Problem set 5. Due Feb 24 in class

February 22, 2011

- Solar wind of temperature $T = 5 \times 10^5$ K, density $n = 5$ cc, propagates with velocity $v = 500$ km/sec. Estimate it's Mach number, post-shock velocity, density, pressure and the Mach number of the post-shock flow.

$$
\begin{aligned}
&c_{s,1} = 64 km/s \\
&M = 7.8 \\
&v_2 = v_1/4 \\
&n_2 = 4n_1 \\
&p_2 \sim n_1 m_p v^2 \\
&T_2 \sim m_p v^2/4 \\
&M_2 = \frac{v/4}{v/2} \sim 1/2, \text{ actually} M_2 = \sqrt{\frac{\gamma - 1}{2\gamma}}
\end{aligned} \tag{1}
$$

- For the parameters in the previous problem, by balancing the momentum flux with the magnetic pressure exerted by the earth's dipole magnetic field, estimate the radius above the earth at which the solar wind passes through a bow shock. Earth magnetic field is $B_E = 1$ G.

$$
\begin{aligned}
&\rho v^2 = B^2/(8\pi) = B_E^2/(8\pi)(r/R_E)^{-6} \\
&r = R_E \left(\frac{B_E^2}{8\pi \rho v^2} \right)^{1/6} \approx 10 R_E
\end{aligned} \tag{2}
$$

- Planet Venus does not have it's own magnetic field , still it is surrounded by magnetic structure related to the interplanetary magnetic field. Typical magnetic field around Venus is 10^{-4} Gauss. Solar wind is moving approximately with $v = 500$ km/sec. Assuming that the size of the wind-Venus interaction is of the order 10000 km, is the fluid approximation applicable? Is the fluid approximation applicable for treating the electrons?

  Larmor radii

$$
\begin{aligned}
&r_{L,i} = \frac{v}{\omega_{B,i}} = 5 \times 10^7 cm = 500 km \\
&r_{L,e} = 0.3 km
\end{aligned} \tag{3}
$$