

Astroparticle Physics (Physics 711)

Exercise 8

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Problem 1: WIMP detection rate (5P)

- a) Estimate the expected detection rate of WIMPs in a detector with a mass of 1kg. Use the following assumptions: The efficiency of the detector is $\epsilon = 0.7$ and the mass of the WIMPs is $M = 100$ GeV. The WIMPs interact with matter through weak interaction with a cross section of $\sigma = G_F^2 \mu^2$, with

$$\mu = \frac{M m_N}{M + m_N} \quad (1)$$

where m_N is the mass of a Germanium nucleus. Use a fermi constant of $G_F = 10^{-5}$ GeV⁻².

- b) Assuming the experiment has not detected any events after one year, compute an upper limit on the cross section for a 90% confidence level. (90 % C.L. means that if the expected number of events is 2.4 or more then the probability to see no events is 10% or less).

Problem 2: Structure formation (5P)

From the Jeans length λ_J one can obtain the Jeans mass as the mass enclosed within a sphere of diameter λ_J . Compute the Jeans mass shortly before the end of radiation domination and shortly after decoupling (Hint: use $c_s^2 = \partial p / \partial \rho$). Do not consider the short period of matter domination before decoupling. Note that the speed of sound for a gas of hydrogen is $c_s^2 = \sqrt{5T / (3m_p)}$. What kind of objects could have formed after the transition?