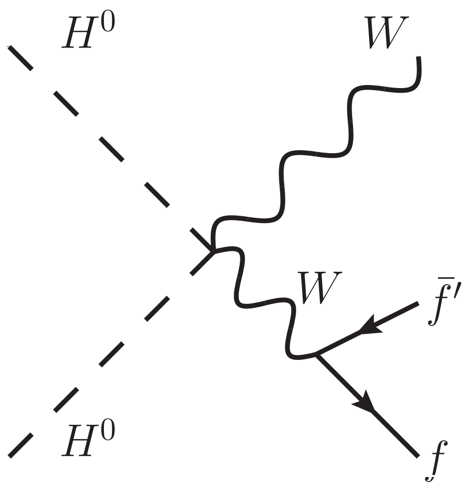
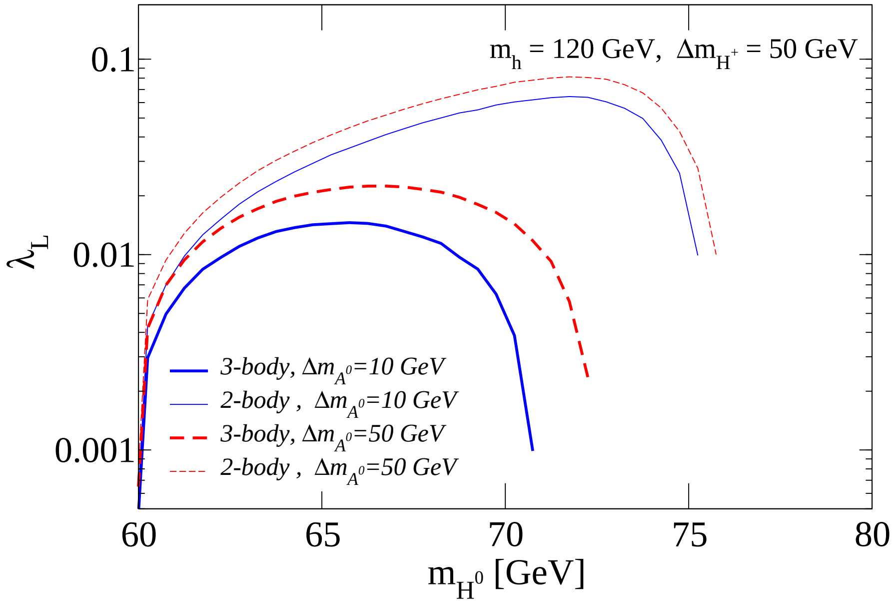
The inert doublet model of dark matter revisited





Based on Phys.Rev.D81:075024,2010,
arXiv:1003.3125 (with Laura Lopez),
and work in progress.

Carlos E. Yaguna
UAM and IFT
2010

In the inert doublet model (IDM) the SM is extended with a second higgs doublet

The idm contains 3 new scalars

$$H_2 = \begin{pmatrix} H^+ \\ (H^0 + iA^0)/\sqrt{2} \end{pmatrix}$$

H_2 is odd under a new Z_2 symmetry

Lightest component is stable

No coupling to fermions

This model features a rich phenomenology

Barbieri, Bergstrom, Gustaffson, Ma, Tytgat, etc

The inert doublet model can account for the dark matter of the Universe

It includes a viable dm candidate

The lightest odd particle: H^0

H^0 has gauge and scalar interactions

$$V=\mu_1^2|H_1|^2+\mu_2^2|H_2^2|+\lambda_1|H_1|^4+\lambda_2|H_2|^4$$
$$+\lambda_3|H_1|^2|H_2|^2+\lambda_4|H_1^\dagger H_2|^2$$
$$+\frac{\lambda_5}{2}\left[(H_1^\dagger H_2)^2+\mathrm{h.c.}\right]$$

The parameter space is rather simple

$$m_{H^0}, m_{A^0}, m_{H^\pm}$$

$$\lambda_L \equiv \frac{1}{2}(\lambda_3+\lambda_4+\lambda_5)$$

Dark matter annihilations might be dominated by three-body final states such as WW^* or $t\bar{t}^*$

A new effect not included in most analysis

Yaguna (2010), Kamionkowski (1998)

nor in DarkSUSY or micrOMEGAs

They affect $\Omega_{\rm dm}$ and the dm detection prospects

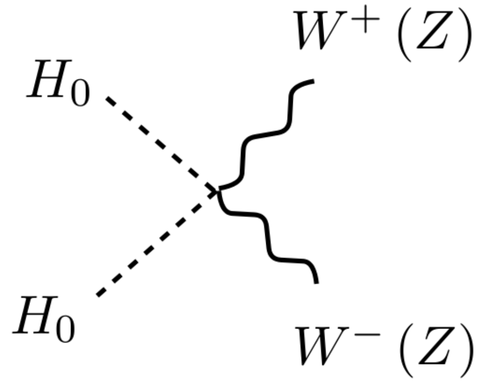
modifying the viable parameter space

H^0H^0 may annihilate into WW^* in the IDM

for $m_{H^0} < M_W$

In the IDM the viable parameter space coincides with the region where $H^0H^0 \to WW^*$ is important

$H^0H^0 \to W^+W^-$ has a purely gauge contribution

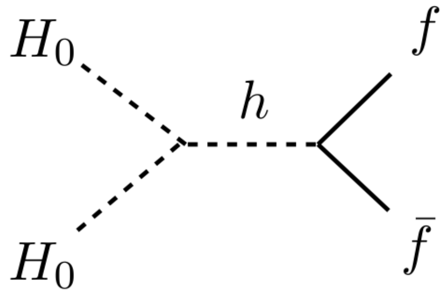


$\propto g^2$

The viable parameter space is $m_{H^0} < M_W$

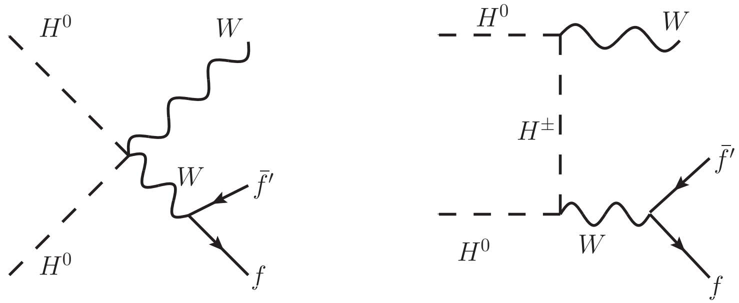
or $m_{H^0} > 500$ GeV

In that region, $b\bar{b}$ is the dominant 2-b final state



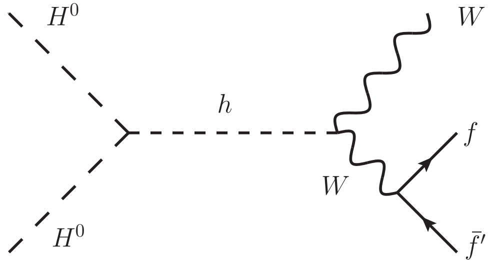
Three different diagrams contribute to $H^0H^0 \to WW^* \to Wf\bar{f}'$ in the IDM

There are two gauge diagrams



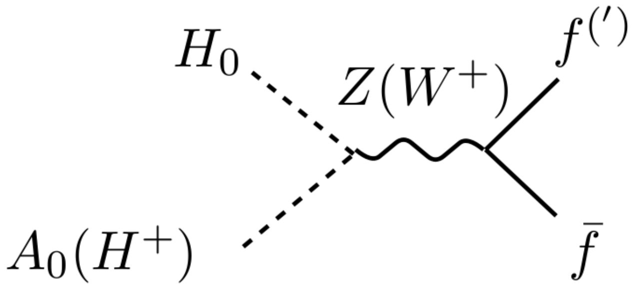
$\propto g^3$

And a higgs mediated diagram



$\propto g^2\lambda_L$

Coannihilations may also affect Ω

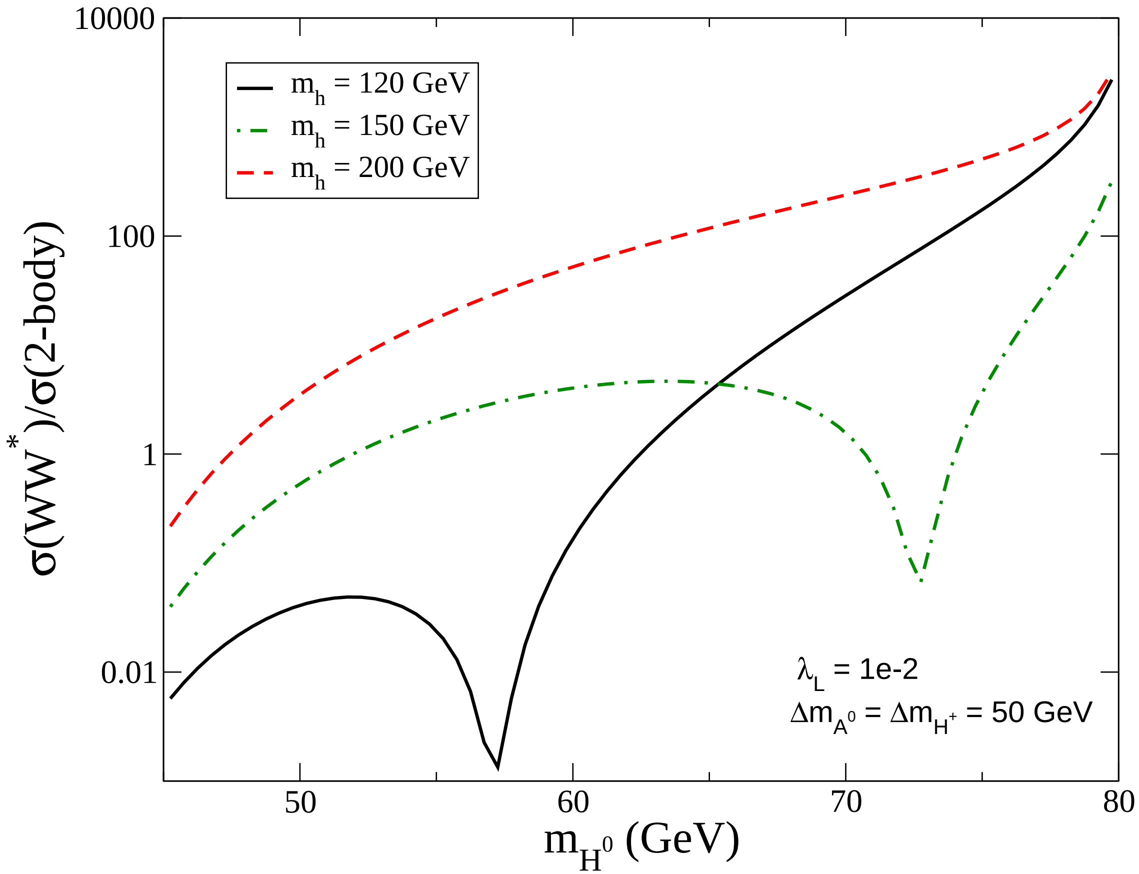


In the IDM, the three-body annihilation rate can be much larger than the two-body one

This effect depends on the higgs mass

The correct σ could be 100 times larger

$\sigma(3\text{-body}) > \sigma(2\text{-body})$ over a wide m_{H^0} range

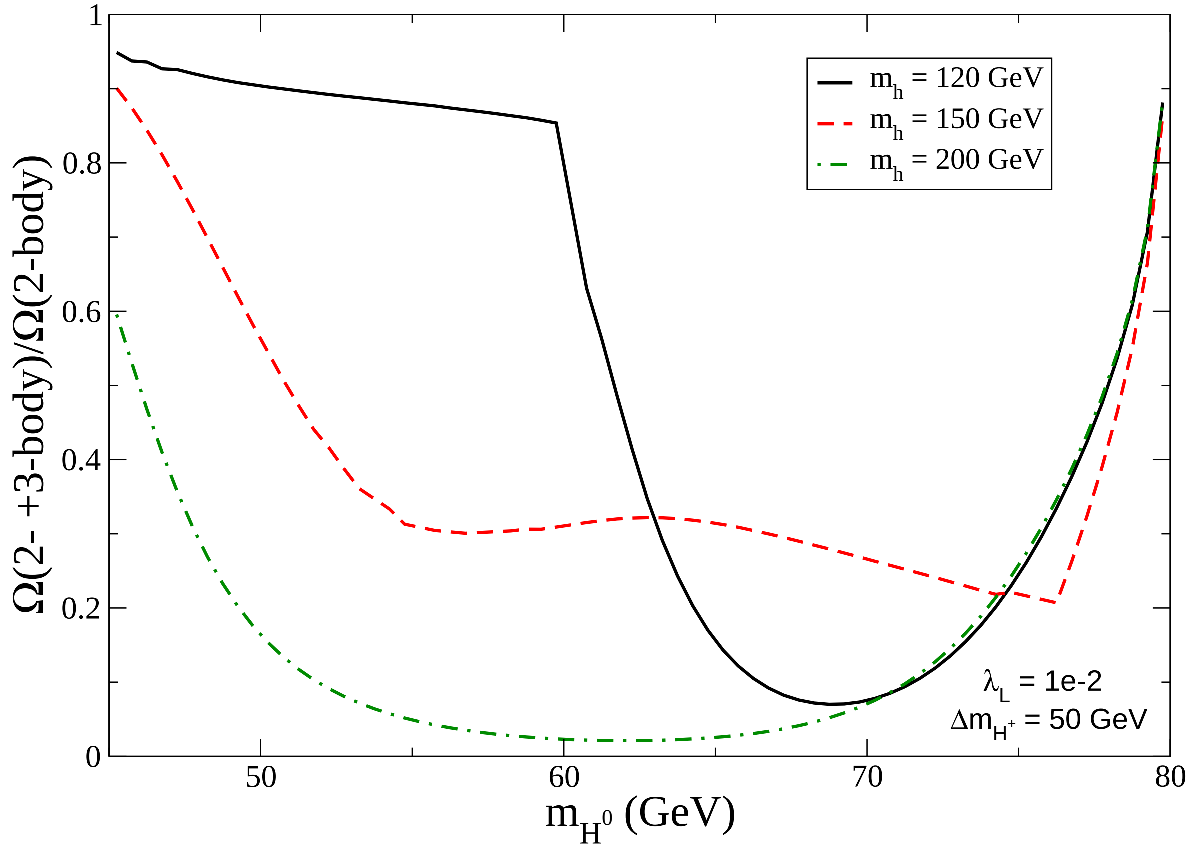


The H^0 relic density is strongly reduced by annihilations into WW^*

A significant effect independently of m_h

Ω could be more than 10 times smaller

This is a generic feature of the IDM

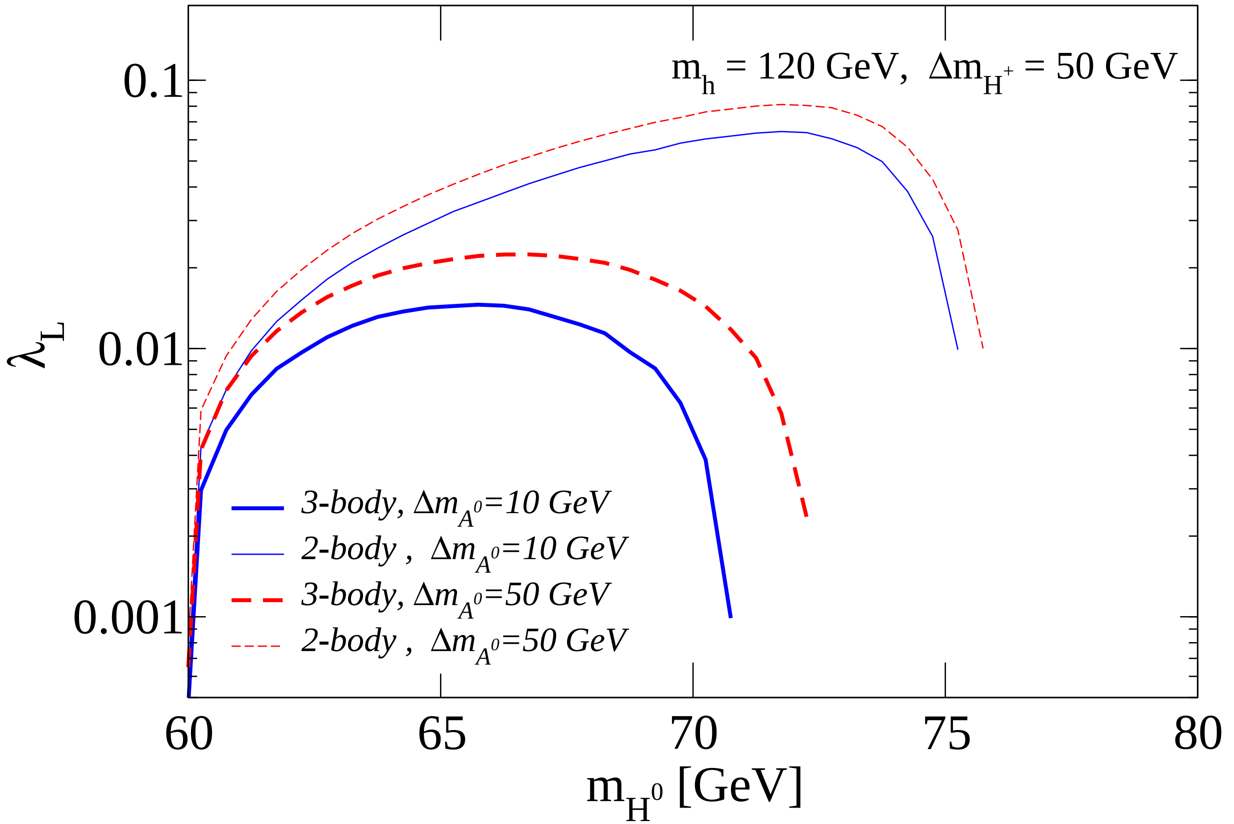


Due to 3-body final states, the viable parameter space of the IDM is substantially modified

The required value of λ_L may be much smaller

The maximum allowed m_{H^0} decreases

Similar results for other parameters

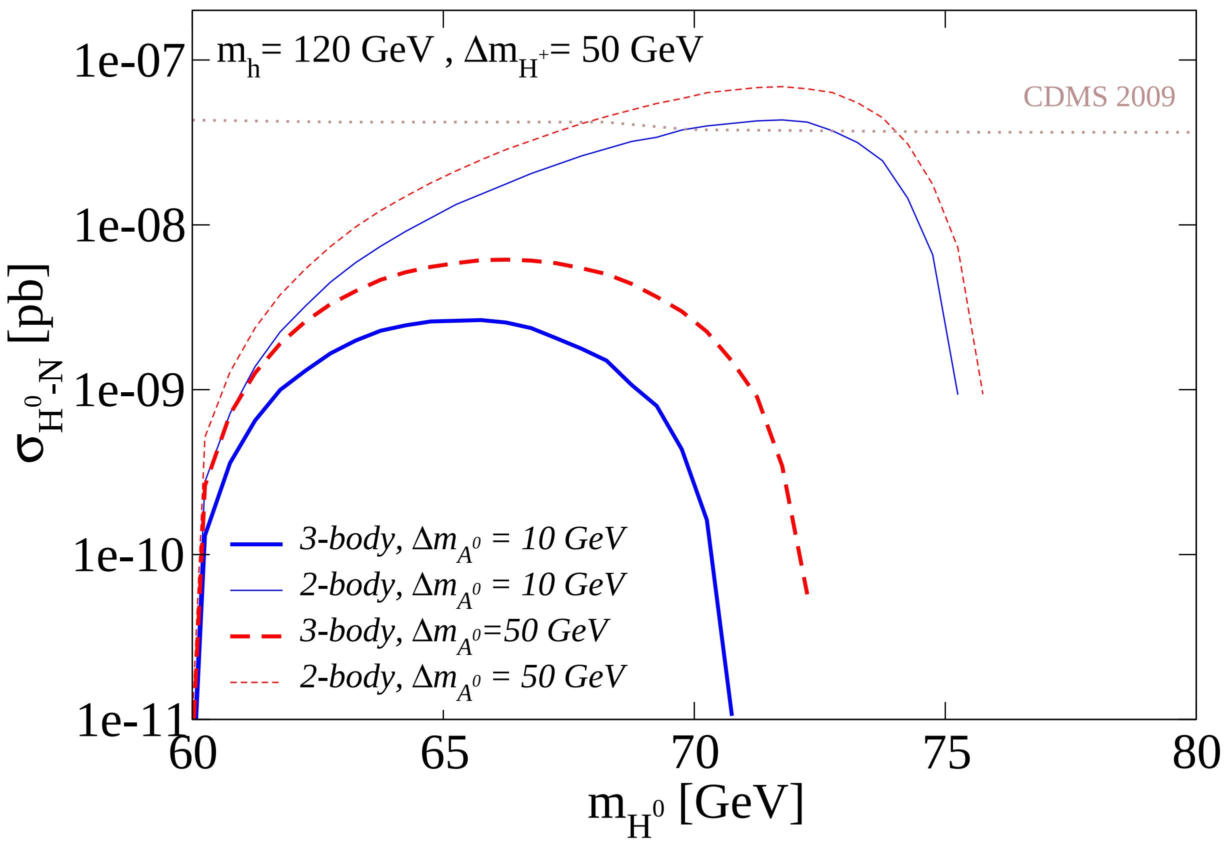


The inert higgs direct detection cross section is much smaller than previously believed

The dd cross section is proportional to λ_L^2

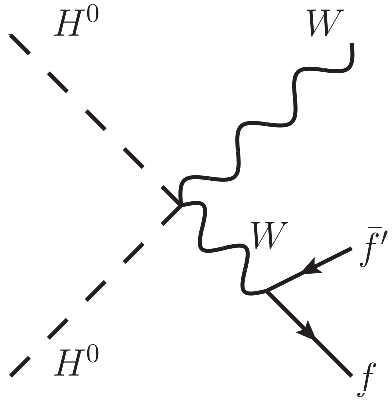
The new σ_{H^0-N} is up to 100 times smaller

Indirect detection signals are also affected



The 3-body final state WW^* plays a major role in the dm phenomenology of the IDM

They modify the viable parameter space



They alter the dm detection prospects

They induce large corrections