Part 2

Emissivity

The ratio between the emittance from a real source, M_S, and the emittance from an ideal blackbody source, M_{BB}, at the same temperature is called the spectral emissivity, ε_S

$$\varepsilon_S(\lambda) = \frac{M_S(\lambda)}{M_{BB}(\lambda)} \qquad (4)$$

If ε_S is a constant < 1 for all wavelengths the source is called a greybody for which $L=\varepsilon_S \cdot M/\pi$. In the general case ε_S is a function of wavelength. Some approximate values of ε_S is shown in the table (taken from http://www.eplus-innovation.com/knowledge.asp) on next page.

Emissivity

Material	Emissivity (ϵ)
Aluminum alloy-oxided	0.40
Aluminum-highly polished	0.04-0.06
Aluminum-oxidized	0.11-0.31
Aluminum-Anodized sheet	0.55
Brass-Oxidized	0.60
Brass-polished	0.03
Chromium-polished	0.10-0.38
Copper-polished	0.02-0.05
Copper-heated at 600°C	0.57
Gold-pure, highly polished	0.02
Iron-polished	0.21
Iron-oxidized	0.94
rusted iron plate	0.65
Iron-rough steel plate	0.94-0.97
Lead-gray and oxidized	0.28
Mercury	0.09-0.12
Nickel-polished	0.12
Nickel-oxidized	0.37-0.85
Platinum-pure polished plate	0.05-0.10
Platinum-wire	0.06-0.16
Silver-pure and polished	0.02-0.03
Stainless steel-polished	0.16
Stainless steel-oxidized	0.74-0.87
Tin-bright	0.07-0.08
Tungsten-filament	0.32-0.39
Zinc-polished commercial pure	0.05
Zinc-galvanized sheet	0.23

METALS

Emissivity

Material	Emissivity (ϵ)
Asbestos Board	0.96
Asphalt, tar, pitch	0.90-0.98
Brick-red and rough	0.93
Brick-fireclay	0.75
Carbon-filament	0.53
Carbon-lampblack	0.96
Cement	0.54
Ceramic	0.90-0.94
Concrete	0.92-0.97
Frost crystals	0.98
Glass	0.80-0.95
Human skin	0.98
Ice	0.96-0.98
Marble-polished light gray	0.90
Paints, lacquers, varnishes Black	0.90-0.95
Paints, lacquers, varnishes aluminum paints	0.55
Paints, lacquers, varnishes flat black lacquer	0.96-0.98
Paints, lacquers, varnishes white lacquer	0.95
Paper	0.94
Plastic	0.84-0.94
Porcelain-glazed	0.92
Propellant-Liquid rocket engine	0.90
P.V.C.	0.91-0.93
Quartz-opaque	0.75
Rubber	0.95-0.97
Sand	0.90
Snorw	0.96-1.00
Soil	0.92-0.95
Tape-Masking	0.92-0.95
Wallpaper	0.85-0.90
Water	0.95-0.96
Wood-planed oak	0.82-0.89

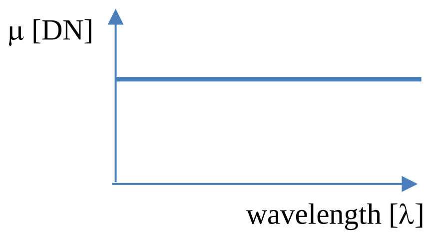
NONMETALS

Thermal and photon detectors

There are two main classes of *infrared detectors*: thermal detectors and photon detectors. The camera you will use in these experiments is based on an array with thermal detectors.

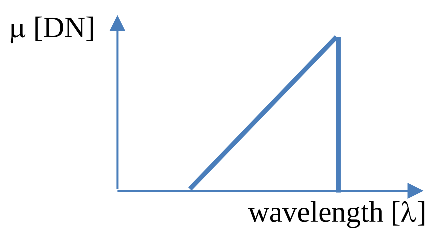
Characteristic features for a thermal detector

- Based on a temperature change of a response element
  ⇒ Slow response, a typical frame rate is up to 50 Hz (video rate)
- No cooling required
  ⇒ Technically simple and cheap (compared with the photon detector)
- Lower sensitivity than the photon detector
- Ideal thermal detector: If radiation falls on the detector at different wavelengths but with constant power, and plot with output signal vs. wavelength is as follows



Characteristic features for a photon detector:

- Based on a photon-electron interaction
  ⇒ Fast response, a frame rate > 10000 Hz is possible
- Requires cooling below 80 K to give good performance in the infrared region
  ⇒ Technically complex and expensive
- High sensitivity
- Ideal photon detector: If radiation falls on the detector at different wavelengths but with constant power, a plot with output signal vs. wavelength is as follows



Hands-on experiments illustrating some basic properties of IR-imaging.

Task 1. The default camera setting of the emissivity is 0.95, which is in good agreement with the emissivity of human skin (~ 0.98). Use the camera to measure the apparent temperature of your or your friend's skin.

- Does the value seem reasonable?
- Try to figure out how apparent temperature changes if the emissivity setting is changed to an erroneous value, e.g. 0.30?
- Find out the answer using the camera!
- Restore the camera to 0.95 emissivity!

Task 2. A problem with imaging in the infrared region is that expensive lens materials such as germanium must be used because the transmission of ordinary lens materials is very poor.

- Investigate the infrared transmission of the glass bowl by e.g. putting your hand into it.
- Investigate the infrared transmission of the plastic bowl by e.g. putting your hand into it.
- Investigate the infrared transmission of the plastic bag by e.g. putting your hand into it. Why is the transmission better now?

Task 3. One thermos contains room-temperature water and the other contains hot water.

- Which one contains hot water and how can you tell?
- Why do you see two strips of tape (one red and one blue) on one thermos, while the IR camera seems to see three stripes?

Task 4. Examples of more investigations.

- Which part of a friend's face is coldest?
- Ask a friend with glasses if you can look at his/her face. What happens to the IR image when you wear glasses?
- Put your hand on the table. Look at it through the IR-camera. Remove the hand. What has happened to the table?