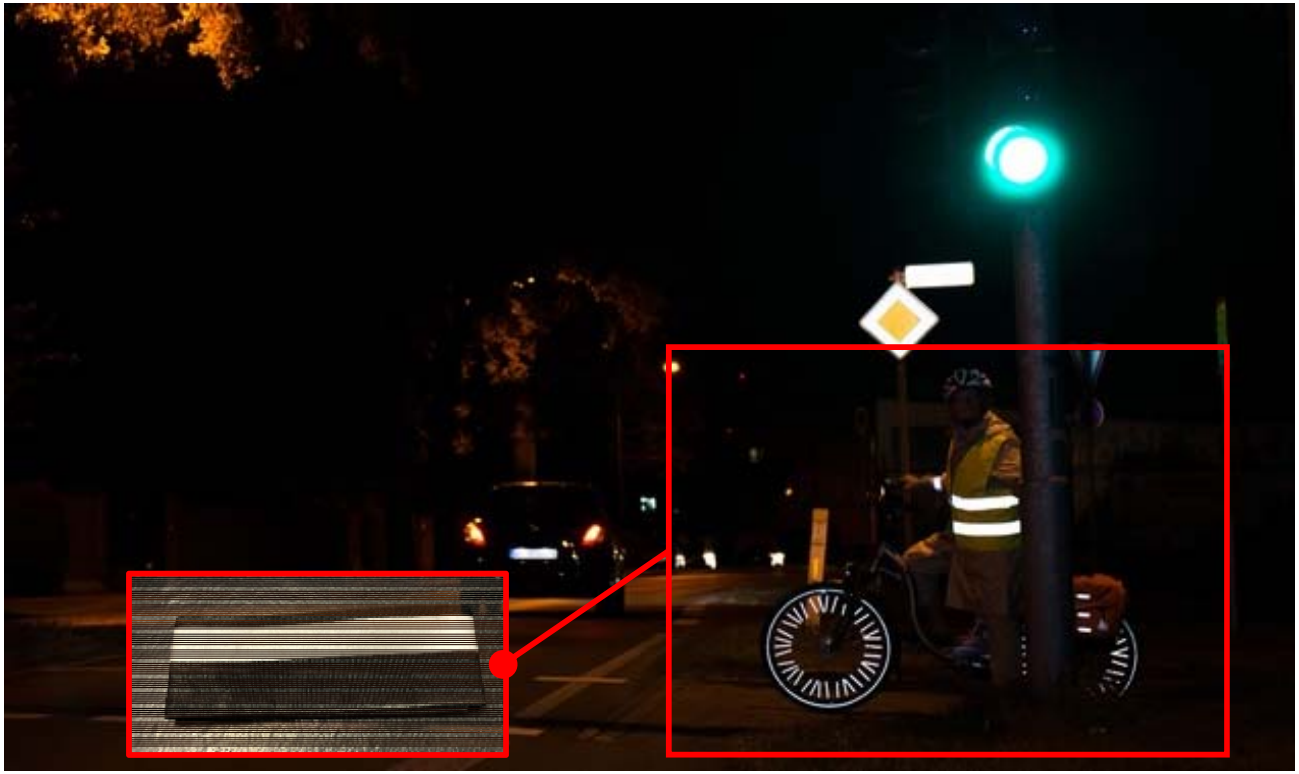
Comprehension questions

In which proportions is divided the radiation that hits a body (real bodies)?

What is the difference between black, grey and real bodies (related to wavelength)?

Safety Advice



Advice:

- Our clothing shows „black body behavior“ in the dark
- Unfortunately, our **eyes adapt** and suggest us, that we can actually still see well ➡ this is **a mistake**

Wear something reflective that will greatly increase your visibility!

Deutscher Verkehrssicherheitsrat (DVR):

Image Caption:
DVR gives tips for more safety in autumn and winter / Good visibility is essential in the dark season. The German Road Safety Council - Deutsche Verkehrssicherheitsrat (DVR) - points this out. Further text about ots and www.presseportal.de/nr/17147 / The use of this picture is free of charge for editorial purposes. Please publish it with reference: "obs/Deutscher Verkehrssicherheitsrat e.V."

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