X-RAY EMISSION FROM HIGH REDSHIFT RADIO-LOUD QUASARS: COMPTONIZED IR VS. BEL PHOTONS ON PARSEC SCALES

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Abstract

Chandra observations reveal hard spectra in the luminous ($L_x \geq 10^{46}$ erg/sec), high redshift quasars. Small optical to X-ray flux ratios characterized by $\alpha_{o,x}$ (~ 1.0) parameter suggest that the X-rays result from beamed, nonthermal radiation. We model the X-ray emission in terms of blazar phenomenon, e.g. the IR and BEL emission is being Compton scattered off relativistic particles in the parsec scale jet. We discuss basic model assumptions appropriate for modeling the two high z quasars: GB 1508+5714 ($z = 4.3$) and PKS 0458-020 ($z = 2.29$).

INTRODUCTION

The production of X-rays in blazars (radio-loud AGNs with jets pointing at or close to the line of sight), is associated with jets. In High Energy Peaked BL Lacs (HBL), the X-rays are produced by synchrotron emission. In Low Energy Peaked BL Lacs (LBL) - the X-rays are produced by Comptonization of the synchrotron radiation (SSC). Finally in Flat Spectrum Radio Quasars (FSRQ) - X-ray emission can be produced by the SSC radiation and/or the so-called external radiation Comptonization (ERC) process, that is, Compton scattering of the photons external to the jet. External photons can come:

- directly from the accretion disk (Dermer & Schlickeiser 1993),
- from the broad line region (BLR) (Sikora, Begelman & Rees 1994), and
- from hot dust as thermal IR radiation (Błażejowski et al. 2000).

The luminosity of FSRQs is dominated by GeV radiation ("GeV-Blazars"). However, there is a subclass of FSRQs with the luminosity peaked in the MeV band ("MeV-Blazars"). A possible explanation for this division could be related to the location of the radiation site in the jet: in GeV-Blazars radiation is produced closer to the central black hole (where BEL play dominant role as the source photons in ERC process) , while in MeV-Blazars, the active region is significantly further from the center (in this case thermal IR photons play the crucial role in Compton scattering; see Sikora et al. 2002).

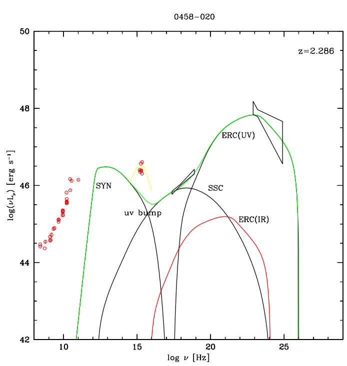

Figure 1: The broad-band spectrum of the "core-jet" structure of PKS 0458-020 and the applied model (SYN - synchrotron radiation, SSC - Comptonization of synchrotron radiation, ERC(IR) - Comptonization of the dust radiation, ERC(BEL) - Comptonization of the BEL radiation, uv bump - UV radiation from the disc). The observational data are obtained form archival data, NED, Chandra and EGRET. The model parameters are as follows: $r_0 = 7.00 \times 10^{17}$cm; $\gamma_{min} = 1.0$; $\gamma_{max} = 1.0 \times 10^4$; the bulk Lorentz factor $\Gamma = 15$; the half-opening angle of the jet: $\theta_j = 0.02$; the observer is located at an angle: $\theta_{obs} = 0.067$; the magnetic field scales with the distance like $B'(r) = (1.46 \times 10^{18})/r$ Gauss; the luminosity of the disc $L_{UV} = 1.0 \times 10^{47} erg/s$; maximal temperature of the dust $T_{d,max} = 800$ K; covering factor of the dust $\xi_{IR} = 0.06$; covering factor of the BEL clouds $\xi_{BEL} = 0.06$, minimal distance of the dust $r_{d,min} = 1.84 \times 10^{19}$ cm, electrons are injected with a double power-law with indices $p = 1.5$ for $\gamma \leq 720$, and $q = 2.8$ for $\gamma > 720$.

GB 1508+5714

- GB 1508+5714 is the first $z > 4$ radio-selected quasar to be detected in X-rays (Mathur & Elvis 1995);
- It is very X-ray luminous ($\sim 10^{47}$erg/s);
- Mathur & Elvis (1995) and Moran & Helfand (1997) argue that this luminosity is partially due to beaming;
- It shows significant variations in radio band (Frey et al. 1997, Moran & Helfand 1997);
- Its optical spectrum is dominated by strong UV bump (Moran et al. 1996);
- Chandra observations show very hard spectrum consistent with the previous ASCA data (Siemiginowska et al 2003, Moran & Helfand 1997), but lower flux;
- Here we model GB1508+5714 broadband radiation in terms of the MeV-Blazar phenomenon.

PKS 0458-020

- PKS 0458-020 is a z=2.29, γ-loud blazar (Thompson et al. 1995);
- The overall SED is dominated by γ-ray emission ($\sim 10^{48}$ erg/sec) peaking @ few GeV;
- PKS 0458-020 has the pronounced UV-bump (Pei et al. 1991);
- The X-rays observed by Chandra, reveals slightly softer ($\alpha_x \sim 0.64$) spectrum in comparison to GB 1508+5714 (Bechtold et al. 2003);
- PKS 0458-020 shows similar features to GeV-Blazars.

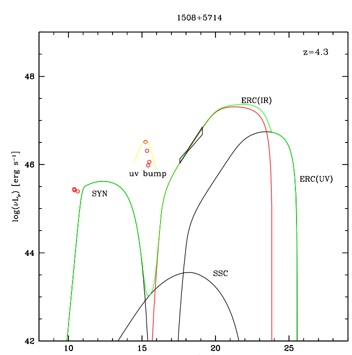

Figure 2: The broad-band spectrum of the "core-jet" structure of GB 1508+5714 and the applied model (SYN - synchrotron radiation, SSC - Comptonization of synchrotron radiation, ERC(IR) - Comptonization of the dust radiation, ERC(BEL) - Comptonization of the BEL radiation, uv bump - UV radiation from the disc). The observational data are obtained form archival data, NED and Chandra. The model parameters are as follows: $r_0 = 6.25 \times 10^{18}$cm; $\gamma_{min} = 1.0$; $\gamma_{max} = 6.0 \times 10^3$; the bulk Lorentz factor $\Gamma = 10$; the half-opening angle of the jet: $\theta_j = 1/10$; the observer is located at an angle: $\theta_{obs} = 1/10$; the magnetic field scales with the distance like $B'(r) = (12.0 \times 10^{17})/r$ Gauss; the luminosity of the disc $L_{UV} = 1.0 \times 10^{47} erg/s$; maximal temperature of the dust $T_{d,max} = 800$ K; covering factor of the dust $\xi_{IR} = 0.6$; covering factor of the BEL clouds $\xi_{BEL} = 0.1$, minimal distance of the dust $r_{d,min} = 1.84 \times 10^{19}$ cm, electron are injected with a power-law with an index $p = 2.0$.

Chandra ACIS-S Data

Table 1: Parameters of the Best Fit Absorbed Power Law Model

Quasar	N_H(gal)	N_H^{abs}(z=0)	Γ	χ^2 (dof)
GB 1508+5714	1.4	4.43±0.93	1.58±0.05	138.246 (156)
PKS 0458-020	7.49	10.16±0.95	1.64±0.04	161.36 (156)

N_H(gal) was fixed. N_H^{abs}(z=0) is the additional equivalent column of Hydrogen at redshift 0. Γ indicates photons index. χ^2 assumes the Gehrels errors. 90% errors are shown for each parameter. We used CIAO 3.0 and *Sherpa* in all the data analysis. The quasars' spectra were extracted from the circular regions with 2 arcsec radius centered on the source centroid. The background spectra were extracted from the annulus centered on each source excluding the source region. The spectra were groupped to have minimum of 20 counts per channel. Then each spectrum was fit assuming 0.3-7 keV energy band and the absorbed power law. Table 1 shows the best fit parameters.

THE MODEL

We follow the radiation model described in Sikora et al. (2001). Because of the spectral similarities of GB 1508+5714 with the MeV-blazars, we assume that external radiation field is dominated by thermal radiation of the hot dust. On the other hand SED of the quasar PKS 0458-020 resembles the GeV-blazar, which motivates us to consider the BEL as the primary target for Comptonisation. In our modeling we self-consistently compute the following components for both sources: synchrotron radiation, SSC, ERC(IR) and ERC(BEL).

SUMMARY & CONCLUSIONS

- We successfully model the broadband spectra of both quasars with the parsec scale jet model;
- The main difference between two sources is related to the difference in the distance between the acceleration (shock) region from the central black hole and the source of the seed photons in Compton scattering process;
- GB 1508-5714 has the X-ray properties of MeV-Blazars, while PKS 0458-020 is a GeV-Blazar.

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