Radboud Universiteit Nijmegen
Afdeling Sterrenkunde
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Astroparticle Physics – 2014/15

Werkcollege 10 – 09.12.2014

Problem 29 Inverse Compton effect

X rays with a mean energy $E_\gamma = 5$ keV are observed from a region of interstellar matter. The x rays are produced through inverse Compton effect between electrons and photons of the 3 K microwave background.

What is the most probable energy of the 3 K background radiation in keV? Hint: use Wien's displacement law to estimate the most probable energy.

Calculate the corresponding energy of the Compton electrons. Use the relation $E'_{ph} = \gamma_e^2 \cdot E_{ph}$. γ_e is the Lorentz factor of the electrons and E'_{ph} and E_{ph} the energies of the photons.

Problem 30 High-energy gamma rays

List the most common production mechanisms for high-energy gamma rays (photons with energies exceeding 100 MeV).

What means Synchrotron Self Compton (SSC)? Sketch a typical spectrum of a high-energy gamma-ray source in which SSC plays an important role.

Problem 31 Gamma-ray detection on satellites

Gamma rays are detected with the GLAST/Fermi experiment. It comprises a tracker module with a thickness of 5 radiation lengths (Pb, $Z = 82$), followed by an electromagnetic calorimeter with a thickness of 8.6 radiation lengths (CsI, $\bar{Z} = 54$).

Estimate the energy of an incident photon (gamma ray) for which the maximum of the developing electromagnetic cascade is just inside the absorber.

Use a Heitler model to calculate the depth of the shower maximum

$$X^\gamma_{max} = X_0 \ln\left(\frac{E_0}{E^e_c}\right).$$

The critical energy of electrons in a solid material with nuclear charge number Z is given as

$$E^e_c \approx \frac{610 \text{ MeV}}{Z + 1.24}.$$

To estimate the critical energy for a combination of materials, use the weighted average of the critical energy in each component.

The solutions will be discussed during the tutorial on 09.12.2014 at 8:30 in HG01.054.
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Lecture web site: http://particle.astro.ru.nl/goto.html?astropart1415