Problem set 2. Due Jan 31 in class

February 3, 2011

- Reconnection at the edge of the Earth magnetosphere (density 10^{10} cc, temperature $T = 10^6 K$) accelerated particles to energy of 1 keV. Acceleration occurred over the radius of the Earth magnetosphere $\sim 10 R_E$, $R_E = 6400$km. Do the accelerated particles come from the tail of the Maxwellian distribution or from the bulk?

$$
\begin{aligned}
& e\Phi = 10^3 eV \\
& E = \Phi/(10R_E) \\
& E_D = e^3 n \ln \Lambda / T \\
& \Phi_D = 10 R_E E_D = 1.5 \times 10^3 \ln \Lambda = 460 keV
\end{aligned}
\tag{1}
$$

  Field is sub-Dreicer.

- Assuming that at the surface of the Sun at $T = 6000K$ the ionization degree is $\sim 50\%$, estimate the electron density.

$$
\begin{aligned}
& \frac{\xi}{1-\xi} = \frac{2}{n_0 \Lambda^3} e^{-\chi/T} \\
& \xi = 50\% \\
& N = 1.7 10^{10} cc \\
& n_e = \xi N = 8 10^9 cc
\end{aligned}
\tag{2}
$$

- Recall problem 3 of Set 1:

  A beam of electrons is accelerated to energy 10 keV and propagates through plasma of density 10^{15} cc. Estimate penetration depth due to binary collisions. Assume Coulomb logarithm $\Lambda = 30$. (Also assume that the beam is faster than electron and ion thermal motion).

  Calculate time in which the electrons of the beam will give (approximately half) of their energy to target ions.

  Before we had

$$\sigma \sim (e^4/T^2)\ln\Lambda_c$$
$$\lambda \sim 1/(n\sigma) = 1.6 \times 10^5\text{cm}$$
$$\tau_{coll} \approx v_e/\lambda = \frac{4}{\pi}\frac{E^{3/2}\sqrt{m_e}}{e^4 n \ln\Lambda} = 4 \times 10^-5 sec \tag{3}$$

Now

$$\tau_{eq} = \frac{m_i}{m_e}\tau_{coll} = \frac{4}{\pi}\frac{E^{3/2} m_i}{e^4 n \sqrt{m_e}\ln\Lambda} = 0.1 sec \tag{4}$$

- Degenerate plasma. Find at what temperature solid state plasma in metals (electron density $n = 10^{23}$ cc) becomes degenerate.

$$T = (2^{1/3}\pi\hbar^2 n^{2/3}/m_e = 75000 \tag{5}$$