Radboud Universiteit Nijmegen
Afdeling Sterrenkunde
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Astroparticle Physics – 2009/10

Werkcollege 5 – 26.03.2010

Problem 13 Stochastic acceleration

Relativistic protons are accelerated at a shock front. At each crossing of the shock the particles gain $\xi = 20\%$ energy. The probability to again cross the shock is $P = 80\%$. Derive the form of the energy spectrum an calculate the spectral index γ.

Problem 14 Second order Fermi acceleration

Particles are accelerated at magnetic clouds with a speed $V = 10^{-4}$ c. Calculate the time needed to accelerate particles form an energy of 100 MeV to 1 PeV. The diffusion coefficient of cosmic rays in the Galaxy is $D = 10^{28}$ cm^2/s.

Compare this time to the confinement time of cosmic rays in the Galaxy.

Consider the first interaction of a cosmic ray particle with a cloud. Calculate the energy gain in the first interaction and compare it to the energy loss through ionization in the interstellar medium. Assume $\rho = 1$ H/cm^3 and $dE/dx = 2$ MeV/(g/cm^2).

Hint: the mean free path between two clouds can be estimated from D.

Problem 15 First order Fermi acceleration

Assume particles are accelerated at the strong shocks of Tycho's supernova. The shell has an expansion speed of about 4600 km/s. How many crossings of the shock front are needed for a particle to be accelerated from 100 MeV to 1 PeV.

Assume, it takes 30000 a to accelerate the particle. Estimate the thickness of the diffusion region around the shock in which the particles propagate during the acceleration process.

Compare the thickness of this region to the radius of the shock ($d = 2.3$ kpc).

Deliver answers to box "astroparticle physics" in front of secretariat Sterrenkunde HG 03.720 before 07.04.2010.
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Lecture web site: http://particle.astro.kun.nl/goto.html?astropart0910