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Problems set # 13 **Physics 167** May 11, 2023

1. Counting photons. *(i)* How many photons are emitted by a 100-watt sodium lamp (550 nm) in one second? (1 watt = 1 J/s) Assume the lamp is 100% efficient in converting electrical energy into light. *(ii)* The absolute threshold of the dark-adapted human eye for the perception of light at 510 nm has been measured as 3.5×10^{-17} J. How many photons does this correspond to?

2. The temperature of a nuclear blast is 10^7 K. Conclude from this why it is not advised to be in the line of sight of a nuclear blast.

3. Light of wavelength 50 nm strikes a clean metal surface in vacuum, emmiting electrons of maximum kinetic energy 12.4 eV. What is the maximum wavelength of light that can eject electrons from this metal, in nm? [Hint: Use $hc = 1240$ eV $\cdot$ nm to do your calculation].

4. A non-relativistic particle of mass m has a position uncertainty equal to its de Broglie wavelength. What is the minimum fractional uncertainty in its velocity, $\Delta v/v$?

5. *(i)* Stars behave approximately like blackbodies. Use Wien's displacement formula to obtain a rough estimate of the surface temperature of the Sun, assuming that it is an ideal blackbody as suggested by the ASTM data shown in Fig. 1 and that evolution on Earth worked well (i.e., that the human eye uses optimal the light from the Sun). *(ii)* The solar constant (radiant flux at the surface of the Earth) is about 1.365 kW/m^2. Find the effective surface temperature of the Sun *(iii)* Assuming that the surface of Neptune and the thermodynamics of its atmosphere are similar to those of the Earth estimate the surface temperature of Neptune. Neglect any possible internal source of heat. [*Hint:* Astronomical data which may be helpful: radius of Sun $R_\odot = 7 \times 10^5$ km; radius of Neptune $R_{\rm N} = 2.2 \times 10^4$ km; mean Sun-Earth distance $r_{\rm SE} = 1$ AU $= 1.5 \times 10^8$ km; mean Sun-Neptune distance $r_{\rm SN} = 4.5 \times 10^9$ km.]

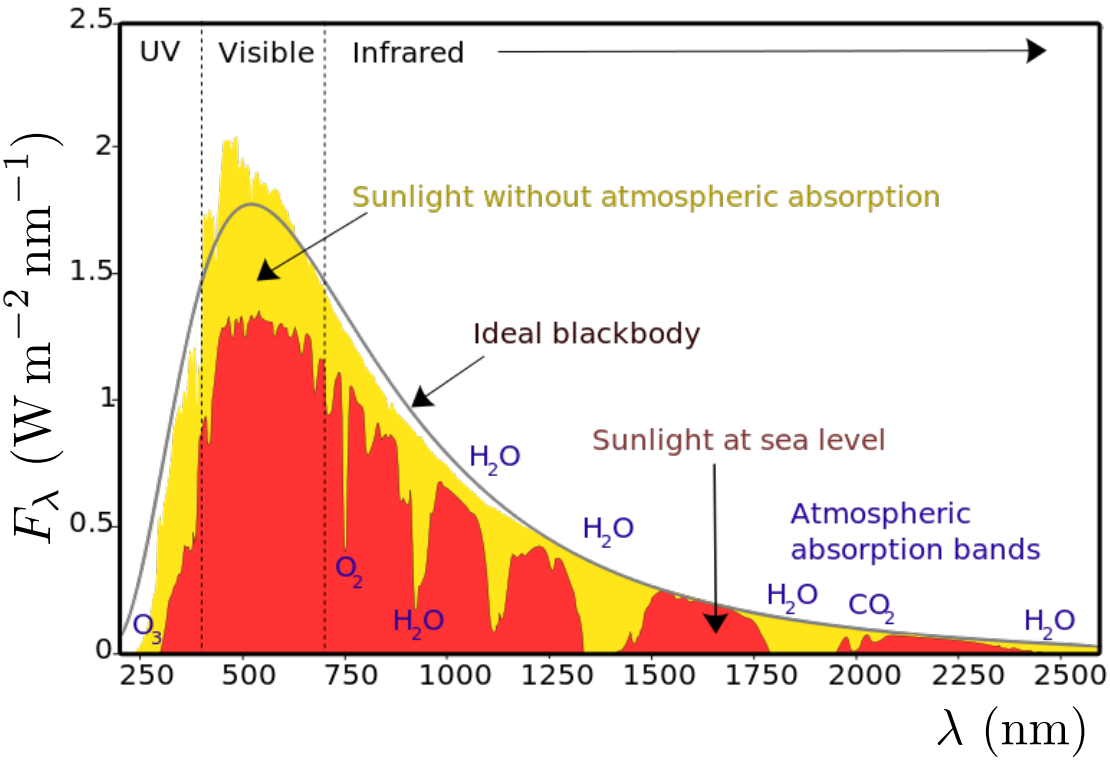

Figure 1: Solar energy incident at Earth's atmosphere and surface. The yellow band is the radiation incident at the top of the atmosphere, while the red band is the radiation at Earth's surface, diminished by the atmospheric absorbers shown. The radiation approximates a blackbody curve. These data are from the American Society for Testing and Materials (ASTM) Terrestrial Reference Spectra.