When LHC/TEVATRON combine with XENON to exclude scalar DM

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Outline

• The Scalar DM extension of the Standard Model

• Dark matter constraints

• Invisible Higgs decay and LHC/TEVATRON analysis

• Perspective and Conclusion
Extensions of the SM

• Extension of the content of the SM: $v_R$, SUSY

• Extension of the Gauge group, new «force»: extra $U(1)$, $SO(32)$

• Extension of the space-time structure: supergravity, KK, strings
Singlet Extension of the SM

To build the simplest gauge invariant extension of the SM

\[ \mathcal{L} = \mathcal{L}_{SM} + \frac{1}{2} \partial_\mu S \partial^\mu S - \frac{\lambda_S}{4} S^4 - \frac{\mu_S^2}{2} S^2 - \frac{\lambda_{HS}}{4} S \]

No phenomenology \(<S> = 0\)

\[ \sigma_{S-p}^{SI} = \frac{m_p^4 \lambda_{HS}^2 (\sum q f_q)^2}{16\pi (m_p + m_S)^2 M_H^4} \]

\[ \langle \sigma_{ff'} v \rangle = \frac{\lambda_{HS}^2 (m_S^2 - m_f^2)^{3/2} m_f^2}{16\pi m_S^3 [(4m_s^2 - M_H^2)^2 + M_H^2 \Gamma_H^2]} \]
Constraints in «portal like» models

Except around the pole: $2M_{\text{DM}} = M_h$: small $\delta$ to respect WMAP

$\Rightarrow$ small $\sigma_{\text{DM-SM}}$

In this case, high indirect detection rates!!
Invisible width of the Higgs

\[ \Gamma_H(S) = \frac{\lambda^2_{SS} M^2_H}{16\pi} \]

Visible decay

\[ \Gamma_H(H \rightarrow SS) = \frac{\lambda^2_{SS} M^2_H}{32\pi} \]

Invisible decay

\[ \Gamma_{inv} = \sigma_{SI} S^{-p} = \left( m_S + m_P \right)^2 M^2_H - 4m^2_S \]

\[ \sigma_{SI} (pb) \]

WMAP + LEP + XENON100 upgrade + LHC prospect

2012

\[ m_s (GeV) \]

\[ m_H (GeV) \]
And if LHC sees nothing?

What if invisible is largely the dominant mode?

\[ L_{0} = \frac{L_{0}}{1 - Br_{\text{inv}}} \] to be excluded/observed

Luminosity required for exclusion at 95% CL at 7 TeV [ATLAS]

\begin{align*}
    m_{S} &= 50 \text{ GeV}, \quad \lambda = 0.2 \\
    \text{SM Higgs}
\end{align*}

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95% CL bound from Xenon100
Conclusion

- Scalar DM is very predictive
- The model could be excluded by the end of the year
- Complementarity with LHC is fundamental