

EVIDENCE FOR A NEW LIGHT BOSON FROM COSMOLOGICAL GAMMA-RAY PROPAGATION?

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DA.R.Ma: arXiv:0707.2695 [astro-ph]

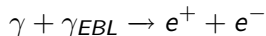
DA.R.Ma: arXiv:0707.4312 [astro-ph]

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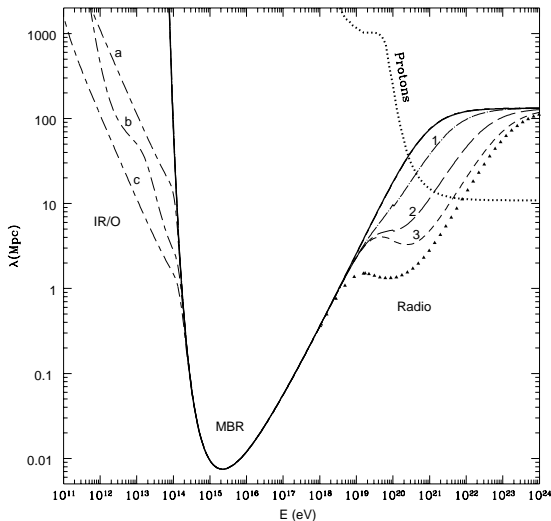
INTRODUCTION

Thanks to IACTs like H.E.S.S., MAGIC, CANGAROO and VERITAS we know that the Universe is more transparent to VHE gammas than expected.

QED pair-creation processes



are an energy-dependent source of opacity with mean free path given by:



Hence absorption becomes important above 100 GeV.

In particular, the blazar 3C279 at $z = 0.54$ has been OBSERVED by MAGIC in the band 220 – 600 GeV with significance 5.1σ (6.1σ below 220 GeV).

Even for the lowest EBL density compatible with cosmology the attenuation is 58% at $E = 100$ GeV and 2% at $E = 500$ GeV, so that 3C279 should be VERY HARDLY VISIBLE in the above mentioned energy range.

Therefore, it looks sensible to explore which kind of NEW PHYSICS provides a way out of this difficulty.

As we are going to show, a natural possibility is provided by a new very light spin-0 neutral boson X enjoying the coupling

$$\mathcal{L} = \frac{1}{4M} F^{\mu\nu} \tilde{F}_{\mu\nu} \varphi = \frac{1}{M} \mathbf{E} \cdot \mathbf{B} \varphi ,$$

where φ stands for the X field.

EXPERIMENTAL LIMITS ON THE PARAMETERS

CAST experiment $\implies M > 1.14 \cdot 10^{10}$ GeV
for $m < 0.02$ eV

energetics of
1987a supernova $\implies M > 3 \cdot 10^{11}$ GeV
for $m < 10^{-10}$ eV

The above mentioned lagrangian

$$\mathcal{L} = \frac{1}{4M} F^{\mu\nu} \tilde{F}_{\mu\nu} \varphi = \frac{1}{M} \mathbf{E} \cdot \mathbf{B} \varphi$$

gives rise to $\gamma - X$ OSCILLATIONS in the presence of an external magnetic field \mathbf{B} .

Intergalactic magnetic fields have a domain-like structure with strength 10^{-9} G, coherence length 1 Mpc and random orientation.

In order to have an unsuppressed amplitude, we work in the strong-mixing regime, which entails

$$m^2 \ll \frac{2 \mathbf{E} \cdot \mathbf{B}}{M} .$$

EVOLUTION OF THE $\gamma - X$ SYSTEM

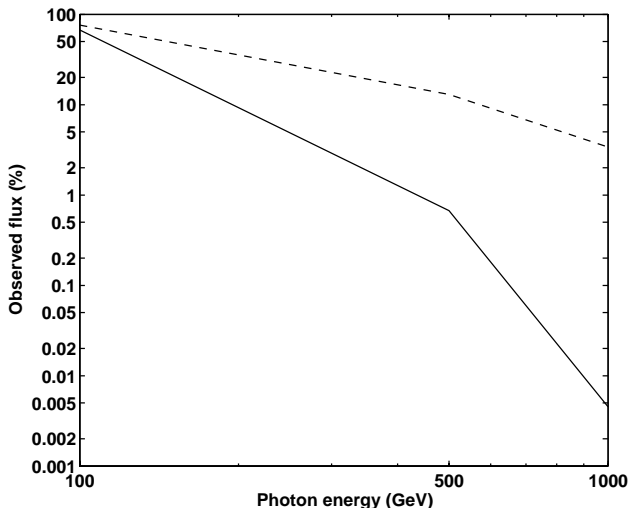
It is straightforward to compute the transition probability over a single domain, and the total transition probability arises as the incoherent average over all domains crossed by the LOS.

That is, we start with an unpolarized photon beam and iterate the single-domain evolution as many times as the total number of intercepted domains, taking each time a random realization of **B**.

RESULT FOR 3C279

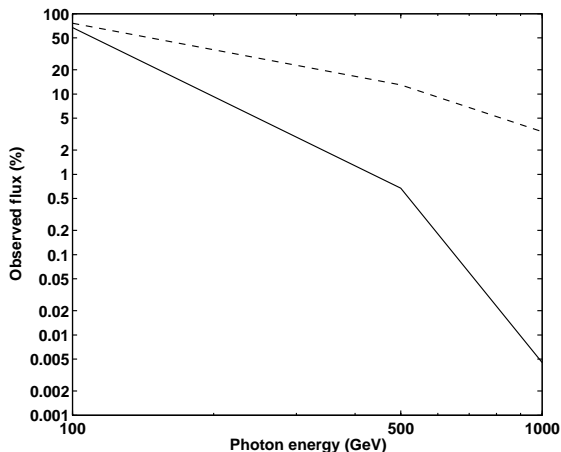
We exhibit our result for $M = 4 \cdot 10^{11}$ GeV in the case of 3C279.

The solid line represents the standard situation, while the dashed one pertains to the considered case.



COMMENTS FOR 3C279

It follows that
at $E = 100$ GeV the
enhancement is only by
a factor 1.1,
which becomes
19.4 at $E = 500$ GeV
and
755.5 at $E = 1$ TeV.



A further enhancement of a few percents at $E = 500$ GeV might come from the $\gamma - X$ conversion mechanism taking place in the source.

CONCLUSIONS

In conclusion, we have shown that the existence of a very light boson coupled to photons – as predicted by many extensions of the Standard Model – explains the observed transparency of the VHE gamma-ray sky.

Our prediction concerning the spectral distortion of VHE gamma-ray sources at cosmological distances can be tested with IACTs as well as with gamma-ray satellites AGILE and GLAST.