

Indirect detection constraints on a p -wave model through an s -wave bremsstrahlung process

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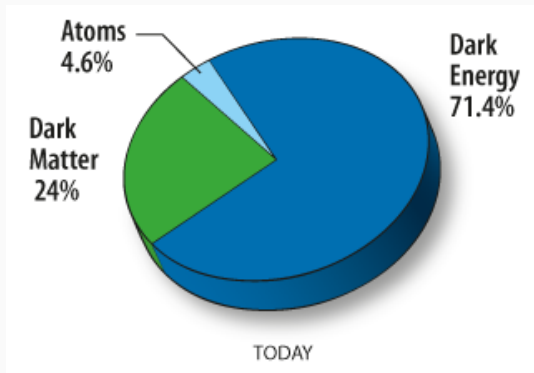
Collaboration with:

J. Dent, B. Dutta, and L. Strigari;

Phys.Rev. D99 (2019) no.8, 083003; arXiv:1901.01454

Introduction

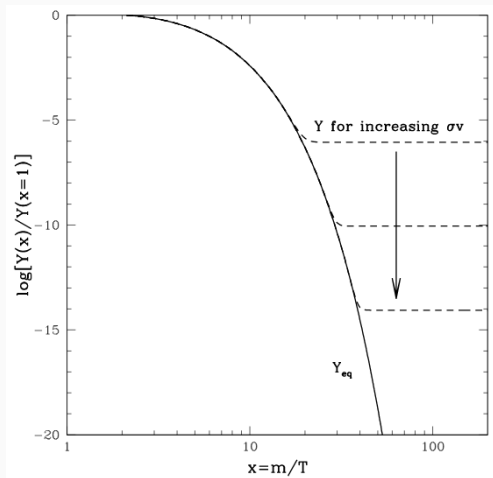
Dark matter makes up $\sim 25\%$ of the energy density in the Universe today



https://wmap.gsfc.nasa.gov/universe/uni_matter.html

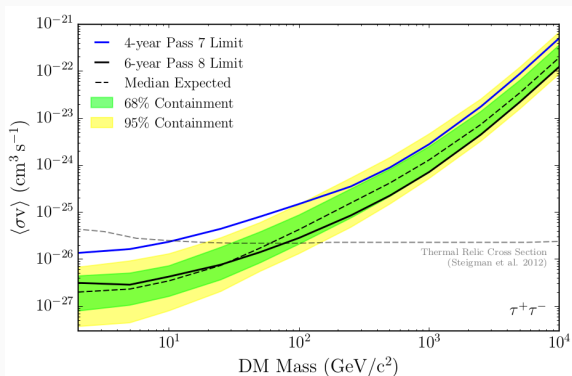
Relic Abundance

The relic abundance is set by the thermally averaged cross section



Fermi Limits

Strong limits are placed on numerous dark matter annihilation models ruling out thermal parameter space



M. Ackermann, et al.; arXiv:1503.02641

s and *p* wave Cross Sections

Thermally averaged cross section:

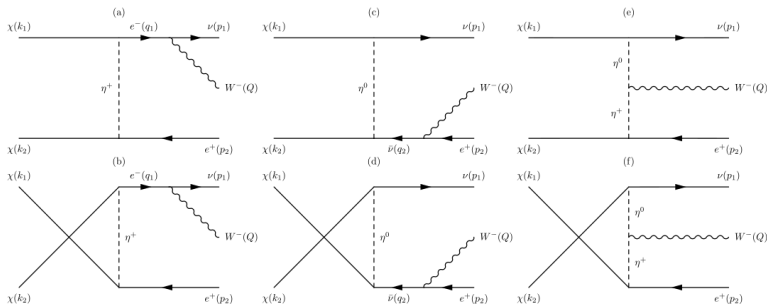
$$\langle \sigma v \rangle = a + b v^2 + \dots$$

The annihilation cross section today is the same as at freeze out for *s*-wave models, but for *p*-wave, the cross section is much lower

Due to the velocity suppression, *p*-wave models are very hard to probe

Bremsstrahlung Gauge Boson

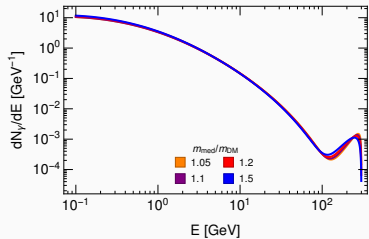
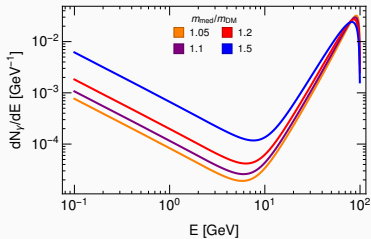
Through the addition of a bremsstrahlung gauge boson, velocity suppression is lifted, and an s-wave cross section is present



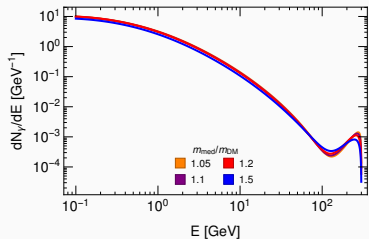
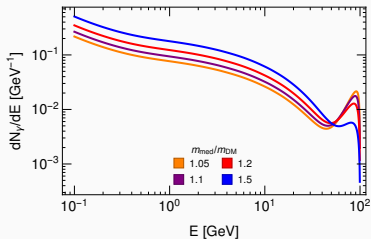
Bell, Dent, Galea, Jacques, Krauss, and Weiler; arXiv:1104.3823

Bremstrahlung Photon Spectra

electron



tau



Experiments

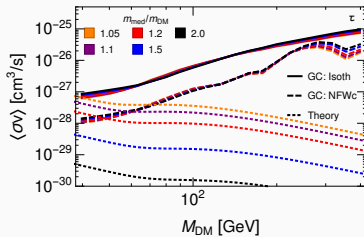
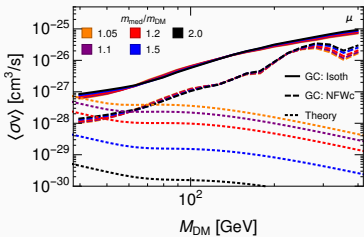
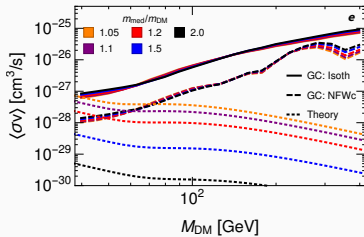
Compared
with multiple experiments to estimate their constraining capabilities:

Fermi-LAT — Gamma-ray Spectrum
Galactic Center
dSph

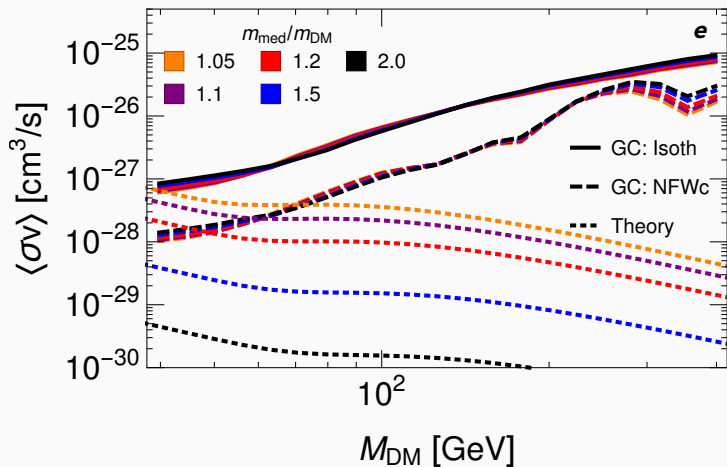
EDGES — 21 cm

Planck — CMB

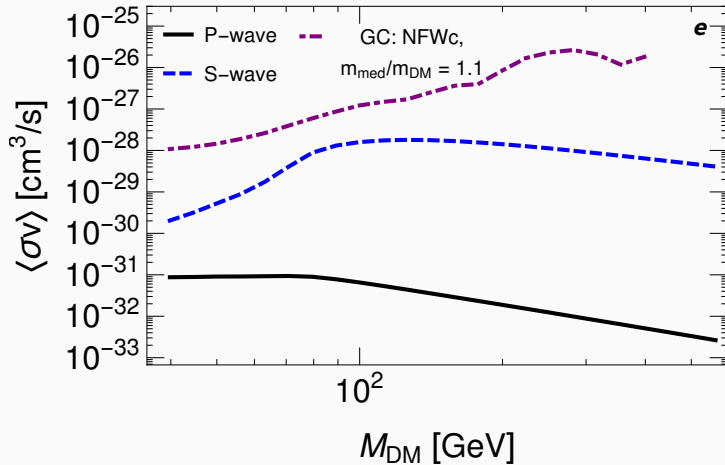
Model Constraint



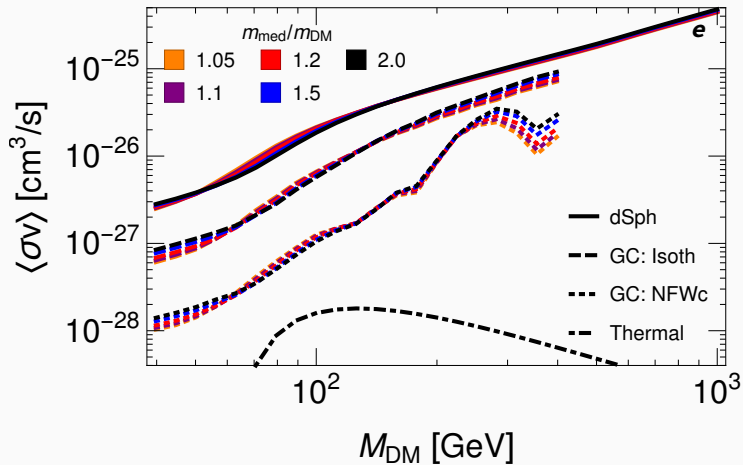
Model Constraint



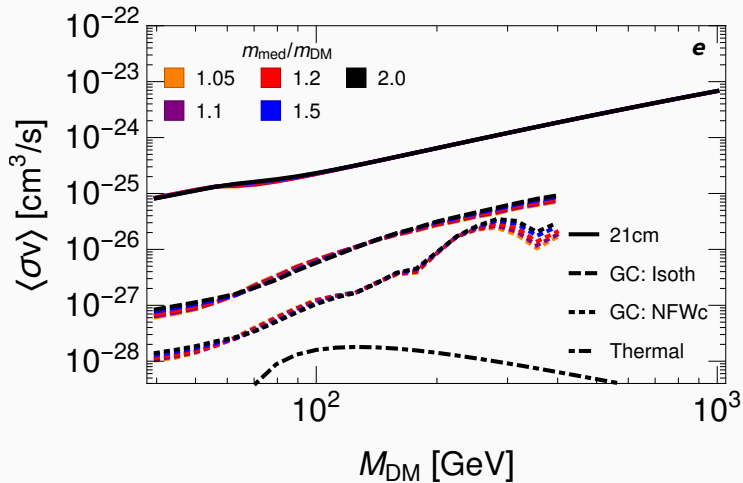
Improvement over Base p -wave Model



Thermal Model Constraint



Thermal Model Constraint

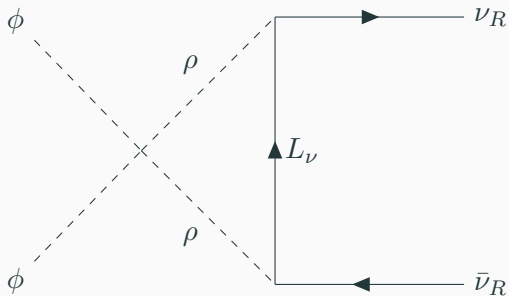


Annihilation to Neutrinos Example

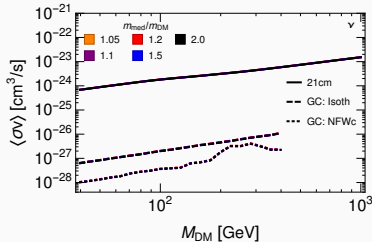
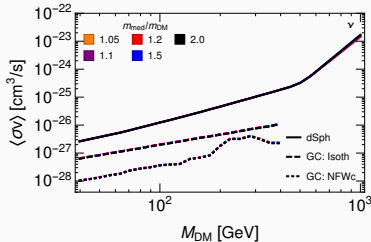
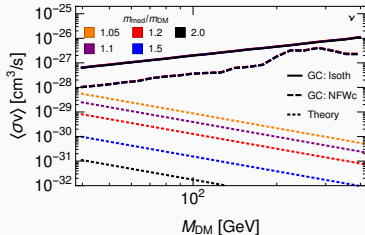
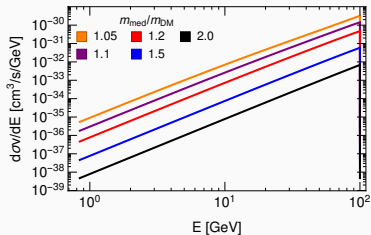
ρ is a scalar doublet

L is a fermion-like doublet

Photon brem is possible from the charged loop



Annihilation to Neutrinos



Summary

The relic abundance is set by p -wave interactions

Today, higher order s -wave channels can dominate over the simple p -wave interactions

These s -wave channels provide an avenue to investigate experimentally difficult models

Thank You!