Lecture 2 : Principles of Radiative Transfer

Astrophysics is that special branch of science where there is no scope of examining the object of interest in a controlled, laboratory setting. We must simply decipher the signals that are coming to us from distant astrophysical objects. And to do that, we must understand the signals properly. Till the discovery of gravitational waves just a few years ago, the electromagnetic radiation happened to be our sole window to the world.

Because, most of the information concerning the physical nature of celestial bodies (such as their chemical composition, density, temperature, etc.) is obtained through detecting and analyzing the electromagnetic radiation from them at various wavelengths. This second lecture introduces the 'FUNDAMENTAL PRINCIPLES OF RADIATIVE TRANSFER' and deals with the fundamental principles of absorption and emission of radiation in a medium. The concepts introduced in this lecture will be important for the rest of the lectures in this series.

Suggested Reading-

G. B. Rybicki & A. P. Lightman, 2004, ***Radiative Processes in Astrophysics***, Wiley

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Suggested Problems

1. Calculate the energy received at Earth from the Sun per square metre per second. Express the result in Watts per square metre per second. Which physical quantities you must know the value of to do this calculation?

2. (a) The surface temperature of the sun is approximately 6,000 Kelvin. The Moon is much closer to us than the Sun. Imagine that we heat the Moon to the same temperature as the surface of the sun. Will we be fried to death?!

   (b) Calculate the ratio of the energy received at the earth from the Moon and the Sun (per unit area per unit time) if their surface temperatures are the SAME!

3. Consider two gaseous regions A and B of the following nature. a) A and B are both comprised of ionised Hydrogen but A has higher density, b) A is made up on ionised Hydrogen and B is made up of fully ionised Helium, but both have the same density. In each case, determine which region would be optically thicker. Explain why.

4. (a) Starting from Planck's Law find an analytical expression for the brightness temperature, T_B. Also find the approximate expression if $h\nu << k_B T$.

   (b) The operating wavelength of an observatory is $\sim$ 10 meter. The brightness temperature of an astrophysical source measured at this observatory is $\simeq 10^{20}$K. Convince yourself that the detected radiation can not be thermal.

5. Starting from the equation of radiative transfer show that the presence of absorption lines in the spectra of the Sun, when looking straight at the disk, is indicative of the fact that the interior temperature of the Sun is higher than the temperature of its outer layers.

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