Mapping Correlation of a Simulated Dark Matter Source and a Point Source in the Gamma-Ray Sky

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Abstract

In my research, I analyzed how two gamma-ray source models interact with one another when optimizing to fit data. This is important because it becomes hard to distinguish between the two point sources when they are close together or looking at low energy photons. The reason for the first is obvious, the reason why they become harder to distinguish at lower photon energies is the resolving power of the Fermi Gamma-Ray Space Telescope gets worse at lower energies.

When the two point sources are highly correlated (hard to distinguish between), we need to change our method of statistical analysis. What I did was show that highly correlated sources have larger uncertainties associated with them, caused by an optimizer not knowing which point source's parameters to optimize. I also mapped out where there is high correlation for 2 different theoretical mass dark matter point sources so that people analyzing them in the future knew where they had to use more sophisticated statistical analysis.

Dark Matter

“Something” we have only been able to detect via gravity

Candidates: WIMP (weakly interacting massive particle), MOND, and MACHOS.

If Dark Matter is a WIMP:

Possibly annihilates into particles we can observe.

Gamma-Ray Sky

The Fermi LAT 1FGL Source Catalog

Dark Matter Piece

Monte Carlo Simulations

Inputs: Sources, IRFS

Sources : Profile, Position, Normalization

IRFS: Instrument Response Function

Probability Density Function: probability of detecting a photon in a given space at a given energy

Likelihood

The product of the probability of observing your data from your input model in each bin.

$$Likelihood = \prod p_k$$

Specifically for a poisson distribution

$$Likelihood = \prod \frac{m_k^{n_k} e^{-m_k}}{n_k!}$$

Identifying a Signal

Nuisance Parameters:

Parameters that aren't of immediate interest, but should be taken into account when analysing the parameters of interest.

i.e.: variance

Correlation

$$\text{Cov}(X, Y) = \langle (X - \mu_X)(Y - \mu_Y) \rangle = \langle XY \rangle - (\mu_X * \mu_Y) = \sigma_{XY} \quad (1)$$

$$\text{Correlation} = \frac{\sigma_{XY}}{\sqrt{\sigma_{XX} * \sigma_{YY}}} \quad (2)$$

Mapping Correlation Between a Point Source and Dark Matter

Determining When to Use Nuisance Parameters

Conclusion

Hope to apply to different mass dark matter to determine where future analysis needs to use more sophisticated statistical analysis

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