702.

Problem 49.3 (RHK)

We have to calculate the wavelength of the maximum spectral radiancy and identify the region of the electromagnetic spectrum to which it belongs for each of the following: (a) *The* 2.7-K *cosmic background radiation, a remnant of the primordial fireball*. (b) *Human body, assuming a skin temperature of* 34^0C. (c) *A tungsten lamp filament at* 1800 K. (d) *The Sun, at an assumed surface temperature of* 5800 K. (e) *An exploding thermo nuclear device, at an assumed fireball temperature of* 10^7 K. (f) *The universe immediately after the Big Bang, at an assumed temperature of* 10^{38} K. *We may assume cavity radiation conditions throughout*.

Solution:

The wavelength $\lambda_{\max}$ at which spectral radiation emitted at temperature T has its maximum is given by the Planck's formula

$$\lambda_{\max} = \frac{2898\ \mu\text{m.K}}{T}\ .$$

We will use this result for answering (a) to (f).

(a) $\lambda_{max} = \frac{2898}{2.7\ \text{K}}\ \mu\text{m.K} = 1.073\ \text{mm}$, microwave region;

(b) $\lambda_{max} = \frac{2898}{307\ \text{K}}\ \mu\text{m.K} = 9.439\ \mu\text{m}$, far infra red;

(c) $\lambda_{max} = \frac{2898}{1800\ \text{K}}\ \mu\text{m.K} = 1610\ \text{nm}$, infra red;

(d) $\lambda_{max} = \frac{2898}{5800\ \text{K}}\ \mu\text{m.K} = 499.6\ \text{nm}$, visible;

(e) $\lambda_{max} = \frac{2898}{10^7\ \text{K}}\ \mu\text{m.K} = 2898 \times 10^{-13}\ \text{m} = 289.8\ \text{pm}$, gamma ray;

(f) $\lambda_{max} = \frac{2898}{10^{38}\ \text{K}}\ \mu\text{m.K} = 2898 \times 10^{-44}\ \text{m}$, ultra-gamma ray.