



Astroparticle Physics – 2012/13

Werkcollege 3 – 26.09.2012

Problem 7 Power in cosmic rays

The energy density of cosmic rays is $\epsilon_{KS} \approx 1 \text{ eV/cm}^3$. During their propagation through the Galaxy, the particles traverse about $X = 10 \text{ g/cm}^2$ interstellar matter. The total mass of interstellar matter amounts to about $M = 10^{43} \text{ g}$. Calculate the power in cosmic rays [eV/s].

Problem 8 Synchrotron radiation

Protons and electrons with a kinetic energy of 100 GeV propagate through the Galaxy in a magnetic field with field strength $B = 3 \mu\text{G}$. Calculate the power radiated as synchrotron radiation for both particle species and give the result in [eV/s].

Hint: the radiated power for a particle with charge e and energy E , moving on a circular trajectory with radius r , amounts to

$$P(E, r) = \frac{e^2 c}{6\pi\epsilon_0 r^2} \left(\frac{E}{m_0 c^2} \right)^4 .$$

The permittivity of vacuum is given as $\epsilon_0 = 8.85 \cdot 10^{-12} \text{ A s/V m}$.

Estimate the time needed until the electrons have radiated their complete energy through synchrotron radiation.

Problem 9 Mean free path

Cosmic-ray particles move through the Galaxy. Estimate the mean free path of cosmic-ray particles between two collisions with particles of the interstellar medium. Assume a particle density of the interstellar medium of 1 proton/cm^3 ($m_p = 1.67 \cdot 10^{-24} \text{ g}$).

Use the geometrical cross section with a radius $r_A = r_0 A^{1/3}$ for nuclei with mass number $A > 1$ ($r_0 = 1.3 \text{ fm}$) and $r_p = 0.8 \text{ fm}$ for protons ($1 \text{ fm} = 10^{-15} \text{ m}$).

Calculate the mean free path for protons, oxygen nuclei, and iron nuclei. Give the result as column density [g/cm^2].

The solutions will be discussed during the werkcollege on 26.09.2012 at 15:30 in HG02.028.
Student assistant: Johannes Schulz j.schulz@astro.ru.nl

Lecture web site: <http://particle.astro.ru.nl/goto.html?astropart1213>

In week 39: Monday, 24.9., 13:30 hoorcollege, Wednesday, 26.9., 15:30 werkcollege.