Tareas 5 – Física Nuclear

28 de Febrero 2024

1. The most important method of energy production in the sun is the fusion of protons into 4He nuclei. This predominantly takes place through the reactions $p + p \to d + e^+ + \nu_e$, $p + d \to^3$ He $+ \gamma$ and ^{3}He $+^3$ He $\to^4$ He $+ p + p$. A total of 28.3 MeV is released for every ^{4}He nucleus produced. 90 % of this energy exits as electromagnetic radiation and the rest is mostly converted into the kinetic energy of neutrinos (typically 0.4 MeV).
(a) What is the flux of solar neutrinos at the earth (distance from the sun: $a_0 = 1.5 \times 10^8$ km)?
(b) In a tunnel in the Abruzzi the GALLEX experiment measures neutrinos through the reaction $^{71}_{31}$Ga $+ \nu_e \to^{71}_{32}$ Ge $+ e^-$. The cross-section of this reaction is about 2.5×10^{-45} cm^2. One looks for radioactive ^{71}Ge atoms (lifetime $\tau = 16$ days) which are produced in a tank containing 30 t of dissolved gallium (40 % ^{71}Ga, 60 % ^{69}Ga) chloride. About 50 % of the neutrinos have an energy above the reaction threshold. One extracts all the germanium atoms from the tank. Estimate how many ^{71}Ge atoms are produced each day and after three weeks? How many if one waits forever?

2. A neutron star with mass, $M = 1.5 M_{\text{sol}}$ ($\approx 3.0 \times 10^{30}$ kg), and radius $R \approx 10$ km is the remnant of a supernova. The stellar material originates from the iron core ($R \gg 10$ km) of the supernova.
(a) How much energy was released during the lifetime of the original star by converting hydrogen into iron? (The binding energy of ^{56}Fe is $B = 8.79$ MeV/nucleon.) NB: Since after the implosion only a part of the original iron core remains in the neutron star, the calculation should be performed only for this mass.
(b) How much energy was released during the implosion of the iron core into a neutron star?
(c) In what form was the energy radiated off?