Breaks in gamma-ray spectra of distant blazars: 2018 update

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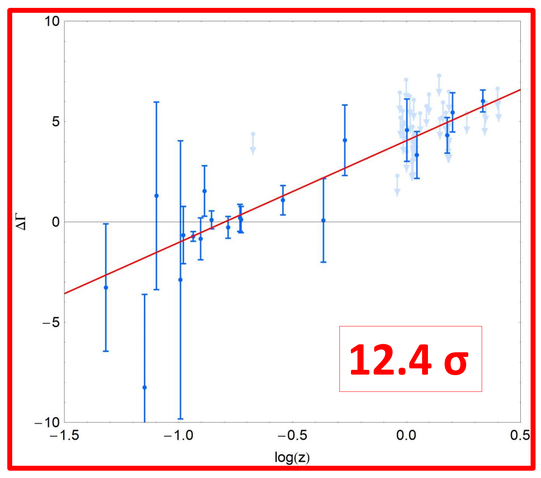
MOTIVATION

Energetic gamma rays scatter on soft extragalactic background radiation (EBL) when propagating through the Universe, producing electron-positron pairs. The expected opacity of the intergalactic space limits the mean free path of TeV gamma rays to dozens of Megaparsecs. However,

- TeV photons from numerous more distant sources have been detected
- Previous studies indicated that spectra of these sources, upon correction for the absorption, exhibit unusual spectral hardenings which happen precisely at the energies where the correction becomes significant.[Horns and Meyer 2012] [Rubtsov and Troitsky 2014]



Opacity of the Universe seems to be overestimated!

Possible explanations:

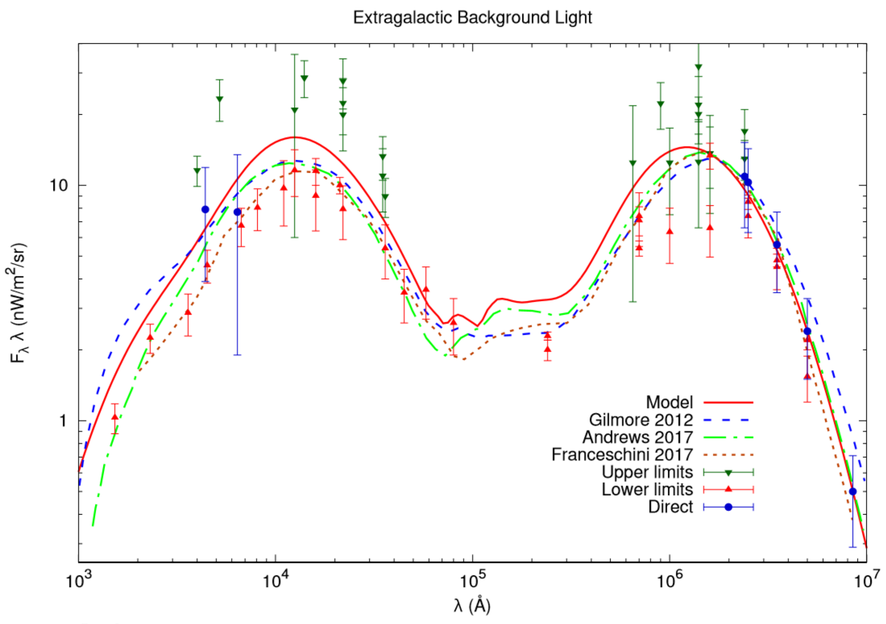
- Incorrect estimation of the EBL.
- Novel physical phenomena: axion-photon mixing

Here, we address this subject with the most recent clean sample of distant gamma-ray blazars, making use of published results of imaging atmospheric Cerenkov telescopes and of Pass 8 Fermi-LAT data, supplemented by the newest absorption models and individual measurements of sources' redshifts.

NEW EBL MODEL*

***https://github.com/Semk0/EBL-model**

We develop new flexible EBL model while maintaining the explicit dependence on the astrophysical parameters involved.



Four groups of the EBL parameters:

1. Parameters of the GMC (size, lifetime, opacity etc)
2. Parameters of initial mass function
3. Parameters of dust particles
4. Global parameters (SFR scaling factor, star truncation mass, star formation starting redshift)

Experimental constraints on the EBL → Constraints on parameters

UPDATED RESULTS ON GAMMA-RAY UPWARD BREAKS

We consider the ensemble of very-high-energy gamma-ray sources observed at distances and energies where significant absorption of gamma rays is expected due to pair production on the extragalactic background light.

Sample of blazars: selection criteria

Redshift criteria:

- the redshift is spectroscopic
- the redshift is determined in a) a dedicated study or b) in 2dF or 6dF survey or c) in SDSS, the result is unique and does not change from one release to another

Spectral criteria:

- information for at least 5 energy bins is available
- the minimal energy of the last spectral bin is higher than E_0 and the lowest energy of the second spectral bin is below E_0

Method of reconstruction of initial blazar spectra

$$\begin{cases} F_0(E) = AE^{-\Gamma_1} & \text{for} \quad E < E_0 \\ F_0(E) = A\frac{E_0^{-\Gamma_1}}{E_0^{-\Gamma_2}}E^{-\Gamma_2} & \text{for} \quad E > E_0 \end{cases}$$

Then fitting parameters A, Γ_1, Γ_2 to give observed spectra after absorption

E_0 – such energy, that optical depth $\tau(E_0, z) = 1$

Analysis

$\Gamma = \Gamma_1 - \Gamma_2$ → $\Gamma = a \log_{10}(z) + b$

Strong breaks → New data → Tuning parameters of the EBL with Markov Chain Monte Carlo method

IS IT POSSIBLE TO FIND PARAMETERS WHICH ARE ASTROPHYSICALLY ACCEPTABLE AND ELIMINATE BREAKS?

NEW FLEXIBLE EBL MODEL CAN GIVE AN ANSWER