Search for Axion signatures in AGN

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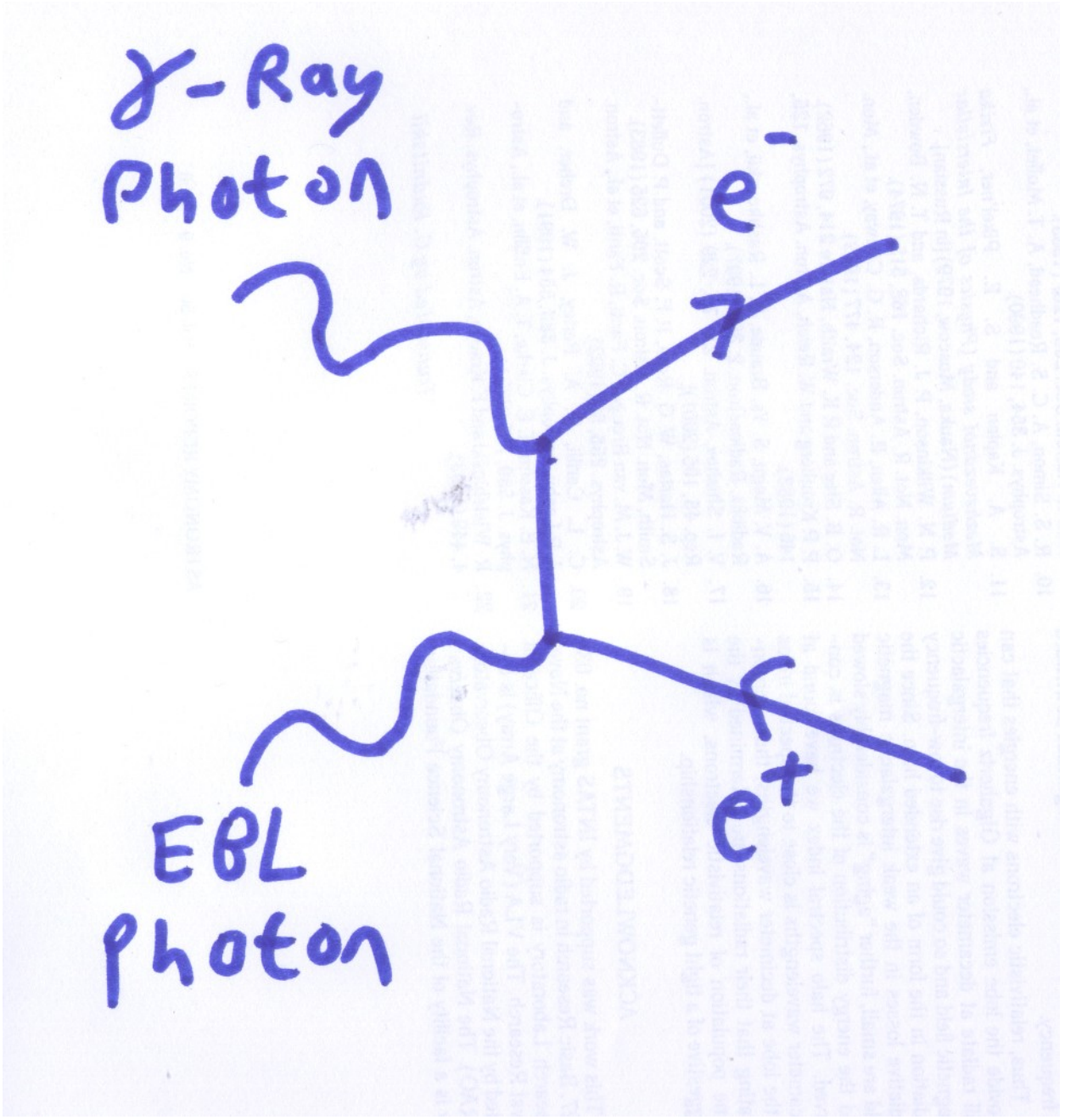
Summary

- Extragalactic Background Light
- How this makes the universe opaque to gamma-rays
- Axions and their motivation
- What role CTA can play

Extragalactic Background Light

- Photons that are present throughout the universe
- We're interested in Infrared-UV wavelengths
- These are primarily by stars and star formation
- Because the amount of stars/star formation evolves along with the universe, the EBL intensity at a given wavelength is a function of redshift

EBL absorbs high energy photons...



...but not as much as expected

provide an upper limit on the background light at optical/near-infrared wavelengths that appears to be very close to the lower limit given by the integrated light of resolved galaxies[8]. The background flux at these wavelengths accordingly seems to be strongly dominated by the direct starlight from galaxies, thus excluding a large contribution from other sources – in particular from the first stars formed[9]. This result also indicates that intergalactic space is more transparent to γ-rays than previously thought.

Aharonian et al. Nature 440, 1018 (2006)

TeV observations were consistent only with the very lower limits of EBL intensity derived from galaxy counts.

3C 279, at a distance of more than 5 billion light-years (a redshift of 0.536). No quasar has been observed previously in very-high-energy gamma radiation, and this is also the most distant object detected emitting gamma rays above 50 gigaelectron volts. Since high-energy gamma rays may be stopped by interacting with the diffuse background light in the universe, the observations by MAGIC imply a low amount for such light, consistent with that known from galaxy counts.

Magic Collaboration, Science, 320, 1752 (2008)

- Sets limits on other types of emission e.g. from the poorly understood Population III stars
- The HESS 2006 result still required a spectral index of 1.5, if the spectrum is softer it would mean even less absorption.

Axions

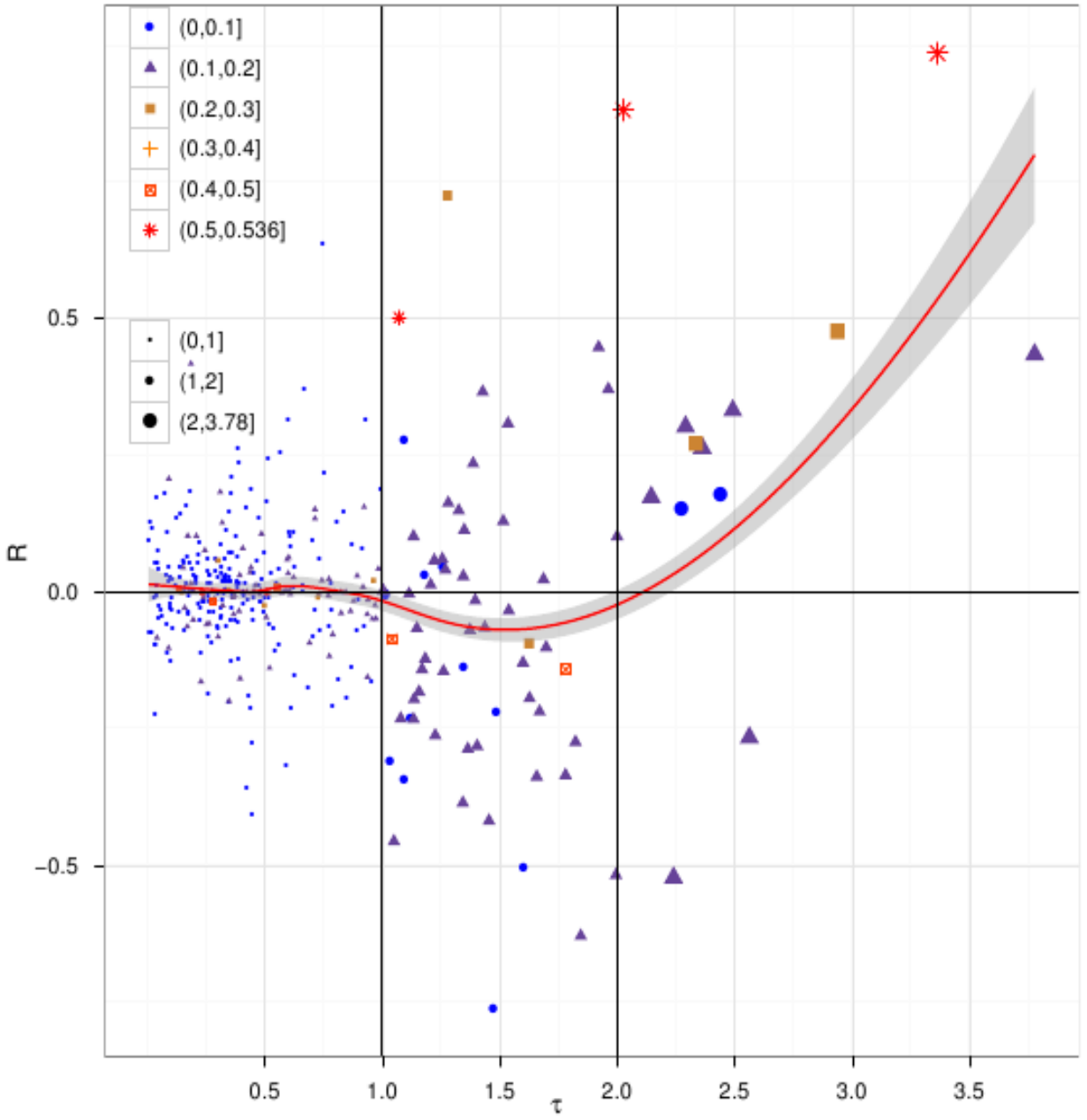
- Another possibility is the EBL models are correct but there is less gamma-ray absorption than predicted.
- One of the possibilities is the existence of axions.
- A particle proposed as an extension to the Standard Model to explain lack of CP violating strong interactions.

Axions

- In the presence of a B-Field, a photon can oscillate into an axion and back.
- There would be conversion to axions at the source.
- The axion can then travel through the universe without being absorbed like a gamma-ray would.
- The axion then reconverts to a photon in the Milky Way's B-Field

Horns & Meyer

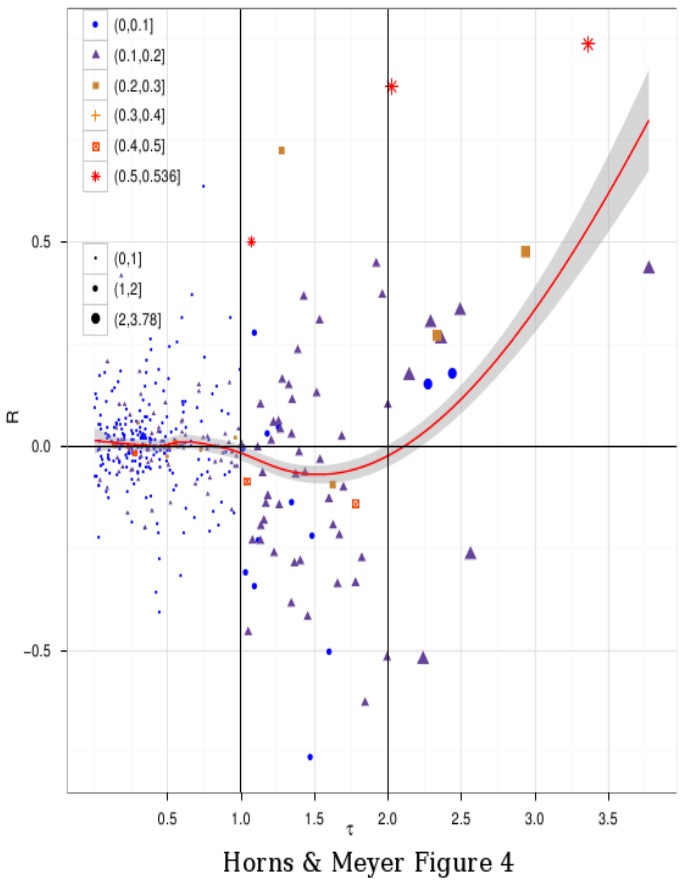
- The most systematic study to date is probably Horns & Meyer JCAP02(2012)033
- They study the gamma-ray spectra of 25 sources in the optically thin regime (little EBL absorption)
- They then extrapolate these spectra to the optically thick regime **using the lower limit model of the EBL** and compare them to observations at these energies.



Horns & Meyer Figure 4

Sigf = 4.2 s.d.

What can CTA do?



Horns & Meyer Figure 4

- CTA is expected to detect ~20 blazars at z>1 (Inoue, PoS(AGN 2011)025)

- At z=1 and CTA peak sensitivity (0.9 TeV) the object will have an optical depth of 9.

- So we should be able to extend this graph out by a factor for 3 and see if the predicted trend continues.

- This may also be a promising topic for the CTA mini-array (thanks Paula!). The mini-array has a very high energy threshold and there will also be very low noise at this energy. So, we can pick a few objects that will only be detectable with certain EBL model/axion combinations.

Thank you!

Kneiske Lower Limit Model

- “A lower limit EBL is used, which by definition is missing some amount of emission”