Exploring minimal dark matter models with gamma-ray observatories

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Dark matter is one of the most intriguing problems nowadays, in this project, we intend to explore some well-motivated minimal dark matter models which goes beyond the standard WIMPs, which are currently vastly constrained. To make the analysis, we will use the most recent HESS data, combined with the prospects for the CTA and SWGO observatories. We will explore the galactic centre region, modelling the background through a template analysis to get the most stringent possible limits.

1 The minimal models

Several extensions of the standard model predict new scalar particles, including two Higgs doublet models, inert doublet models and so on. In this work, we intend to explore a model where the dark matter may connect with a new scalar. We may follow the idea that we may have two dark matter particles annihilating into two sequential scalars, namely, which decays like the standard Higgs particle [2]. This scenario, usually called secluded, has the advantage of escape from the current strong limits from direct searches, and also have distinct indirect signatures.

In another possible model, we will study the called right-handed neutrino portal, where the dark matter particle annihilates directly into them. Right-handed neutrinos appear in several extensions of the standard model to address the neutrino masses. Combining neutrinos physics with dark matter particles seems to be a natural way to find solutions for both problems. At the same time, the standard WIMP scenarios are getting more and more constrained by the recent XENON1T limits. In this way, we intend to explore the DM particle annihilating into two right-handed neutrinos, which subsequently decay into pairs of W bosons and electrons, and also Z bosons and neutrinos in the TeV dark matter mass range [1].

2 Setting Limits with γ-ray observations

In recent years H.E.S.S. observed the Galactic Centre region regularly. There are now almost 300 hours of data available. Comparing that with the used 10 hours of data in [1] this makes the analysis more sensitive by a factor of about 5. Besides the search for Dark Matter annihilation, the region is of interest in many different astrophysical studies like the central source, the diffuse emission along the Galactic Plane and interactions with the Cosmic Ray Sea with the Gas. We can make use of these results by including them in the modelling of the region in three dimensions. Hence, there is no need to exclude the gamma-ray emitting regions from the analysis. Therefore, we expect more gamma-ray flux due to the DM annihilation processes which hopefully results in an increased sensitivity. A similar study has been performed for assumed annihilations into standard model particle pairs such as $DM + DM \to W^+ + W^-$, $DM + DM \to b\bar{b}$, $DM + DM \to t\bar{t}$. However, the effect of at this time not understood systematic uncertainties was affecting the results. We now have a better estimate of the systematics due to the background template and IRFs and the methods to include them in the analysis directly. By using this new scheme and more data we are expecting to set reasonable and

strong limits. The limits will be verified by a comparison with the established ON-OFF method of setting limits.
We also plan to increase the mass range by including CTA in the template-based analysis. Another possibility in the future would be to include data taken by SWGO.

References

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