Ph 612: High Energy Astrophysics — March 11, 2011
Spring 2011 — Due March 25, 2011

Problem Set 1

0. Choose a topic for your *Chandra* proposal in consultation with Prof. Hughes.

1. Show that the minimum of the Bethe-Bloch equation occurs at $\gamma = 2$.

2. Over the 0.1–10 keV band the total photoelectric cross-section for the interstellar medium (ISM), assuming normal cosmic abundances, can be approximated by a power law

$$\sigma(E) \sim 2.4 \times 10^{-22} (E/1\,\mathrm{keV})^{-2.4}\,\mathrm{cm}^2.$$

   Assume that the X-ray spectrum of a source is a power law with photon index $\alpha = 2$ (e.g., $dN/dE \propto E^{-\alpha}$). At what energy does the spectrum, incident on a telescope near the Earth, peak for values of the ISM column density of $N_\mathrm{H} = 10^{20}, 10^{21}$, and 10^{22} atoms cm^{-2}.

3. Derive the nonrelativistic and extreme relativistic limits to the total Compton scattering cross-section given by the Klein-Nishina formula.

4. In class it was shown that pair production, in which a photon is converted into an electron-positron pair, requires a nucleus to be present. However, it is also possible for pair production to occur in the vicinity of the electrostatic field of an electron. Show that the minimum photon energy for the production of electron-positron pairs in this case is $4m_e c^2$.

5. Determine both the X-ray reflectivity and polarization sensitivity of reflectivity for graze angles of $28'$ and $52'$ (these are the graze angles of the innermost and outermost Chandra mirror pairs) and the following table of Ir optical constants.

Energy(keV)	δ	β
0.1	7.743×10^{-2}	3.387×10^{-2}
0.316	8.997×10^{-3}	1.136×10^{-2}
1.0	2.382×10^{-3}	1.008×10^{-3}
3.16	3.128×10^{-4}	1.284×10^{-4}
10.0	3.416×10^{-5}	2.340×10^{-6}