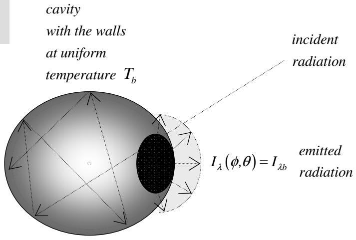
BLACKBODY RADIATION

BLACKBODY

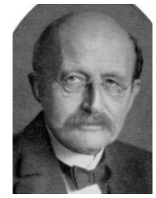
Blackbody can be modeled as an imaginary surface of a small opening of a cavity



Blackbody is defined as an imaginary ideal surface, such that:

- *it absorbs all incident radiation*
- *no other surface can emmit more energy than blackbody (at prescribed surface temperature and wavelength)*
- *diffuse surface (emmited radiation does not depend on direction)*

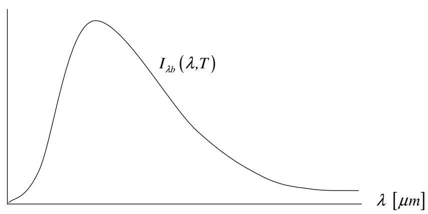
Blackbody is a perfect diffuse absorber and emitter



Max Planck (1858-1947)

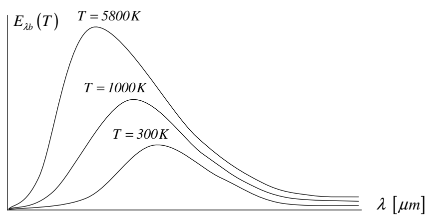
PLANCK DISTRIBUTION

Spectral intensity of radiation emitted by a blackbody at temperature T :



$$I_{\lambda b}(T) = \frac{2hc_0^2}{\lambda^5\left(e^{\frac{hc_0}{\lambda k T}} - 1\right)} \quad \left[\frac{W}{m^2 \cdot \mu m \cdot sr}\right]$$

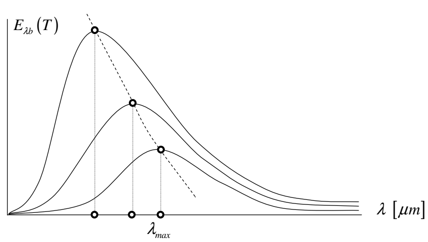
SPECTRAL EMISSIVE POWER OF BB



$$E_{\lambda b}(T) = \pi I_{\lambda b}(T)$$

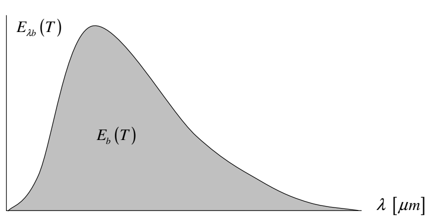
$$E_{\lambda b}(T) = \frac{c_1}{\lambda^5\left(e^{\frac{c_2}{\lambda T}} - 1\right)} \quad \left[\frac{W}{m^2 \cdot \mu m}\right]$$

WIEN'S DISPLACEMENT LAW



$$\lambda_{max} = \frac{c_3}{T} \quad [\mu m]$$

STEFAN - BOLTZMANN LAW



$$E_b(T) = \sigma T^4 \quad \left[\frac{W}{m^2}\right]$$

$$I_b(T) = \frac{\sigma T^4}{\pi} \quad \left[\frac{W}{m^2 \cdot sr}\right]$$

RADIATION CONSTANTS

$c_0 = 2.998e8 \left[\frac{m}{s}\right]$ *speed of light in the vacuum*

$c_1 = 2\pi h c_0^2 = 3.742e8 \left[\frac{W \cdot \mu m^4}{m^2}\right]$

$c_2 = \frac{hc_0}{k} = 14{,}388 \; [\mu m \cdot K]$

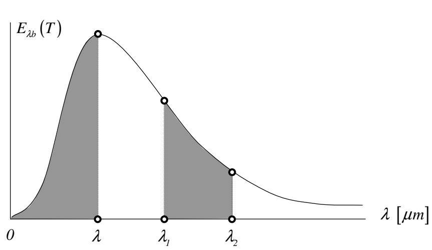
$c_3 = 2897.8 \; [\mu m \cdot K]$

$h = 6.626e-34 \; [J \cdot s]$ *Planck constant*

$k = 1.381e-23 \left[\frac{J}{K}\right]$ *Boltzmann constant*

$\sigma = 5.67e-8 \left[\frac{W}{m^2 \cdot K^4}\right]$ *Stefan-Boltzmann constant*

BAND EMISSION



Fractional blackbody emissive power:

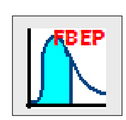
$$F_{0\to\lambda}(T) = \frac{\int_0^\lambda E_{\lambda b}(T)\, d\lambda}{\sigma T^4}$$

$$F_{\lambda_1\to\lambda_2}(T) = F_{0\to\lambda_2} - F_{0\to\lambda_1}$$

$F_{0\to\lambda}(T)$ *is a function of* (λT)

TABLE 12.1 Blackbody

λT ($\mu m \cdot K$)	$F_{(0\to\lambda)}$
200	0.000000
2,800	0.227897
2,898	0.250108
3,000	0.273232



Fractional Blackbody Emissive Power Calculator