dark disks and *Fermi*: the good, the bad, and the ugly...

Greg Dobler (KITP, UCSB)
dark halo shapes

the good, the bad, and the ugly...

Greg Dobler (KITP, UCSB)
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dark halo shapes

dark disks and Fermi: the good, the bad, and the ugly...

Greg Dobler (KITP, UCSB)
Ilias Cholis (SISSA)
Neal Weiner (NYU, IAS)
dark disk morphology
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see Read et al. (2008)
dark disk morphology

\[ \Gamma_{\text{ann}} = \frac{1}{2} \left( \frac{\rho_{\text{SH}}}{m_\chi} \right)^2 \langle \sigma_{\text{ann}} | v | \rangle_{\text{SH}} + \frac{1}{2} \left( \frac{\rho_{\text{DD}}}{m_\chi} \right)^2 \langle \sigma_{\text{ann}} | v | \rangle_{\text{DD}} + \left( \frac{\rho_{\text{SH}} \cdot \rho_{\text{DD}}}{m_\chi^2} \right) \langle \sigma_{\text{ann}} | v | \rangle_{\text{mixed}} \]
dark disk morphology (prompt)

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Einasto (prompt)

Einasto + dark disk ("worst" case) (prompt)
dark disk morphology (inverse Compton)

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Cholis & Goodenough (2010)

Einasto

(IC, galprop $E=3$ GeV)

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Einasto

(IC, galprop \(E=3\) GeV)

Einasto + dark disk (“worst” case)

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dark disk can slightly impact the morphological classification of the DM signal, but not (significantly) the amplitude
halo shapes (oblate, prolate, spherical, triaxial....)

DM only simulations generically yield prolate halos (e.g., Diemand et al 2008, Kuhlen et al 2008, Springel et al 2008, Vera-Ciro et al 2011)

for indirect detection with Fermi, the MW halo is likely prolate
halo shapes (oblate, prolate, spherical, triaxial....)

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Recent findings of triaxial (and/or oblate) shapes are mostly for the outer parts of the halo (Vera-Ciro et al 2011).

For indirect detection with Fermi, the MW halo is likely prolate.
halo orientation (???)

- some evidence for perpendicular alignment with Galactic disk from distribution of Galactic satellites (eg., Zenter et al 2005)

- alternative alignments (prompt only):

- correlation with known foregrounds vary at the 30% level
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![Diagram of halo orientation](image)

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the Fermi haze/bubbles

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visible even with no templates, no fitting, no subtraction, etc...
the Fermi haze/bubbles
e.g., Dobler et al. (2010); Su, Finkbeiner, & Slatyer (2010); Dobler, Cholis, & Weiner (2011)

Dobler, Cholis, & Weiner (2011)

different templates yield somewhat different morphologies:
hourglass vs. oval
Dobler, Cholis, & Weiner (2011)
the Fermi haze/bubbles from DM annihilation

assuming: prolate halo $r=2$, anisotropic diffusion

dark matter inverse Compton, $E = 3$ GeV

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Dobler, Cholis, & Weiner (2011)
the Fermi haze/bubbles from DM annihilation

- assuming: prolate halo $r=2$, anisotropic diffusion
- matches spectrum, amplitude (BF=30), and morphology of the haze/bubbles

outstanding issues: low latitude shape? edges? flat profile?
summary

. dark disks will **not** particularly impact **morphological** searches for DM annihilation

. the MW dark halo is likely **prolate** in the regions of interest

. the orientation of the halo is not well known
  - some evidence for perpendicular orientation
  - other orientations affect observable signal
  - some orientations can be confused with known non-DM signals

. the *Fermi* haze/bubbles can be reasonably fit with a prolate halo
  - BF = 30, hard spectrum, elongated morphology
  - anisotropic diffusion effects
Summary (haze/bubbles)

This structure is very odd!

1.) sharp edges plus flat profile

2.) lower energy "cutoff"

1.) seems to imply a very contrived electron distribution since constant volume emissivity gives limb-darkened profiles and shell emissivity gives limb brightened profiles.

2.) seems to imply injection of electrons at ~TeV with a very hard spectrum

The contenders:

- Wind (e.g., Crocker & Aharonian 2011)

- Starburst

- AGN (e.g., Guo & Matthews 2011)

- 2nd order Fermi acc. (e.g., Mertsch & Sarkar 2011)

- DM annihilation (e.g., Dobler, Cholis, & Weiner 2011)
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- wind (e.g., Crocker & Aharonian 2011): time scales too long, no Hα, violates 1.)
- starburst: no Hα, likely violates 1.) and 2.)
- AGN (e.g., Guo & Matthews 2011): violates 1.), instabilities at the edge?, radio?
- 2nd order Fermi acc. (e.g., Mertsch & Sarkar 2011): violates 1.), synchrotron?
- DM annihilation (e.g., Dobler, Cholis, & Weiner 2011): violates 1.)
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IF THE EDGES ARE REAL, DOES THIS SUGGEST A HYBRID SCENARIO???