The Blazar Sequence and The Cosmic Gamma-ray Background Radiation In the Fermi era

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The Cosmic X-ray/Gamma-ray Background

What is the origin?

**Blazars?** (Stecker & Salamon ’96, Chiang & Mukherjee ’98, Mucke & Pohl 00, Narumoto & Totani ’06, Dermer ‘07)

**Galaxy Cluster Merger?** (Loeb & Waxman ’00; Totani, & Kitayama ’00)

**Dark Matter annihilation?** (Oda et al. ’05; Horiuchi & Ando ’06; Ando+ ‘07 )
Blazars Cosmological Evolution

Since the blazar cosmological evolution is poorly known, it is uncertain whether blazars are dominant of the extragalactic gamma-ray background (EGRB) or not.

Stecker & Salamon ‘96

Blazars can account for 100% of the EGRB. But, their model was not compared with the luminosity and redshift distribution of EGRET blazars.

Pure Luminosity Evolution (PLE) model (Chiang & Mukherjee ‘98)
Luminosity Dependent Density Evolution (LDDE) model (Narumoto & Totani ’06)

Better fit to EGRET data than PLE model

25-50% of the EGRB can be accounted for by blazars.

However these studies assumed a simple power-law model for blazar spectral energy distribution (SED).
Blazar sequence is that the peak energy decreases as the bolometric luminosity increases. (Fossati+’97,’98 & Donat+’01)

However, SED sequence models have discrepancy in the luminosity of Compton component.

We make some minor modifications to their SED models to be continuous.
Constructing blazar gamma-ray luminosity function (GLF) based on AGN X-ray luminosity function, assuming “the bolometric luminosity of jet is proportional to disk X-ray luminosity”.

AGN X-ray Luminosity functions

- Hard X-ray luminosity function: Ueda+’03 (hereafter U03)
- Soft X-ray luminosity function: Hasinger+’05 (hereafter H05)

Constrain the parameters of GLF by likelihood analysis using EGRET blazar data. GLF models: $U03(q)$, $U03(q,\gamma_1)$, $H05(q)$, and $H05(q,\gamma_1)$.

Faint end slope index $\gamma_1$

The ratio between Blazar bolometric luminosity and disk X-ray luminosity $q$.
EGRET Blazars

Redshift distribution

Luminosity distribution

$L_{\text{jet,bol}} = 10^5 \cdot L_{\text{disk,X}}$

EGRET data is reproduced well with the assumption of AGN LDDE model and relation between jet and disk. This suggests EGRET blazars are high-accretion rate AGNs.
EGRB Composition  CIB absorption + Cascade

High energy photons (>20 GeV) are absorbed by the interaction with cosmic IR-background (CIB). Pair created positrons and electrons scatter CMB photons (Cascade emission) (Kneiske & Manheim ’08)

The fraction of EGRB flux absorbed in IGM is not large, and the cascade component does not significantly alter the EGRB spectrum.
The predicted EGRB spectrum is in agreement with a wide range of the observed data from X-ray to GeV, within the systematic uncertainties in the EGRB determination by EGRET. These results indicate that AGNs including blazars are the primary source of EGRB.

Recent study on the origin of the cosmic MeV gamma-ray background suggested that by considering the non-thermal component it would be explained by the non-blazar AGNs, which compose of the cosmic X-ray background (YI, Totani, & Ueda 2008).
**Prediction for the Fermi**

- Fermi will find \(~1000\) blazars & \(1-30\) Non-blazar AGNs.
- Fermi will resolve \(~99\%\) of total blazar EGRB flux. EGRB from non-blazar AGNs will be hardly resolved into discrete sources by Fermi.

**Expected Number of Fermi Blazars and Non-blazar AGNs**

- Fermi will find \(~1000\) blazars & \(1-30\) Non-blazar AGNs.

**Differential Flux distribution multiplied by flux of blazars and non-blazars**

- Fermi will resolve \(~99\%\) of total blazar EGRB flux. EGRB from non-blazar AGNs will be hardly resolved into discrete sources by Fermi.
Conclusion

• Constructing Blazar GLF using EGRET data based on LDDE model taking into account Blazar SED sequence.

• AGNs including blazars are the primary source as the origin of cosmic X-ray/Gamma-ray background radiation.

• *Fermi* will find ~1000 blazars and 1-30 non-blazars.

• *Fermi* will resolve ~99% of blazar EGRB.

• EGRET blazars are possibly high-accretion rate AGNs.