Contribution ID: **78** Type: **Poster Contributions**

An Empirical Determination of the Intergalactic Background Light from UV to FIR Wavelengths Using FIR Deep Galaxy Surveys and the Gamma-ray Opacity of the Universe

Wednesday, September 14, 2016 5:45 PM (15 minutes)

Our direct results on the IBL are consistent with those from complimentary \gray analyses using observations from the {\it Fermi}-LAT \gray space telescope and the H.E.S.S. air \v{C}erenkov telescope. Figure \ref{Ackermann} indicates how well our opacity results for $z = 1$ overlap with those obtained by the {\it Fermi} collaboration (Ackermann et al. 2012). Our results are also compatible with those obtained from higher energy \gray observations using H.E.S.S. (Abramowski et al. 2013). This overlap of results from two completely different methods strengthens confidence that both techniques are indeed complimentary and supports the concept that the spectra of cosmic \gray sources can be used to probe the IBL (Stecker et al. 1992).

Thus, we find no evidence for modifications of \gray spectra by processes other than absorption by pair production, either by cosmic-ray interactions along the line of sight to the source (Essey \& Kusenko 2014) or line-of-sight photon-axion oscillations during propagation ({\it e.g.}, De Angelis et al. 2007; Mayer \& Horns 2013). In this regard, we note that the {\it Fermi} Collaboration has very recently searched for irregularities in the \gray spectrum of NGC 1275 that would be caused by photon-axion oscillations and reported negative results (Ajello et al. 2016).

We conclude that modification of the high energy \gray spectra of extragalactic sources occurs dominantly by pair production interactions of these \grays with photons of the IBL. They therefore support the concept of using the future {\it \v{C}erenkov Telescope Array} instruments to probe the cosmic background radiation fields at infrared wavelengths. This method can be used in conjunction with future deep galaxy survey observations using the near infrared and mid-infrared instruments aboard the {\it James Webb Space Telescope}.

Summary

We have previously calculated the intergalactic background light (IBL) as a function of redshift from the Lyman limit in the far ultraviolet to a wavelength of 5 μm near infrared range, based purely on data from deep galaxy surveys. Here we utilize similar methods to determine the mid- and far-infrared IBL from 5 μm to 850 μm. Our approach enables us to constrain the range of photon densities, by determining the uncertainties in observationally determined luminosity densities and spectral gradients. By also including the effect of the 2.7 K cosmic background photons, we determine upper and lower limits on the opacity of the universe to \grays up to PeV energies within a 68\% confidence band.
Our direct results on the IBL are consistent with those from complimentary \gray analyses using observations from the {\it Fermi} \gray space telescope and the H.E.S.S. air \v{C}erenkov telescope.
Thus, we find no evidence of previously suggested processes for the modification of \gray spectra other than that of absorption by pair production alone.

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Session Classification: Poster Session (coffee at 15:00) & CERN Visit

Track Classification: Gamma-ray astrophysics