

Physics/Astro 562/ Peterson: Problem Set #2  
Due: Thursday, 2/15/2024  
Intro to High Energy Astrophysics

1) **Data Analysis:** Describe in detail what is meant by analyzing the: a) energy, b) arrival time, and c) spatial position of photons. Mention the complications to building a perfect telescope in each case. Then describe how one might perform data analysis using all measurements of a photon together (spatially-resolved time-dependent spectroscopy).

2) **Photon Scattering:** Photons scatter many times in the interior of the sun. The cross-section for that scattering is approximately given by the Thomson Cross-Section ( $\sigma_T = 6.65 \times 10^{-25} \text{cm}^2$ ). Calculate the mean free path of a photon in the Sun assuming that the density is about  $150 \text{ g cm}^{-3}$  and the plasma is fully ionized and contains 25% Helium and 75% Hydrogen.

3) **Black-Body Radiation:** : The spatial energy density per unit frequency interval of blackbody radiation is given by

$$u_\nu = \frac{8\pi h}{c^3} \frac{\nu^3}{e^{\frac{h\nu}{k_B T}} - 1}$$

a) First, write down an expression for the total energy of a photon gas of volume  $V$  (Hint: this will be an integral over frequency) b) Then, approximate the denominator by  $e^{\frac{h\nu}{k_B T}} - 1 \approx e^{\frac{h\nu}{k_B T}}$  and evaluate the integral in part a.