

Question Sheet: Revision

1. In the spectrum of hydrogen, what is the ratio of the longest wavelength in the Lyman series to the longest wavelength in the Balmer series?

2. Calculate the wavelength of the Lyman alpha spectral line of hydrogen. This wavelength differs by 1.8×10^{-10} cm in spectra taken at opposite ends of the Sun's equator. What is the speed of a particle on the equator due to the Sun's rotation?

3. In the case of Thomson scattering, the dimensionless quantity τ , defined by $d\tau = n_e \sigma_T dr$, is called the *optical depth*. (n_e is the electron number density) It is a measure of the transparency of a medium to radiation. Show that the equation of hydrostatic equilibrium may be written as:

$$\frac{dp}{d\tau} = \frac{g\mu_e}{\sigma_T}, \quad (1)$$

where g is the gravitational acceleration and μ_e is the mean molecular mass per electron.

4. Show that the total luminous power P intercepted by Earth is

$$P = \pi R_{\text{Earth}}^2 (L_{\odot}/4\pi r^2), \quad (2)$$

where R_{Earth} is the radius of Earth, $L_{\odot} = 3.9 \times 10^{33}$ erg/s the luminosity of the Sun and r the distance of the Earth from the Sun (1.50×10^{13} cm).

Taking into account the rotation of the Earth, what is the average energy flux \bar{f} incident on Earth? Assume that only 61 percent of \bar{f} is absorbed by Earth, the other 39 percent being reflected from cloudtops, the ground and the oceans. The former flux of light heats the surface to an average temperature T , and the Earth reradiates this energy effectively as a black body. Compute T . Is your answer reasonable? What explains the discrepancy between T and the observed average temperature of 290 K?

5. An ideal monatomic gas is in thermal equilibrium at room temperature T so that the molecular velocity distribution is Maxwellian. (i) Calculate the most probable speed of the particles in this gas. (ii) Calculate the root mean square speed of the particles in the gas.

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