Examination sheet

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I.- Estimate the maximum and minimum mass and cross section interaction for the dark matter candidate in order to account for the dark matter abundance of the standard model of cosmology depending on the production mechanism:

- I.a.- Freeze-out mechanism
- I.b.- Freeze-in mechanism
- I.c.- Decays of other particles
- I.d.- Gravitational production
- I.e.- Misalignment mechanism
- I.f.- Spontaneous symmetry breaking:
  - I.f.1.- Topological Defects
  - I.f.2.- Pseudo-Nambu-Goldstone bosons
- I.g.- Asymmetric DM

Comment your assumptions and plot the final results in a common figure σ vs m (for example, σ can be defined as $\sigma \equiv \langle\sigma_A v\rangle/\sqrt{\langle v^2\rangle}$ for the freeze-out mechanism, but other definitions can be used for other types of production).

II.- Discuss if a $M = 50$ TeV dark matter particle annihilating into the W^+W^- channel can explain the gamma ray spectrum observed with the HESS array of Cherenkov telescopes coming from the Galactic Center region and identified with the source HESS J1745-290:

$$\frac{d\Phi_{\rm DM}}{dE} = A^2 \cdot \frac{dN^{(2)}_{WW}}{dE}\,, \tag{1}$$

where the constant

$$A^2 = \frac{\langle\sigma v\rangle\,\Delta\Omega\,\langle J_{(2)}\rangle_{\Delta\Omega}}{8\pi M^2} \tag{2}$$

is proportional to the stantard astrophysical factor $\langle J_{(2)}\rangle$:

$$\langle J_{(a)}\rangle = \frac{1}{\Delta\Omega}\int_{\Delta\Omega}{\rm d}\Omega\int_0^{l_{max}(\Psi)}\rho^2[r(l)]dl(\Psi)\,. \tag{3}$$

For that purpose, assume that one can use a power-law background in addition to the dark matter signal:

$$\frac{d\Phi_{\rm Tot}}{dE} = \frac{d\Phi_{\rm Bg}}{dE} + \frac{d\Phi_{\rm DM}}{dE}\,. \tag{4}$$

with

$$\frac{d\Phi_{\rm Bg}}{dE} = B^2 \cdot \left(\frac{E}{\rm GeV}\right)^{-\Gamma}\,, \tag{5}$$

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where the background parameters can be fixed by the Fermi-LAT data at lower energies corresponding to 25 months of observations: $\Gamma \simeq 2.80$ and $B \simeq 5.18 \times 10^{-4}\,\mathrm{GeV}^{-1/2}\mathrm{cm}^{-1}\mathrm{s}^{-1/2}$.

In order to analyse this possibility, compute the χ^2 value for fitting this function to the HESS data with $A = 4.98 \times 10^{-7}\,\mathrm{cm}^{-1}\mathrm{s}^{-1/2}$.

#Spectrum data points HESS j1745-290

#Last points are 95% CL upper limits

#E(TeV)	dN/dE (cm^-2s^-1TeV^-1)	Lower Flux	Upper Flux
0.2838	4.186e-11	3.734e-11	4.653e-11
0.3491	2.439e-11	2.249e-11	2.633e-11
0.4273	1.565e-11	1.452e-11	1.681e-11
0.5208	1.059e-11	9.871e-12	1.133e-11
0.634	6.245e-12	5.786e-12	6.719e-12
0.7723	4.987e-12	4.655e-12	5.33e-12
0.9406	2.694e-12	2.478e-12	2.918e-12
1.145	1.744e-12	1.596e-12	1.898e-12
1.393	1.176e-12	1.073e-12	1.285e-12
1.694	8.214e-13	7.472e-13	8.992e-13
2.061	4.364e-13	3.885e-13	4.87e-13
2.504	3.919e-13	3.532e-13	4.327e-13
3.044	2.099e-13	1.85e-13	2.365e-13
3.697	1.445e-13	1.259e-13	1.644e-13
4.492	9.503e-14	8.214e-14	1.089e-13
5.463	5.554e-14	4.686e-14	6.5e-14
6.646	3.538e-14	2.924e-14	4.215e-14
8.112	2.243e-14	1.823e-14	2.71e-14
9.926	1.118e-14	8.566e-15	1.416e-14
12.17	6.265e-15	4.534e-15	8.286e-15
14.91	2.038e-15	1.139e-15	3.159e-15
18.23	2.795e-15	1.865e-15	3.903e-15
22.21	7.175e-16	3.216e-16	1.266e-15
26.9	1.714e-16	2.656e-17	5.301e-16
32.36	4.119e-16	1.668e-16	7.763e-16
38.69	4.577e-17	0.577e-17	4.577e-17
46.17	8.898e-17	0.898e-17	8.898e-17
55.05	1.222e-16	0.222e-16	1.222e-16

FIG. 1: Gamma ray data of the HESS J1745-290 source.