HIGH-ENERGY PROPERTIES OF PKS 1830–211

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ABSTRACT

We report an analysis of X-ray and γ-ray observations of PKS 1830–211, based on long-term campaigns carried out by INTEGRAL and COMPTEL. The INTEGRAL data currently available provide a 33 σ significance detection in the 20–100 keV band, while the COMPTEL 6 yr data provide a 5.2 σ significance detection in the 1–3 MeV energy band. In hard X-rays, INTEGRAL and supplementary Swift observations show flux variability on timescales of months. In γ-rays, the source shows persistent emission over years. The hard X-ray spectrum is well represented by a power-law model, with index Γ ∼ 1.3 in the 20–250 keV band. This photon index is consistent with a previous report of Γ ∼ 1.3 obtained at E > 3.5 keV from XMM-Newton data fitted with a broken power-law model. The joint XMM-Newton and INTEGRAL spectrum presented here is thus fitted with a broken power-law model; the parameters are refined as compared with the previous fits. The results show that the photon index changes from ∼1.0 to ∼1.3 at a break energy of ∼4 keV. At MeV energies, the spectrum softens to Γ ∼ 2.2. These results, together with an EGRET measurement at E ≥ 100 MeV, constitute a broadband spectrum containing the peak of the power output at MeV energies, similar to most high-luminosity γ-ray blazars. The measured spectral characteristics are discussed in the framework of gravitational lensing effects.

Subject heading: X-rays: individual (PKS 1830–211)

Online material: color figures

1. INTRODUCTION

Since the first gravitational lensing candidate was detected in 1979 (Walsh et al. 1979), the total number of such systems known has been growing (e.g., Schneider et al. 1992). Among them is the high-redshift blazar PKS 1830–211 (z = 2.507), gravitationally lensed by an intervening galaxy at z = 0.89. The discovery of this as a lensed system traces back to radio observations (Rao & Subrahmanyan 1988). The radio map showed two compact components separated by 1′, which are thought to be the split images from the central region of the source, and an extended structure that is most probably from a jet; the source is regarded as an unusually strong Einstein ring (see Jauncey et al. 1991; Nair et al. 1993). Steppe et al. (1993) have shown that PKS 1830–211 is radio-variable on timescales of months.

X-ray observations by Chandra and the International Gamma-Ray Astrophysics Laboratory (INTEGRAL) have revealed a quite hard spectrum, which has been modeled as a power law with photon index 1.09 ± 0.05 over the 0.5–80 keV energy band (De Rosa et al. 2005). The spectral flattening at low energies has often been modeled with absorption in excess of the Galactic column (N_H = 2.05 × 10^{21} cm^{-2}; Kalberla et al. 2005). The column density has been measured in soft X-rays by ROSAT (Mathur & Nair 1997) and ASCA (Oshima et al. 2001), as well as by Chandra (De Rosa et al. 2005), and the results suggest a column density of either ∼10^{22} cm^{-2} at the lensing galaxy (z = 0.86) or ∼10^{23} cm^{-2} intrinsic to the source. XMM-Newton observations yield similar results, but the best fit is obtained with a broken power-law model, with the photon index changing from ∼1.0 to ∼1.3 at energies around 3.5 keV (Foschini et al. 2006).

PKS 1830–211 was included in the first INTEGRAL catalog by Beckmann et al. (2006), with a photon index of 1.96^{+0.37}_{-0.24} in the 20–100 keV energy band, and in the INTEGRAL extragalactic survey by Bassani et al. (2006) with a 20–100 keV flux at the ∼3 mcrocrab level averaged over the first 2.5 yr of INTEGRAL observations. At MeV energies, PKS 1830–211 was first reported by Collmar (2006). The first 4 years of COMPTEL observations (1991–1995) revealed a 4.5 σ detection in the 1–3 MeV band. Contemporaneously, PKS 1830–211 was detected by EGRET at ≥100 MeV with 7.8 σ significance and a photon index of 2.59 ± 0.13 (Hartman et al. 1999).

Given that the amount of public INTEGRAL data has significantly increased since the last report, we decided to carry out a detailed analysis of PKS 1830–211 with all available INTEGRAL data. We also reanalyzed the XMM-Newton data with a newer software version, which allows us to extend the analysis down to 0.2 keV. The data from COMPTEL and EGRET were also reanalyzed and added in order to obtain the best broadband high-energy spectrum available to date.

Long-term observations by Swift in hard X-rays and by COMPTEL at MeV energies were used to investigate the flux variability. The results are discussed below in the context of a gravitational lensing system, as is appropriate to PKS 1830–211.

In the following, we assume H_0 = 73.4 km s^{-1} Mpc^{-1} and q_0 = 0, as measured from the latest Wilkinson Microwave Anisotropy Probe data (Spergel et al. 2007).

2. OBSERVATIONS AND DATA ANALYSIS

2.1. INTEGRAL

INTEGRAL is an ESA scientific mission dedicated to high-resolution spectroscopy (E/ΔE ≈ 500 with the SPI instrument; Vedrenne et al. 2003) and imaging (angular resolution 12′ FWHM,
point-source location accuracy $\approx 1'\sim 3'$, with IBIS; Ubertini et al. 2003) of celestial $\gamma$-ray sources in the energy range from 15 keV to 10 MeV, with simultaneous monitoring in X-rays (3–35 keV, angular resolution $3'$, with JEM-X; Lund et al. 2003) and optical wavelengths (Johnson $V$ filter, 550 nm with the OMC; Mas-Hesse et al. 2003). All the instruments on board INTEGRAL except the OMC work with coded masks. The observational data from the IBIS/ISGRI detector (20–250 keV; Lebrun et al. 2003) are considered in our analysis of PKS 1830–211, because of their very high quality.

The available INTEGRAL observations when PKS 1830–211 fell into the fully coded field of view of ISGRI (through 2006 April 29; see Table 1) comprise about 1095 science windows (SCWs), for a total exposure of 2500 ks; that is, about 550 ks of new data are analyzed here for the first time. Most of these observations were carried out in $5 \times 5$ dithering mode. The analysis was performed by using the INTEGRAL Offline Scientific Analysis (OSA) package, version 7.0, whose algorithms for IBIS are described by Goldwurm et al. (2003). All the sources within the field of view brighter than or comparable to PKS 1830–211 were taken into account in extracting the source spectrum and light curve. An additional 3% systematic error was added to the data products are therefore the source light curves and are publicly available.\footnote{See the Swift BAT Transient Monitor results provided by the Swift team at http://swift.gsfc.nasa.gov/docs/swift/results/transients.}

The imaging Compton telescope COMPTEL (1991–2000) on board the Compton Gamma Ray Observatory (CGRO) was sensitive to $\gamma$-rays in the 0.75–30 MeV energy range with an energy resolution of $\approx 10\%$. It had a large field of view and was able to detect $\gamma$-ray sources with an accuracy on the order of $1' \sim 2'$.\footnote{See the Swift BAT Transient Monitor results provided by the Swift team at http://swift.gsfc.nasa.gov/docs/swift/results/transients.}


table

| INTEGRAL Observation Log for PKS 1830–211 |
|-------------------------------------------|
| Resolution  | MJD  | Number of SCWs | Exposure (ks) |
| 50–65        | 52,710–52,757 | 138 | 250.9 |
| 105–122      | 52,875–52,927 | 247 | 585.1 |
| 164–186      | 53,052–53,119 | 108 | 205.9 |
| 225–249      | 53,234–53,305 | 161 | 388.3 |
| 286–310      | 53,417–53,488 | 97  | 192.1 |
| 348–371      | 53,602–53,672 | 209 | 609.1 |
| 407–432      | 53,777–53,854 | 135 | 266.1 |

Fig. 1.—ISGRI significance map of the PKS 1830–211 region in the 20–100 keV band, obtained by combining the observations from 2003 to 2006. [See the electronic edition of the Journal for a color version of this figure.]

2.3. Swift

Swift is a $\gamma$-ray burst explorer and was launched in 2004 November 20. It carries three co-aligned detectors (Gehrels et al. 2004), namely, the Burst Alert Telescope (BAT; Barthelmy et al. 2005), the X-Ray Telescope (XRT; Burrows et al. 2005), and the Ultraviolet/Optical Telescope (UVOT; Roming et al. 2005). BAT has rather a large field of view of 1.4 sr in partially coded mode and works in the 15–150 keV energy band. This makes it possible for a source to be monitored daily in hard X-rays. The data products are therefore the source light curves and are publicly available.\footnote{See the Swift BAT Transient Monitor results provided by the Swift team at http://swift.gsfc.nasa.gov/docs/swift/results/transients.}

The imaging Compton telescope COMPTEL (1991–2000) on board the Compton Gamma Ray Observatory (CGRO) was sensitive to $\gamma$-rays in the 0.75–30 MeV energy range with an energy resolution of $\approx 10\%$. It had a large field of view and was able to detect $\gamma$-ray sources with an accuracy on the order of $1' \sim 2'$. The BAT light curve traces PKS 1830–211 back to 2005 February 12 in the 15–50 keV energy band (see Fig. 2). This light curve has a weighted-average flux of $(4.56 \pm 0.48) \times 10^{-3}$ counts cm$^{-2}$ s$^{-1}$, corresponding to 2 mcrab, at $\sim 9.5 \sigma$ over a time period of roughly 2.5 yr.

2.4. COMPTEL

The imaging Compton telescope COMPTEL (1991–2000) on board the Compton Gamma Ray Observatory (CGRO) was sensitive to $\gamma$-rays in the 0.75–30 MeV energy range with an energy resolution of $\approx 10\%$. It had a large field of view and was able to detect $\gamma$-ray sources with an accuracy on the order of $1' \sim 2'$. The standard maximum likelihood imaging method was applied for the COMPTEL data analysis. The detection significance can be estimated from the quantity $-2 \ln \lambda$, where $\lambda$ is the ratio of the likelihood $L$ for the background and that for the source plus background. For a known source, $-2 \ln \lambda$ has a $\chi^2$ distribution with one free parameter in addition to the null hypothesis.
(χ²; de Boer et al. 1992). The point-spread function of the instrument is applied by assuming an E−2 power-law shape for the input spectrum. The background is derived, to first order of approximation, with a filter technique in data space (Bloemen et al. 1994).

PKS 1830–211 was marginally detected in the 1–3 MeV band at the 4.5 σ level, using the data from the first 4 yr (Collmar 2006). Here we take the complete 6 yr COMPTEL data set (see Table 4), up to the second reboost of the satellite in 1997, after which the background changed considerably, making it difficult for further research, to investigate again the MeV emission. These data are subdivided into so-called CGRO phases, with each period covering typically 1 yr of observations. The source is again detected mainly in the 1–3 MeV band, but the detection significance improves to 5.2 σ (−2 ln λ ∼ 27) by using data from an additional 2 yr. Figure 3 shows the sky map in the 1–3 MeV band. The source fluxes are given in Table 5, in four energy bands (0.75–1, 1–3, 3–10, and 10–30 MeV).

3. TIME VARIABILITY

The ISGRI light curve, on an SCW basis, shows no clear flux variability (see Fig. 4). A fit to this light curve with a constant results in χ² ∼ 0.72. To improve the statistics, data from each observational group (in total there are seven, separated by long observational gaps) were combined to produce alternative light curves, as also shown in Figure 4. The flux tends to drop smoothly during the first 2.5 yr from 2003 and then to rise in the following years. A search for flux variability on shorter timescales (4 day bins) resulted in two interesting episodes (see Fig. 5). In the first, the flux dropped by a factor of about 6 on a timescale of about 20 days, while in the second (this one has low significance), the flux changed by a factor of 2 on a timescale of 8 days. Such a flux excess, although weak, is indicated as well in the 20–40 and 40–100 keV energy bands. However, these events might be regarded only as hints of flux variability, and the statistics are not sufficient for a detailed investigation.

Swift’s BAT has provided daily light curves in the 15–50 keV energy band since 2005 February. However, the large error bars, mainly due to systematics, prevent us from inferring any trends in flux evolution. Therefore, the data were combined in 10 day bins; the resulting light curve shows three time intervals with a persistent flux excess (see Fig. 2). Accordingly, the observations were divided again into six parts, over which the weighted flux averages are shown in Figure 2 (bottom). This light curve suggests that PKS 1830–211 is rather variable in hard X-rays on a timescale of months.

The light curves from COMPTEL (1–3 MeV, time period 1991–1997) and EGRET (≥100 MeV, time period 1991–1995) are shown in Figure 6, with each bin presenting the average of one CGRO observing phase. These light curves indicate that PKS 1830–211 likely has persistent emission over a timescale of years at γ-ray energies.

4. BROADBAND ENERGY SPECTRUM

We performed a joint fit to the XMM-Newton and INTEGRAL data. The results are shown in Table 6 and Figure 7. The source luminosity in the 0.2–250 keV energy band is calculated to be 3.5 × 10^{48} erg s^{-1}. We note that the fit with a simple power-law model (Γ ∼ 1.12) resulted in a reduced χ² ∼ 1.13 with 1408 dof. Therefore, the broken power law model turns out again to be the best-fitting model, with an improvement over the single power law model of greater than 99.99% as calculated with the F-test.

At MeV energies, the spectrum can be well represented (χ² = 0.4 for 2 dof) by a single power law model with Γ = 2.23 ± 0.36, as measured from COMPTEL data combined from CGRO.
Fig. 2.—Swift light curves (15–50 keV), with bins representing timescales of 1 day (top), 10 days (middle), and an observational grouping (bottom). The observational groups are defined to have persistent emission excess as seen in the light curve from the middle panel.
| Viewing Period | Date       | MJD      | Target           | Offset Angle (deg) |
|---------------|------------|----------|------------------|--------------------|
| **CGRO Phase 1** |            |          |                  |                    |
| 5.0..         | 1991 Jul 12–26 | 48,449–48,463 | Galactic center  | 12                 |
| 7.5..         | 1991 Aug 15–22 | 48,483–48,490 | Gal. 025−14      | 15                 |
| 13.0..        | 1991 Oct 31–Nov 7 | 48,560–48,567 | Gal. 025−14      | 15                 |
| 16.0..        | 1991 Dec 12–27 | 48,602–48,617 | Sco X−1          | 29                 |
| 20.0..        | 1992 Feb 6–20 | 48,658–48,672 | SS 433           | 28                 |
| 27.0..        | 1992 Apr 28–May 7 | 48,740–48,749 | 4U 1543−47       | 41                 |
| 35.0..        | 1992 Aug 6–11 | 48,840–48,845 | ESO 141−55       | 41                 |
| 38.0..        | 1992 Aug 27–Sep 1 | 48,861–48,866 | ESO 141−55       | 41                 |
| 42.0..        | 1992 Oct 15–29 | 48,910–48,924 | PKS 2155−304     | 40                 |
| 43.0..        | 1992 Oct 29–Nov 3 | 48,924–48,929 | Mk 509           | 29                 |
| **CGRO Phase 2** |            |          |                  |                    |
| 209.0..       | 1992 Feb 9–22 | 49,027–49,040 | 2CG 010−31       | 30                 |
| 210.0..       | 1992 Feb 22–25 | 49,040–49,043 | Galactic center  | 20                 |
| 214.0..       | 1993 Mar 29–Apr 1 | 49,075–49,078 | Galactic center  | 20                 |
| 219.4..       | 1993 May 5–6 | 49,112–49,113 | Galactic center  | 31                 |
| 223.0..       | 1993 May 31–Jun 3 | 49,138–49,141 | Galactic center  | 14                 |
| 226.0..       | 1993 Jun 19–29 | 49,157–49,167 | Gal. 355+05      | 20                 |
| 231.0..       | 1993 Aug 3–10 | 49,202–49,209 | NGC 6814         | 12                 |
| 229.0..       | 1993 Aug 10–11 | 49,209–49,210 | Gal. 005+05      | 13                 |
| 232.0..       | 1993 Aug 24–26 | 49,223–49,225 | Gal. 348+00      | 25                 |
| 232.5..       | 1993 Aug 24–26 | 49,225–49,237 | Gal. 348+00      | 25                 |
| **CGRO Phase 3** |            |          |                  |                    |
| 302.3..       | 1993 Sep 9–21 | 49,239–49,251 | GX 1+4           | 18                 |
| 323.0..       | 1994 Mar 22–Apr 5 | 49,433–49,447 | Gal. 357–11      | 16                 |
| 324.0..       | 1994 Apr 19–26 | 49,461–49,468 | Gal. 015+05      | 12                 |
| 330.0..       | 1994 Jun 10–14 | 49,513–49,517 | Gal. 018+00      | 8                  |
| 332.0..       | 1994 Jun 18–Jul 5 | 49,521–49,538 | Gal. 018+00      | 8                  |
| 334.0..       | 1994 Jul 18–25 | 49,551–49,558 | Gal. 009–08      | 4                   |
| 336.5..       | 1994 Aug 4–9 | 49,568–49,573 | GRO J1655−40     | 33                 |
| 338.0..       | 1994 Aug 29–31 | 49,593–49,595 | GRO J1655−40     | 28                 |
| 339.0..       | 1994 Sep 20–Oct 4 | 49,615–49,629 | 3C 317           | 47                 |
| **CGRO Phase 4** |            |          |                  |                    |
| 414.3..       | 1995 Mar 29–Apr 4 | 49,805–49,811 | GRO J1655−40     | 26                 |
| 421.0..       | 1995 Jun 6–13 | 49,874–49,881 | Galactic center  | 18                 |
| 422.0..       | 1995 Jun 13–20 | 49,881–49,888 | Galactic center  | 18                 |
| 423.0..       | 1995 Jun 20–30 | 49,888–49,898 | Galactic center  | 11                 |
| 423.5..       | 1995 Jun 30–Jul 10 | 49,898–49,908 | PKS 1622−297     | 32                 |
| 429.0..       | 1995 Sep 20–27 | 49,980–49,987 | Gal. 018+04      | 11                 |
| **CGRO Phase 5** |            |          |                  |                    |
| 501.0..       | 1995 Oct 3–17 | 49,993–50,007 | Gal. 028+04      | 18                 |
| 508.0..       | 1995 Dec 14–20 | 50,065–50,071 | Gal. 005+00      | 9                  |
| 509.0..       | 1995 Dec 20–1996 Jan 2 | 50,071–50,084 | Gal. 021+14      | 21                 |
| 513.0..       | 1996 Feb 6–13 | 50,119–50,126 | PKS 2155−304     | 47                 |
| 516.1..       | 1996 Mar 18–21 | 50,160–50,163 | GRO J1655−40     | 33                 |
| 520.4..       | 1996 May 21–28 | 50,224–50,231 | PKS 2155−304     | 47                 |
| 524.0..       | 1996 Jul 9–23 | 50,273–50,287 | GX 339−4         | 29                 |
| 529.5..       | 1996 Aug 27–Sep 6 | 50,322–50,332 | GRO J1655−40     | 28                 |
| **CGRO Phase 6** |            |          |                  |                    |
| 624.1..       | 1997 Feb 4–11 | 50,483–50,490 | Gal. 016+00      | 10                 |
| 619.2..       | 1997 May 14–20 | 50,582–50,588 | GRS 1915+105     | 35                 |
| 620.0..       | 1997 Jun 10–17 | 50,609–50,616 | Gal. 016+04      | 10                 |
| 625.0..       | 1997 Aug 5–19 | 50,665–50,679 | GRS 1758–258     | 13                 |
| 615.1..       | 1997 Aug 19–26 | 50,679–50,686 | PKS 1622−297     | 30                 |
In such a broadband view, the power output of PKS 1830–211 shows a bump located at MeV energies, as expected within the common view of high-luminosity blazars, in which the high-energy part of the spectral energy distribution (SED) is due to inverse Compton emission from relativistic electrons in a jet scattering seed photons from a source external to the jet (broad-line region, accretion disk, etc.; see Fossati et al. 1998; Ghisellini et al. 1998; Maraschi et al. 2008).

5. DISCUSSION AND SUMMARY

The most interesting feature in the broadband high-energy spectrum of PKS 1830–211 is the spectral flattening below ~4 keV. Such a feature has also been observed by De Rosa et al. (2005) in the combined Chandra + INTEGRAL spectrum, but the best-fit model proposed there is a single power law with $\Gamma = 1.09 \pm 0.05$ extending over the entire 0.5–80 keV band, absorbed by cold gas from the intervening galaxy at $z = 0.89$, with column density $N_H \sim 2 \times 10^{22}$ cm$^{-2}$. Instead, in this work, by analyzing a spectrum covering a wider energy range (0.2–250 keV), we have provided evidence of a photon deficit at low energies in addition to the absorption from the intervening galaxy, confirming and extending the results obtained with XMM-Newton alone (0.4–10 keV) reported by Foschini et al. (2006). This low-energy photon deficit can be best fitted with a power law that is harder ($\Gamma \sim 1.0$) than the one at energies greater than ~4 keV ($\Gamma \sim 1.3$).

Such a low-energy photon deficit has often been observed in high-redshift flat-spectrum radio quasars (Fiore et al. 1998; Worsley et al. 2004). According to Fiore et al. (1998), the photospheric absorption intrinsic to the quasar is likely to be the origin of these low-energy roll-offs. However, in the case of PKS 1830–211, the tests performed to fit the low-energy data with an ionized absorber gave the worst results (§ 2.2). A broken power law is statistically required, and this suggests that the spectral break is likely due to intrinsic curvature of the spectrum near the low-energy end of the external Compton (EC) component, while the relative importance of the synchrotron self-Compton (SSC) component likely decreases as a result of the increasing importance of the external (broad-line region, accretion disk, other) radiation field (Tavecchio et al. 2007; Ghisellini et al. 2007).

However, in the case of PKS 1830–211 the gravitational lensing should have an impact on the spectral and variability properties of the source, but it is not clear how to weigh this at high energies. Such effects in the $\gamma$-ray band on distant blazars have been discussed by Combi & Romero (1998) and Torres et al. (2002, 2003). The observed hard X-rays, and probably the soft X-rays as well, are a combination of the contributions from SSC and EC, which in turn are generated in different places. Therefore, the lensing can act differently, resulting in changes in spectral shape.

We can further probe the possible shapes of the intrinsic spectrum and the amplification factor corresponding to different parts of the energy spectrum of PKS 1830–211. We assume that, apart from the absorption components in Table 6 due to the Galactic column and the intervening system, the spectral break and rolloff at low energies are caused by a difference in amplification factor. Therefore, we take as the intrinsic spectrum of PKS 1830–211 a power law with $\Gamma \sim 1.3$ from ~4.3 to 250 keV. We extend this value to low energies, calculate the flux in the 0.2–4.3 keV energy band, and compare with the observed one. The ratio of amplification factors at energies below and above 4.3 keV is estimated to be about 0.8. This value appears to be too low, as it is expected that the amplification factor should increase with energy and, so far, the available modeling of the magnification factor from radio/optical observations has yielded values in the range 2–4 (Nair et al. 1993; Swift et al. 2001; Courbin et al. 2002).

A time variability analysis could offer another way to try to estimate the impact of the gravitational lensing. PKS 1830–211 is known to be radio-variable on timescales of months (Steppe et al. 1993). Other estimates of the timescales are 44 ± 9 days (van Ommen et al. 1995) and 24 ± 2 days (Lovell et al. 1998). In the modeling of PKS 1830–211 by Subrahmanyan et al. (1990), the time lag between the two main components (northeast and southwest) is expressed as $\sim 6(z_g/0.1)(2h)^{-1}$ days, where $z_g$ is the redshift of the lensing galaxy and $h$ is the Hubble constant in units of 100 km s$^{-1}$ Mpc$^{-1}$. By setting the redshift of the lensing
Fig. 4.—ISGRI light curves in the 20–100 keV band, on basis of SCWs (top) and observational groupings (bottom), for the time period from 2003 to 2006.

Fig. 5.—Top, two high-variability episodes detected by ISGRI in the 20–100 keV energy band, with each bin representing 4 days; bottom, the corresponding background light curves.
galaxy to \( z = 0.89 \) and \( h/C_2 = 75 \) km s\(^{-1}\) Mpc\(^{-1}\), we have a time lag of about 71 days. Therefore, the lag between the two core components might lie in the range 24–70 days.

The hard X-ray variability displayed in the light curves from ISGRI in the 20–100 keV band and BAT in the 15–50 keV band is quite beyond this range. The source flux can vary by a factor of 2 on timescales of months to a year, and the relatively poor statistics prevent us from establishing convincing evidence of flux variability on shorter timescales. The observed variability might be the result of evolution of either the relativistic jet plasma or the inverse Compton–scattered soft target photons. It might

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\begin{array}{l}
\text{Fig. 6.—COMPTEL (top) and EGRET (bottom) light curves, with each bin averaged over one CGRO phase. The error bars are 1 } \sigma. \\
\end{array}
\]

galaxy to \( z = 0.89 \) and \( h \sim 75 \) km s\(^{-1}\) Mpc\(^{-1}\), we have a time lag of about 71 days. Therefore, the lag between the two core components might lie in the range 24–70 days.

The hard X-ray variability displayed in the light curves from ISGRI in the 20–100 keV band and BAT in the 15–50 keV band is quite beyond this range. The source flux can vary by a factor

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\begin{array}{l}
\text{Fig. 7.—Spectral fit with a broken power law model for the combined XMM-Newton data (below 10 keV) and ISGRI data (above 20 keV). For better illustration, the XMM-Newton spectra have been rebinned in the plot. [See the electronic edition of the Journal for a color version of this figure.]}
\end{array}
\]

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\begin{array}{l}
\text{Fig. 8.—Broadband energy spectrum of PKS 1830–211. The solid lines represent the broken power law shape obtained from XMM-Newton and INTEGRAL in X-rays, the power-law shape from COMPTEL at MeV energies, and EGRET at } \geq 100 \text{ MeV (Hartman et al. 1999). The dashed lines are the 1 } \sigma \text{ errors in the spectral shape.}
\end{array}
\]

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\begin{array}{l}
\text{TABLE 6} \\
\text{RESULTS OF FITTING THE JOINT XMM-NEWTON AND INTEGRAL DATA (0.2–250 keV) WITH A BROKEN POWER LAW PLUS TWO ABSORPTION COMPONENTS}
\end{array}
\]

| Parameter | Value |
|-----------|-------|
| \( w_{abs} \): | \( N_{H} = 0.205 \) (fixed) |
| \( zw_{abs} \): | \( N_{H} = 1.96 \pm 0.09 \) |
| \( z \): | \( z = 0.886 \) (fixed) |
| \( bknpow \): | \( \Gamma_1 = 0.93^{+0.04}_{-0.03} \) |
| \( E_{break} \): | \( 3.63^{+0.29}_{-0.28} \) |
| \( \Gamma_2 \): | \( 1.29 \pm 0.04 \) |
| \( N \): | \( 1.05 \pm 0.04 \) |
| \( \chi^2/\text{dof} \): | \( 1.04/1406 \) |

\[
\begin{array}{l}
\text{Notes.—Absorption columns are in units of } 10^{22} \text{ cm}^{-2}, \text{ the break energy is in keV, and the normalization } N \text{ is in } 10^{-1} \text{ counts cm}^{-2} \text{ s}^{-1} \text{ keV}^{-1}. \text{ The intercalibration constant between EPIC-pn and ISGRI is ISGRI: pn } = 0.63 \pm 0.07.
\end{array}
\]
be that, given a steady jet plasma, the density of the soft target photons evolves over months to a year, causing the long-term variability that shows up in hard X-rays. De Rosa et al. (2005) reproduced the SED of PKS 1830–211 with an SSC+EC model in which the EC component was dominated by the photon field from the torus. This scenario could fit in with the observed hard X-ray variability on a yearlong timescale, if this variability is attributable to the evolution of the target photons’ density. However, we would point out that the SED built by De Rosa et al. (2005) was corrected at high energies by the amplification factor due to the gravitational lensing, which in turn is affected by large uncertainties, as we have already emphasized. One of the main effects of the amplification is to change the luminosity of the seed photon source, and therefore the conclusions of De Rosa et al. could be severely biased by the not fully justified assumption of the amplification correction. Measurement of a time lag at hard X-ray energies in the future may help to resolve the contribution, if any, of the core region to the jet-dominated emission.

One indicator might be that, as already pointed out by De Rosa et al. (2005), PKS 1830–211 is not the only blazar to have persistent MeV emissions, which are always detectable by COMPTEL. The other two COMPTEL blazars with MeV emission visible over years are 3C 273 (Collmar et al. 2000) and 3C 354.3 (Zhang et al. 2005). Such long-term, steady MeV emission has been discussed in Zhang et al. (2005) for 3C 454.3 in the framework of lepton multicomponent models in which the MeV emission might be dominated by EC of seed photons coming directly from the accretion disk. The bulk Lorentz factor in this case is argued to remain at a relatively high level to keep the MeV emission visible over a timescale of years. In the case of PKS 1830–211, the bulk Lorentz factor has been estimated to be about 17 by Foschini et al. (2006), where—given the uncertainties regarding lensing at high energies—the modeling of the SED was performed on the observed data without any correction.

In summary, we present here the most up-to-date broadband high-energy spectrum of PKS 1830–211. The source exhibits a low-energy roll-off that can be explained efficiently in terms of a natural interplay between SSC and EC, as seen in other high-z flat-spectrum radio quasars. However, the weight of the amplification factor due to the gravitational lensing is not clear. Future observations at X-ray energies with higher spatial resolution should allow us to assess this factor.

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