Department of Astronomy & Astrophysics, University of Toronto

RADIATION PROCESSES – AST1440F

Review Questions for Section 6

1. How in principle is an EM-wave dispersed in an ionized plasma? Why is it considered a "cooperative" phenomenon?
2. In estimating the polarization of an ionized medium, we neglect the ions. Why?
3. How does the propagation of a wave with $\omega > \omega_p$ differ from that with $\omega < \omega_p$? What happens when ω drops below the collision frequency of the gas particles?
4. In view of your answer to the first part of the last question, can you explain why the frequency band responsible for energy propagation in any astrophysical source is always *higher* than ω_p, the plasma frequency?
5. How, in principle, can a *neutral* gas be polarized into a dielectric medium? Speculate as to why n should *exceed* unity in this case whereas, in an ionized gas, the index of refraction is *less* than unity?
6. Why can't *optical* radiation polarize the ISM gas?
7. Why do AM radio waves propagate around the Earth much more effectively than FM waves?
8. Sketch an amplitude modulated wave, showing how the group velocity can be different from the phase velocity.
9. How can observations of pulsar pulses give us information on the electron density in the ISM? What is the nominal figure for $\langle N_e \rangle_{\rm ISM}$?
10. How can an EM-wave polarize an ionized medium without suffering any attenuation? [Ignore electron scattering.]
11. Explain why the plane of polarization of a linearly polarized beam *rotates* in a magnetized plasma.
12. The right-handed circularly polarized component has a *shorter* wavelength than the left-handed one. Why does this make its $\boldsymbol{E}$-vector rotate through a *greater* angle over a given distance of propagation?
13. What would be the expected Faraday rotation of a linearly polarized wave propagating through the ISM over a distance of 1 Kpc?
14. How can the dispersion measure $D_{\rm M}$, together with the rotation measure $R_{\rm M}$, yield information on the mean values of both the galactic disk electron density and the magnetic field?
15. Explain why the top signs in the equations on page 92 correspond to left-handed circular polarization.
16. Why should a LHC polarized wave be subject to different dispersion than a RHC one?

Superficially, there seems to be no symmetry that would favor one over the other. [Hint: look at the equations on p92.]

17. We learned earlier that a uniformly moving charge cannot radiate in a vacuum. But in a neutral gaseous or fluid medium this rule is no longer valid. Why? Exactly what conditions are necessary for charges in such a medium to radiate?
18. Give two real-life examples of Cherenkov radiation.
19. In what way are sonic booms from jet aircraft the acoustic analogs of Cherenkov radiation?
20. The Razin effect (hypothetically) predicts the quenching of synchrotron radiation at low frequencies. Why physically should this happen? Why is it difficult to observe the effect?