

ASTR 589 – Physics of Astrophysics
Assignment III, on Radiative Transfer and Processes
Due Date: Thursday October 19

1. The Coma cluster is a galaxy cluster with a radius of approximately $R = 3$ Mpc. X-ray observations reveal some amount of hot gas, with a thermal spectrum indicating a temperature of $T = 8.8 \times 10^7$ K. Assume that the gas consists of 75% hydrogen and 25% helium by mass. Wherever necessary, use a Gaunt factor of 1.2.
 - (a) Do you expect the gas to be fully ionized? Explain your reasoning (or derive the ionization fraction using Saha equation).
 - (b) Verify that most of the emission is radiated in the X-ray regime and calculate the average free electron density in the gas, if the X-ray luminosity is $L_X = 5 \times 10^{44}$ erg s⁻¹. Assume here the gas is optically thin.
 - (c) Consider Bremsstrahlung absorption and Thomson scattering and find at which frequency the gas becomes optically thick. (For combined scattering and absorption, p. 36 of Rybicki & Lightman might be useful.)
 - (d) What is the cooling time for this gas?
2. Problem 6.4 from Rybicki & Lightman