GRBs & Solar Flares

Science Working Group

GLAST
the Gamma-ray Large
Area Space Telescope

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Phenomenological Constraints on Lorentz Invariance

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MOTIVATION

- Absence of GZK cutoff on UHECR spectrum

- Proposal of Lorentz Invariance (LI) by Coleman and Glashow PhysRevD59 (1999)

- GZK absence now questioned (Berezinsky hep-ph 0204357)

- New tendence on searching for limits on LI.

- Different parametrization of limit but both related to energy threshold limit:
  - Liberati et al. (hep-ph) 0110094
  - Stecker and Glashow (astro-ph 0102226)

Liberati et al. paper

- Basic Eqns:

  -
    $$E^2 = p^2 + m^2 + \left[Ap^2 + Bp^3/K_0 + Cp^4/K_0^2 + O(p^5) \right]$$
  -
    $$E_a^2 \approx p_a^2 + m_a^2 + \eta_a p_a^n / K_0^{n-2}$$

- Photon Decay

  -
    $$k_{\text{th}} = \left(\frac{8m^2}{2\xi - \eta} \right)^{1/3} \quad \text{for } \xi \geq 0,$$

    $$k_{\text{th}} = \left(\frac{-8m^2\eta}{(\xi - \eta)^2} \right)^{1/3} \quad \text{for } \eta < \xi < 0.$$

- Cerenkov Vacuum

  -
    $$p_{\text{th}} = \left(\frac{m^2}{2\eta} \right)^{1/3} \quad \text{for } \eta > 0 \text{ and } \xi \geq -3\eta,$$

    $$p_{\text{th}} = \left(-\frac{4m^2(\xi + \eta)}{(\xi - \eta)^2} \right)^{1/3} \quad \text{for } \xi < -3\eta < 0 \text{ or } \xi < \eta \leq 0.$$

- **Observational limits e- 100 TeV and 10 TeV photons**
  $$\eta < 10^{-3}$$

Stecker and Glashow paper

- Basic Eqn:
  - $$c_e \equiv c_\gamma (1 + \delta) , \qquad 0 < |\delta| \ll 1$$

- Case I (Photon Decay) $c_e < c_\gamma \ (\delta \leq 0)$
  - 50 TeV photons from Crab nebula
  - $$E_{\max} = m_e \sqrt{2/|\delta|}$$
  - $-\delta < 2 \times 10^{-16}$

- Case II (Vacuum Cerenkov) $c_e > c_\gamma \ (\delta \geq 0)$
  - >1 TeV CR electrons
  - $\delta < 1.3 \times 10^{-13}$
  - IR absorbtion