Deciphering the gamma-ray background: star-forming galaxies, AGN, and the search for Dark Matter in the GeV Band.

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The gamma-ray sky

4 days of Fermi LAT
Credit: LAT collaboration
What is making the GeV isotropic diffuse background?

- Guaranteed sources: active galaxies, star-forming galaxies
- Hypothesized source classes: galaxy clusters, dark matter cusps
How to break the degeneracies?

\[ C_{\ell}^{\text{tot}} = f_{\text{EG}}^2 C_{\ell}^{\text{EG}} + f_{\text{DM}}^2 C_{\ell}^{\text{DM}} \]

\[ f_{\text{EG}} + f_{\text{DM}} = 1 \]

\[ I_{\text{DM}} = I_{\text{tot}} \left( \frac{C_{\ell}^{\text{EG}} + C_{\ell}^{\text{DM}}}{C_{\ell}^{\text{EG}} + C_{\ell}^{\text{DM}}} \right) \]

\[ I_{\text{EG}} = I_{\text{tot}} \left( \frac{C_{\ell}^{\text{EG}} - C_{\ell}^{\text{DM}}}{C_{\ell}^{\text{EG}} + C_{\ell}^{\text{DM}}} \right) \]

At minimum:

\[ C_{\ell}^{\text{DM}} = \frac{C_{\ell}^{\text{EG}} C_{\ell}^{\text{tot}}}{C_{\ell}^{\text{EG}} - C_{\ell}^{\text{tot}}} \]

Hensley, Siegal-Gaskins & Pavlidou 2009
On arXiv soon!
Deconvolve the components!

We could measure the annihilation spectrum!

Hensley, Siegal-Gaskins & VP 09
What about the foregrounds?

Some people’s foreground is other people’s signal!

- If deconvolution can be done:
  I no longer have to carefully model foreground to obtain DM spectrum from residuals

- A deconvolved extragalactic source intensity spectrum encodes physics about the parent population
What physics can we learn about AGN?

- How much diffuse gamma-ray emission due to all AGN, everywhere, ever?
- Physics input to this calculation:
  - Energy spectrum
  - Luminosity function
  - Duty cycle
  - Extragalactic UV, optical, IR backgrounds!

Credit: J. Buckley 1998 (Science), illustration: K. Sutliff
What physics can we learn about galaxies?

- **How galaxies make gamma rays:**
  - Gas makes stars
  - Stars blow up and make supernova remnants
  - Supernova remnants accelerate cosmic rays
  - Cosmic rays collide with gas, make pions,
  - Pions decay into gamma rays

- **How much diffuse gamma-ray emission due to all galaxies, everywhere, ever?**
  Physics input to this calculation:
  - Cosmic star formation history (how much star formation, gas)
  - Cosmic-ray -- gas interactions
  - Cosmic-ray acceleration, confinement, escape

Learn about B-field at high-z!

VP & Fields 02, Ando & VP 09
Conclusions

1. **Gamma-ray background is a multi-component emission.** starforming galaxies, blazars, galaxy clusters, dark matter ...

2. Combining intensity energy spectrum + anisotropy energy spectrum may allow us to DECONVOLVE the components.

3. For DM: can measure annihilation spectrum *independently of any model for the foreground components*! Measure mass, annihilation channel.

4. Deconvolution can turn foregrounds into signal: extract physics of e.g. blazar or star-forming galaxy population.

5. Deconvolution not feasible in all cases BUT: if feasible...