

FYSH371 Particle Astrophysics Phenomena and Processes
Final exam 11.01.2013

Answer either in English or in Finnish. Exam time 4 hours.

1. Explain briefly following concepts (9p)
 - a) CNO-cycle
 - b) GZK-cut off
 - c) Gamma-ray Burst
 - d) Pulsar
 - e) Air-Cherenkov technique
 - f) Core-collapse supernova
 - g) Cosmic Microwave Background
 - e) Delayed coincidence method
 - f) WIMP

2. What are cosmic rays and their origin? Sketch the spectrum of primary cosmic rays and explain its properties and why it looks like that. Explain how the different energy-regions can be studied. (12p)

3. Select three of the following topics and explain the basic principle of the detection method (what is measured and how) in following cases. Give also an example of the process where primary particle(s) could be originated.
 - a) Measurement of energy of a electron neutrino in liquid-scintillation detector
 - b) Identifying primary cosmic proton from anti-proton in space.
 - c) Study high-energy gammas on ground
 - d) Observe gravitational waves
 - e) Dark matter WIMP indirectly(12p)

4. One way to explain the acceleration of charged cosmic ray particles is Fermi acceleration.
- a) Explain briefly the 1st order and 2nd order Fermi processes (2p)
 - b) Energy gain of a particle in one collision with magnetic cloud follows $E_{n+1} = (x + 1)E_n$ and the probability to escape is P_{esc} .
 - i) What is the energy of a particle after N collision? (1p)
 - ii) How many collisions particle needs to obtain energy E? (1p)
 - iii) Calculate the fraction of particles that have energy more than E? (1p)
 - iv) What becomes the formula of spectral index? (1p)
5. Describe the role of neutrinos in astroparticle physics, their advantages and disadvantages, origins and information they may carry. (max 2 pages)
(9p)