Department of Astronomy, University of Toronto

RADIATION PROCESSES – AST1440F

Review Questions for Section 3

1. An analysis of thermal bremsstrahlung normally ignores electron-electron and ion-ion encounters. Why? Give an example of a system or source which radiates (i) electric quadrapole emission, and (ii) magnetic dipole emission.
2. Why is the classical treatment of free-free radiation restricted to the low frequency part of the spectrum?
3. Sketch the spectrum of a single electron as its orbit is deflected by a nearby ion. Which two factors limit the spectrum's bandwidth; i.e., force a cutoff at high frequency?
4. Why should the power radiated at a given frequency increase like v^2 at low velocity but then fall off like v^{-2} at high v?
5. The classical formula for $dW/d\nu$ appears to allow for any angle of deflection θ. But on closer analysis, the treatment breaks down for large angles. That is, it is invalid. Why?
6. Why does the classical treatment overestimate the free-free emission at low frequencies when the temperature is high?
7. Why does the classical Gaunt factor $\bar{g}_{\rm ff}(\nu, T)$ become negative at high ν? Can you derive an approximate frequency dependence at high ν, ignoring quantum mechanical effects?
8. Explain why the frequency-averaged Gaunt factor $\bar{g}_{\rm B}$ is close to unity even though $\bar{g}_{\rm ff}$ lies in the range 0.1 to 10.
9. For an ionization zone, what are the main frequency dependences of the emission coefficient j_ν and the absorption coefficient α_ν in the radio range (both for free-free radiation)? How would these change at high frequencies?
10. Sketch the thermal bremsstrahlung spectrum of a compact HII region. Why does it turn over at high ν? What is a typical turn-over frequency? Indicate the actual ν-dependences on your diagram in the low and high frequency limits.
11. We have discussed the free-free spectrum of HII regions. What about the free-bound or recombination radiation? Is it important?
12. What is a typical kinetic temperature T_e in HII regions and why is it almost independent of density? Looking more closely at the bottom table on page 55, however, one can see a very weak correlation between temperature and density. What might be an explanation for this?
13. In view of the fact that H II regions have temperatures very similar to the effective temperatures of stars, why don't they shine as brightly in the visible?
14. How can observations of bremsstrahlung fluxes provide a measure of electron densities in HII regions? Are observations at low frequency alone sufficient? What is the observed range of n_e from compact to diffuse (giant) HII regions?

15. Why are mass estimates only a *lower* limit to the actual total mass in a particular cloud?
16. Observations show that diffuse HII regions have much higher ionized gas masses than compact ones. An obvious explanation is that they have more sources of Lyman continuum photons. But this is only part of the story because even a single O star can maintain a much higher ionized mass in a *low* density region than in a *high* density one. Can you explain why physically? Demonstrate that the ionized mass should be inversely proportional to the density.