Blackbody radiation and solar radiation

1) More on Blackbody Radiation;

Black body radiation

2) Magnitude of Solar radiation

Summary

1) Radiation power mainly concentrated in an interval of wavelengths near the peak. The peak in the power spectrum moves to longer wavelengths when T decreases.

$$\Delta_{peak} T = 2.898 \times 10^{-3} m \bullet K$$

Wien's displacement law

2) The integrated (the area below the power spectrum) or total radiation power per unit surface area decreases as T decreases.

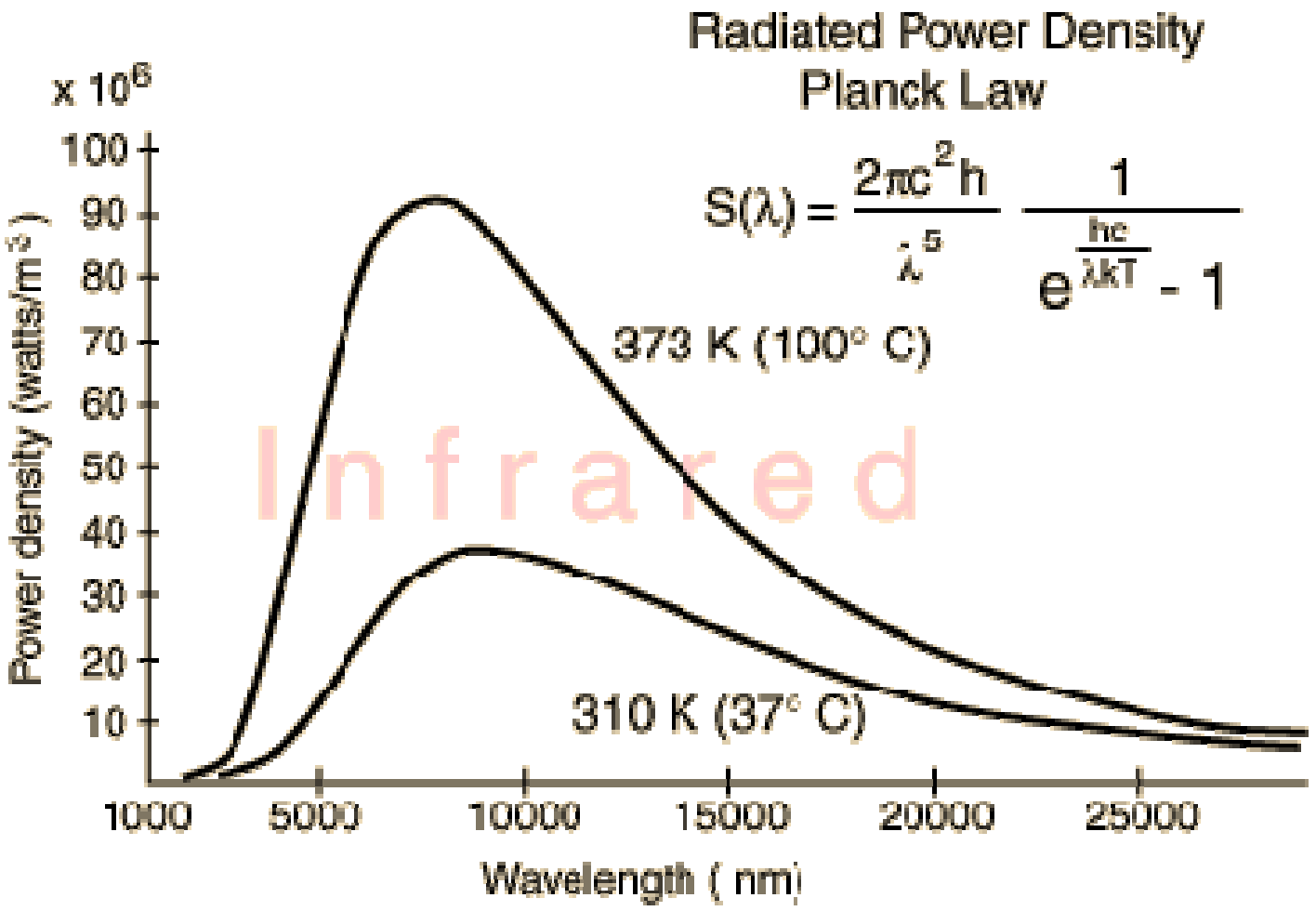
$$\frac{P}{A} = \sigma T^4 \quad J / m^2 s; \quad \sigma = 5.6703 \times 10^{-8} W / m^2 K^4.$$

Stefan-Boltzmann Law

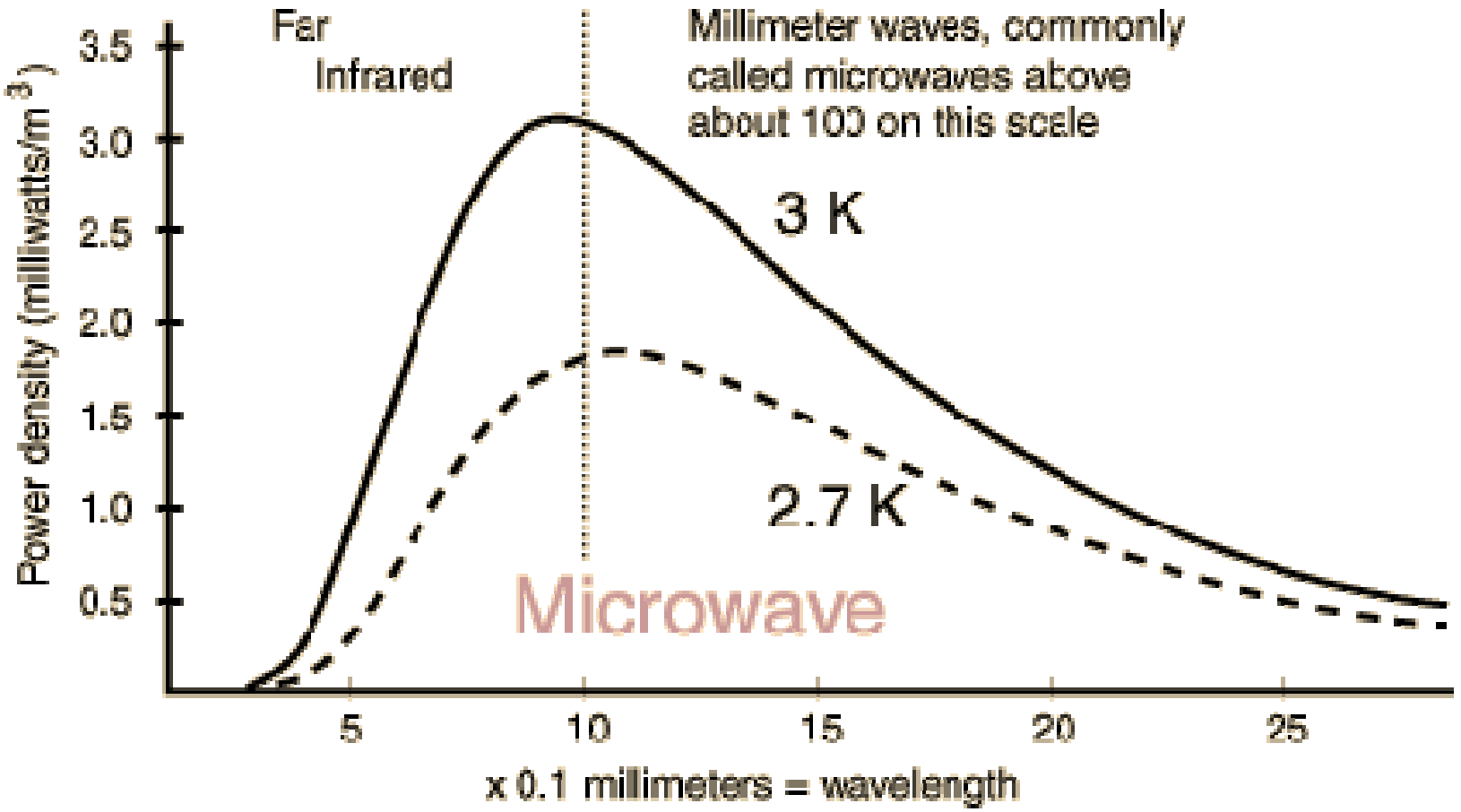
Q1

At about 6000K, the sun is radiating light with peak wavelength about 480nm. For human bodies, estimate the peak wavelength of the blackbody radiation.

1) 1 nm;
2) 100 nm;
3) 9,600 nm;
4) 1 mm;



Blackbody radiation at T=310K



Blackbody radiation at T=3K

Q2

Currently, the temperature of our universe is measured to be 2.7 K. Find the ratio between the radiation power per unit area of the universe (P1) and the radiation power per unit area of our human bodies (P2), i.e. P1/P2.

1) 10,000;
2) 1;
3) 10^(-2);
4) 10^(-8).

Solar radiation

- Solar constant ~1.4 kW/m^2

(incoming radiation POWER per unit area).

Or more accurately annual average solar constant S = 1367 W/m^2

Q3

In Fei's backyard, there are garden lights powered by solar energy. The size of solar panel is about 5X5 cm^2 and in summers in Vancouver, it is under sunshine for about 12 hours each day. Estimate how much energy is stored everyday in solar batteries.

1) 5000KJ;
2) 50 KJ;
3) 1 KJ ;
4) 100 J.

Q4

For a garden light to be on for a whole night, estimate how many watts (at most) can it have?

1) 0.1 W
2) 2 W;
3) 60 W;
4) 200 W

Energy Balance of the Earth

- Incoming energy flux: Solar energy;
- Internal heat (won't be considered);

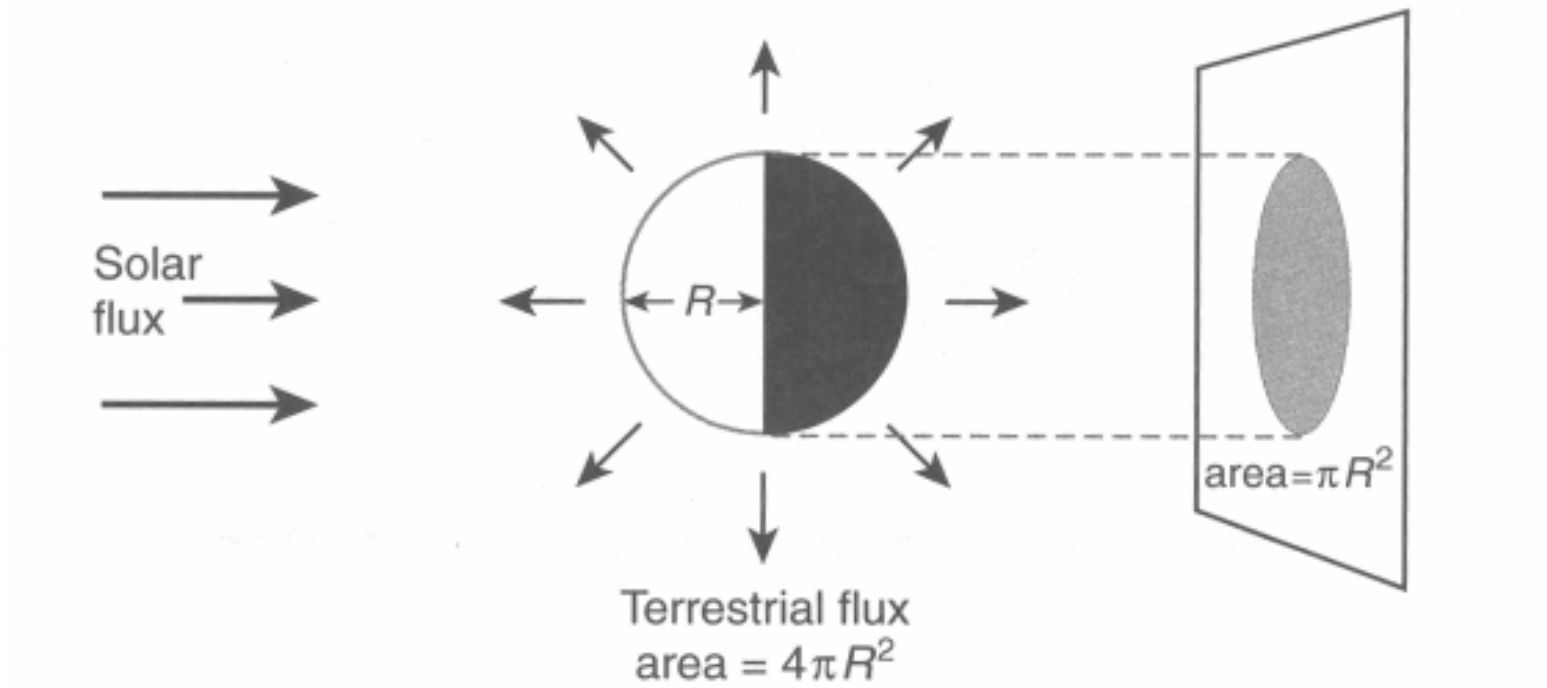
- Outgoing energy: Radiation by the earth.

Reflection coefficients or Albedo

- Overall average reflection coefficient of an object: Albedo
- Albedo of the Earth is about A = 0.3 which means that the Earth as a whole reflects 30% of solar radiation.

Total power of the incoming radiation

$$P_{in} = (1\text{-}A)\, S\, \pi\, R_{Earth}^2$$



Example from Roland B. Stull, Meteorology for Scientist and Engineers