Homework 4

Higgs decaying to Dark Matter

Do NOT worry too much about factors of 2 doing this homework!

Imagine that there exist a neutral scalar particle described by the field a and coupling only to the Higgs boson via the interaction

$$\mathcal{L}_{\text{DM}} = k\Phi^\dagger\Phi aa$$

where Φ is the SM Higgs doublet and k a coupling constant. (This interaction is sometimes referred to as the "Higgs portal to Dark Matter".)

Q1 What are the units of k in the $\hbar = c = 1$ system?
Q2 What is the mass m_a in terms of k and v?

The particle a could be produced in Higgs decay (if $m_a < m_h/2$) and escape the detector unseen. If it has no further interactions, it could be a Dark Matter candidate.

Q3 Compute the total Decay Rate Γ for $h \to aa$ as a function of v, m_a and m_h.

Q4 Knowing from experiment that the Higgs decay width to invisible particles cannot be larger than 3.1 MeV, determine the exclusion region for the parameter m_a. (That is, the values of m_a that are not allowed.)

(Just a comment, not needed for the homework: The Higgs width is not directly measured as in the case of the Z boson in the previous homework because of poor detector resolution but relies on some additional assumptions.)