Advanced Theoretical Astro–Particle Physics (WS 22/23)
Homework no. 8 December 7, 2022)

To be completed by: Thursday, December 15.

1 TeV γ Sources at Sizable Redshift

In class we saw that the brightness of point sources of photons with $E_\gamma \gtrsim 1$ TeV diminishes faster than the square of the luminosity distance, due to absorption of energetic photons on background photons. For sources at significant redshift, $z \gtrsim 0.5$, there are two effects that reduce the brightness at TeV energies even more. What are these? *Hint:* Only one of them is related to the absorption of TeV photons.

2 Time Spent by CR Primaries in our Galaxy

Consider two isotopes A_1 and A_2, with A_2 being the result of a spallation reaction of A_1 on background protons. Let $r = \Phi_{A_2}/\Phi_{A_1} \ll 1$ be the ratio of their fluxes in cosmic rays measured at Earth, and $\sigma_{1\to 2}$ the cross section for the corresponding spallation reaction.

1. How far must A_1 primaries typically have traveled through the interstellar medium of our galaxy, where $n_p \simeq 1/\text{cm}^3$? Scale r to 1% and $\sigma(1 \to 2)$ to 1 mb $= 10^{-27}$ cm^2.

2. How much time will typical A_1 primaries thus spend in our galaxy? How does this compare to the time a photon or neutrino needs to traverse our galaxy at a large angle to the disk?

3. Given that A_1 gets (almost) confined in our galaxy by magnetic fields, how would you expect r to change with energy if $\sigma(1 \to 2)$ was almost independent of energy?