CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

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Project Number

S1701

Project Title

Toward a Better Model of the Extragalactic Background Light: The Value of Splines

Abstract

Objectives/Goals

Our research aimed to more effectively model the extragalactic background light (EBL), which is the sum of all the optical and infrared light that has been emitted since the stars lit up. Understanding the EBL has intrinsic importance, and it also allows us, for example, to estimate the rate at which the universe is expanding (the Hubble constant). However, because it is difficult to measure the EBL directly, we measure it through high-energy gamma ray interactions with the EBL. For gamma rays that reach earth, we can detect the light emitted by their particle showers using imaging atmospheric Cherenkov telescopes like those at VERITAS. Choosing splines, piecewise polynomial functions used for data interpolation, we developed a model of the EBL.

Methods/Materials

We considered over 20 types of splines. Because of their local control and linearity, we selected Basis Splines and Natural Cubic Splines to compare in more depth. We used CERN ROOT, a C/C++ data analysis environment, and the GNU Scientific Library to develop a spline interpolation method. We then applied it to gamma ray spectra from the VERITAS and other Cherenkov imaging telescopes, produced a model of the EBL, and integrated it into the 2015 Biteau & Williams data analysis protocol to assess our model.

Results

Our research produced two important results. First, that Natural Cubic Splines have improved local control when compared to the previous discipline standard of Basis Splines, which were used to model the EBL in 2008 by Mazin and Raue. Second, that Natural Cubic Splines model the EBL with at least as much accuracy, but with fewer parameters than the most recent approach in the field.

Conclusions/Discussion

The increased local control provided by Natural Cubic Spline interpolation mitigates excess noise and increases the accuracy of results using this type of data. Therefore, this method offers an improved approach to modeling the EBL.

With this research, we have also confirmed with greater confidence conclusions of previous models.

Summary Statement

We developed a spline interpolation protocol with which to analyze high energy gamma ray interactions with the extragalactic background light (EBL) and we produced an improved model of the EBL.

Help Received

We worked under the mentorship of Dr. Jonathan Biteau and Professor David Williams through the Science Internship Program at the University of California Santa Cruz.