# UE 31 – Thermal radiation

**Measuring the emissivity of spacecraft thermal insulation garments**
In order to characterize the emissivity of spacecraft thermal insulation garments we will be working with Kapton material. A sample of this material is positioned inside the vacuum chamber.

The samples inside the vacuum chamber are at room temperature. Set up the system in order to heat up the samples. Record the data of temperature heating up as a function of time for each sample. What time interval would you choose between two acquisitions? Explain why?

The heat balance of each sample could be written as follow:

$$\boxed{m\, C_p\,(T)\;\frac{dT}{dt} = -\sigma\,\varepsilon\,(T)\;S\,T_S^4 + \sigma\,\alpha\,(T)\;S\,T_0^4 + P_c - P_p}$$

Where :

- *Cp:* specific heat capacity (J/K.Kg)
- *m: masse of the sample (Kg)*
- *σ:* Stefan's constant = $5.6703 \times 10^{-8}$ watt/$m^2K^4$
- *ε:* emissivity of the sample used
- *α: absorptivity of the sample*
- *Ts:* temperature of the sample
- *$T_c$:* temperature of surroundings (K)
- *Pc*: heat power of the source (lamp)
- *Pp*: heat lost by convection and conduction

At a certain point the system will reach the equilibrium. How to define the equilibrium state or how to know that the system is at the equilibrium?

Heat balance equation at the equilibrium condition and deduce the emissivity of each sample.

$$m\, C_p\,(T)\;\frac{dT}{dt} = 0$$

$$\varepsilon\,(T) = \frac{P_c - P_p}{\sigma\;\;S\;(T_S^4 - T_0^4)}$$

Compare the measured emissivity to the one give in the table in the supporting materials table 1. Conclude and explain the difference in values if it is the case.

The samples inside the vacuum chamber are already heated to an equilibrium temperature. Set up the system in order to cool down the samples. (Explain to the teacher). Record the data of temperature cooling down as a function of time for each sample. What time interval would you choose between two acquisitions? Explain why?

Fit the obtained data with a suitable polynomial function in order to deduce a function of the temperature T as a function of time T=f(t).

**Supporting materials**

- $P_p = hS\Delta T$
- with S the contact surface
- ΔT the difference of temperature with the surrounding medium.
- h is the exchange coefficient of convection in (W/m$^2$/K) and is estimated as follow:

$$\boxed{h = 14\frac{(P^2\Delta T)^{0.25}}{L^{0.25}}}$$

- P is the pressure in atmosphere inside the vacuum chamber.
- L is the length of the sample

Table 1: Properties and theoretical values of the samples

| Type/Nature | Kapton | Kapton aluminisé |
|---|---|---|
| Poids | 20 g | 20 g |
| Emissivité | 0.625 | 0.160 |
| Chaleur massique | 900 $JK^{-1}kg^{-1}$ | 900 $JK^{-1}kg^{-1}$ |
| Absorptivité | 0.43 | 0.12 |
| Dimensions | $5 \times 5 \times 0.3$ cm$^3$ | $5 \times 5 \times 0.3$ cm$^3$ |

Thermopile calibration:
La puissance émise par les surfaces du cube vaut donc :
*P=U/KG*
avec
• *P* puissance émise par la surface du cube [W.m−2],
• *U* tension relevée sur le voltmètre avec amplificateur [V],
• *K* constante caractéristique de la thermopile [V.m2.W−1], $K = 41{,}3\times10^{-6}$ V.m$^2$.W$^{-1}$
• *G* gain de l'amplificateur.