Optimizing a Mathematical Model for the Intensity of the Extragalactic Background Light

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Background

Since 2018, we have been attempting to make a mathematical model for the intensity of the extragalactic background light (EBL). The EBL reaches our telescopes by traveling vast lengths through space, and dust. Our objective has been to create a model for the intensity of the EBL with and without dust to predict the impact of dust on EBL light.

We use standard relativistic cosmology, and build our models by assuming there are galaxies with a number density $n(z)$ that emit blackbody radiation across all wavelengths at a specific redshift, $F(\lambda_o, z)$ in nW/m^3. Eq. 1 describes our mathematical model without dust.

$$I_\lambda(\lambda_o) = \frac{c}{4\pi H_o}\int_0^{z_f}\frac{n(z)F(\lambda_o,z)(1+z)^{-3}}{\sqrt{\Omega_m(1+z)^3+\Omega_\Lambda}}dz \qquad (1)$$

Not Enough Light

As our research progressed, so did new observations of EBL photons; we discovered that our model predicts much less light than observations indicate. This can be seen in Fig. 1 below. This summer we have been working on our assumptions about the distribution of galaxies at each redshift; our previous code developed with four luminosity density functions from Nagamine et al. [2] simply does not provide enough light to satisfy observational data. We believe that the density of galaxies per redshift is higher than Nagamine predicts; more galaxies per redshift will produce more light, allowing our model to match the observed luminosity of the EBL.

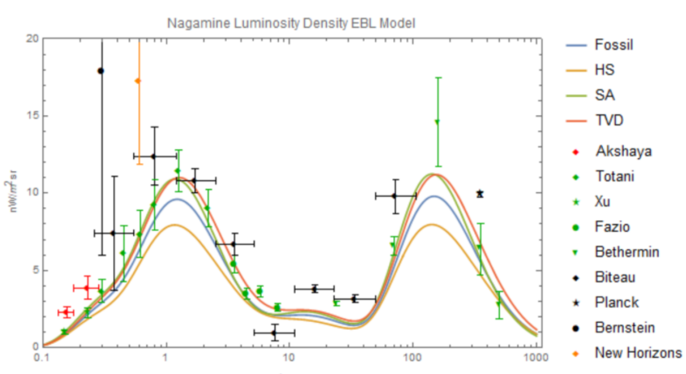

Fig. 1: EBL models according to luminosity density functions from Nagamine et al. data [2]. Lower-limits for EBL intensity from [1] (green points) show higher intensities at longer wavelengths than our EBL model predicts.

Note: This poster is nowhere near an exhaustive description of our research – if you'd like to know more please email me at mjenni4@students.towson.edu!

New Luminosity Density Functions

To correct our model, we use a skewed Gaussian distribution for luminosity density, as shown in Eq. 2. μ, σ, α and C are coefficients used to

$$n(z) = \frac{C}{\sqrt{2\pi}\sigma}\mathrm{Exp}\left(-\frac{(z-\mu)^2}{2\sigma^2}\right)\mathrm{Erfc}\left(-\frac{\alpha(z-\mu)}{\sqrt{2}\sigma}\right) \qquad (2)$$

manipulate the model's shape. Erfc is the complementary error function, and our model is constrained the luminosity at redshift zero. We determined that the ideal luminosity density evolution would increase rapidly between redshifts 0 and 2, and slowly decay past redshift 2; using our coefficients, we are able to define such a function.

Dusty EBL

Implementing dust into our EBL equation, we have Eq. 3. $\tau(\lambda_o, z)$ is a

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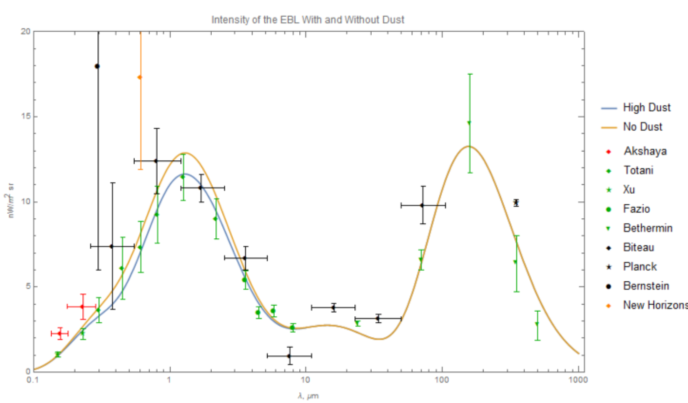
dimensionless function for the absorption of light due to dust in the extragalactic medium (EGM). For simplicity, we assume dust is uniformly distributed throughout the EGM, and has light absorption properties as defined by [3]. Using our optimized luminosity density function along with dust, we found that dust causes a 9.58% decrease in the intensity of the EBL at visible wavelengths, as shown below in Fig. 2.

Fig. 2: Bolometric luminosity of EBL with and without dust. Notice the EBL model with dust (blue line) predicts intensities much closer to observational data than the EBL model without dust (yellow line). This difference is most apparent between 0.1 and 5 μm.



Thanks!
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References

[1] R. Hill, K. Masui, D. Scott. Applied Spectroscopy, 72 (2018), 663-688
[2] K. Nagamine et al., *ApJ* 653 (2006) 881-893
[3] B. Draine, *ARAA* 41 (2003) 241-289
[4] Akshaya et al. (2019) *MNRAS*, 489: 1120-1126