1st ICTP-Trieste/ICTP-SAIFR School on Particle Physics: Dark Matter and Particle Physics – Some exercises

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Below are a list of questions, some simple, some involved, that will help illustrate some of the points raised in lectures. The questions approximately follow the order of topics in the lectures, but you should feel free to approach them in any order you wish.

1 Lecture V

Question 1. *Capture of DM in the Sun, or elsewhere* DM may be captured in the Sun, Earth, or other dense object. Although calculating the capture rate is challenging it is straightforward to determine the evolution of number of DM particles with time. There are 3 competing effects, capture (Γ_{cap}), annihilation (Γ_{ann}), and evaporation (Γ_{evap}). Without worrying about the details of the rate determine its scaling with the number of DM particles in the Sun, *i.e.* determine p for each process with $\Gamma \sim N^p$. Then solve the evolution equation. Consider the limits where evaporation can be ignored, and where all processes are comparable.

Question 2. *Non-relativistic limits* Consider fermionic DM χ coupled to SM fermions f. What are the low velocity limits of the interactions

a. $\bar{\chi}\chi\bar{f}f$

b. $\bar{\chi}\gamma_\mu\gamma_5\chi\bar{f}\gamma^\mu\gamma_5 f$

c. $\bar{\chi}\gamma_\mu\gamma_5\chi\bar{f}\gamma^\mu f$?

Question 3. *Relativistic limits, DM@colliders* Consider fermionic DM χ coupled to SM fermions f. What are the production cross sections for DM at a colldier through each of these interactions

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a. $\bar{\chi}\chi\bar{f}f$

b. $\bar{\chi}\gamma_\mu\gamma_5\chi\bar{f}\gamma^\mu\gamma_5 f$

c. $\bar{\chi}\gamma_\mu\gamma_5\chi\bar{f}\gamma^\mu f$?