Dark Matter in the Left Right Twin Higgs Model

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Work done with Shufang Su, Jessica Goodman
Outline

- the Left-Right Twin Higgs Model
- Relic Density Analysis
- Direct and Indirect detection
- Conclusion
Left Right Twin Higgs Model

- Presented by Chacko, Goh, and Harnik
  - arXiv:hep-ph/0506256v1

- Motivation?
  - Little Hierarchy Problem

- Add a second higgs doublet $\hat{H}$ to the SM that does not get a VEV
introduce dark matter

- add $H_{\hat{h}} \rightarrow (0,0,0,f_{\hat{h}})$
- explain which one is dark matter, why stable
- $H_{L_{\hat{h}}}=(H_1, H_2)$

- $H_2=S+iA$, explain why need $\delta=m_A-m_S$
- introduce $\delta=m_{h_1}-m_{H_2}$

- New Higgs: weak interactions $\rightarrow$ WIMP
Left Right Twin Higgs Model

- Similar to Inert Higgs Doublet Model, proposed by Barbieri et al., the other paper
  - arXiv:hep-ph/0603188v2
  - SM higgs is heavy (Mh~500 GeV)
  - Charged, scalar, and pseudoscalar higgs are only extra particles
Left Right Twin Higgs Model

New particles in Twin Higgs Model

- Heavy gauge bosons
- Heavy top
- Heavy neutrinos
- Charged and neutral scalars
- Charged higgs
- Scalar and Pseudoscalar higgs

make a table show the difference
Relic Density Analysis

- WMAP: $0.093 < \Omega h^2 < 0.128$ at 2$\sigma$ level

- Boltzman eq here

- Consider co-annihilation

- Used program micrOMEGAS_2.0 to calculate the relic abundance
  - calchep_2.4.4 used to calculate tree-level cross sections
Relic Density Analysis

- Modest choice of parameters yields two favored regions
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Relic Density Analysis

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  - Low mass: $M_{h2S} \leq M_w$
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- PLOTS FOR NEXT SLIDES
  - High Mass:
    - $\Omega m g h^2$ vs $f_1$, for various delta
    - $\omega g h^2$ vs delta, for various $f_1$
    - $\Omega m g h^2$ contour in $M_{h2S}$-$f_1$ plane
  - Low Mass:
    - $\Omega m g h^2$ contour in $M_{h2S}$-$f_1$ plane
    - $\Omega m g h^2$ vs $f_1$???
Relic Density Analysis

point out two region, explain pole region
Direct Detection

- General idea: observe recoil of detector nuclei from dark matter collisions.
  - $S+G \rightarrow S+G$ through SM higgs exchange
  - $S+q \rightarrow A+q$ through Z exchange
    - Constrains S-A mass splitting to be non-zero

- Contributions from spin independent and spin dependent cross sections

- Spin independent contribution dominates
Direct Detection

- Best measurements to date:
  - Spin Independent:
    - Xenon10 2007 (BG subtract)
    - CDMS (Soudan) 2004+2005 (Ge)
    - Zeplin II
  - Spin Dependent:
    - NAIAD 2005 (neutron)

- Best projected measurements for future detectors:
  - Spin Independent
    - Super CDMS phase C
    - Zeplin4/Max
    - Xenon1T
  - Spin Dependent
    - NAIAD
direct Detection

- show results, difficult
Indirect Detection

- dark matter annihilate into gamma, neutrino, positron

- gamma
  - MOOnochromatic(?) gamma ray
    - $S,S\rightarrow\gamma,\gamma (\gamma,h) (\gamma,Z)$
    - Through loop processes only
    - Monochromatic
  - hadronization and fragmentation.
    - $S,S\rightarrow q,q_{\overline{b}}$ or $S,S\rightarrow Z,Z \rightarrow Z,q,q_{\overline{b}}$
  - final state charged particle radiation.
    - $S,S\rightarrow \gamma,W^+,W^-$
    - Unique signature
Indirect Detection

- formulas, $\Gamma \sim (\rho)^2$
- Increased events for areas of high density
  - Galactic Halo
- High dependence on halo dark matter density distribution, $J \, \delta \, \Omega = 1 - 100$
- Exp sentivity
Indirect Detection

- 3 plots, PLOTS>>> 
  - $d(\sigma v)/dE$
  - ???

- NUMBERS>>> 
  - THM Limits
  - Current Detector Limits, Future Limits
Conclusion

- Left Right Twin Higgs Model provides a natural dark matter candidate
- Can explain 100% of dark matter observed by WMAP
- Direct difficult
- Indirect detection: hadronization possible, other two difficult
- Thank you!