

Fast variability of γ -ray emission from supermassive black hole binary OJ 287

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Accepted 2010 November 8. Received 2010 November 4; in original form 2010 January 14

ABSTRACT

We report the discovery of fast variability of γ -ray flares from blazar OJ 287. This blazar is known to be powered by a binary system of supermassive black holes. The observed variability time-scale $T_{\text{var}} \lesssim 3\text{--}10$ h is much shorter than the light-crossing time of the more massive ($1.8 \times 10^{10} M_{\odot}$) black hole and is comparable to the light-crossing time of the less massive ($1.3 \times 10^8 M_{\odot}$) black hole. This indicates that γ -ray emission is produced by the relativistic jet ejected by the black hole of smaller mass. Detection of γ -rays with energies in excess of 10 GeV during the fast variable flares constrains the Doppler factor of the jet to be larger than 4. The possibility of studying the orbital modulation of emission from the relativistic jet makes OJ 287 a unique laboratory for the study of the mechanism(s) of formation of jets by black holes, and in particular the response of the jet parameters to changes in the parameters of the medium from which the black hole accretes and into which the jet expands.

Key words: black hole physics – radiation mechanisms: non-thermal – BL Lacertae objects: individual: OJ 287 – galaxies: nuclei – gamma-rays: general.

1 INTRODUCTION

Although large-scale jets ejected by active galactic nuclei (AGN) were discovered almost a century ago, the origin of this phenomenon has remained obscure up to the present day (see Harris & Krawczynski 2006 for a recent review). It might be that the jets are accelerated via the magneto-centrifugal force along twisted magnetic field lines above the accretion disc around the black hole (Blandford & Payne 1982). Otherwise, an outflow could be created via the Blandford–Znajek mechanism of electromagnetic power extraction from a rotating black hole, similarly to the mechanism responsible for the generation of relativistic pulsar winds (Blandford & Znajek 1977).

Blazar OJ 287 ($z = 0.306$, Stickel, Fried & Kuehr 1989) provides a unique laboratory for the study of the mechanisms of AGN activity, because this is one of the few AGN known to host a binary black hole system (Lehto & Valtonen 1996; Valtonen et al. 2009). In this system, a lighter black hole of mass $M_{\text{BH1}} \simeq 1.3 \times 10^8 M_{\odot}$ orbits a heavier black hole of mass $M_{\text{BH2}} \simeq 1.8 \times 10^{10} M_{\odot}$ with a period $P_{\text{orb}} \simeq 11.65$ yr (Valtonen et al. 2009; Sillanpää et al. 1988). Separation of the components of the system at periastron is just about 10 Schwarzschild radii of the heavier black hole, so that the orbital motion is strongly affected by relativistic gravity effects (Valtonen et al. 2008).

OJ 287 is known to belong to the BL Lac subclass of AGN, which means that it emits a relativistic jet with direction aligned

with the line of sight. It is not clear a priori which of the black holes ejects the observed relativistic jet. Following a naive argument, which does not take into account the relativistic beaming of the jet emission, one would assume that the observed relativistic jet is the one ejected by the heavier black hole, simply because the bigger black hole accretes more matter and, therefore, could produce a more powerful jet. Most of the existing studies of multiwavelength blazar activity of OJ 287 adopt this assumption (see e.g. Valtonen et al. 2009). However, relativistic jets in BL Lacs are known to have Doppler factors $\delta \gg 1$. This results in a boosting of the apparent luminosity of the jets by a factor δ^4 when the jets are viewed face-on. Thus, if the less powerful jet emitted by the smaller black hole is aligned with the line of sight while the jet from the larger black hole is not, the jet from the smaller black hole might give a dominant contribution to the source flux.

In what follows we show that the variability properties of γ -ray emission from the source indicate that the relativistically beamed emission comes from the jet produced by the smaller black hole. Independently of the value of the Doppler factor of the jet δ , the shortest observed variability time-scale ΔT_{min} imposes a constraint on the size of the jet's 'central engine', $R_{\text{CE}} \lesssim c\Delta T$ (Celotti, Fabian & Rees 1998; Neronov, Semikoz & Sibiryakov 2008a). In the case of OJ 287, R_{CE} turns out to be much smaller than the Schwarzschild radius of the more massive black hole, but compatible with the size of the smaller mass black hole.

Observation of γ -ray emission from the base of the jet of the smaller black hole in the system makes OJ 287 a unique laboratory for the study of mechanisms of jet production. Regular orbital modulation of the physical parameters of the ambient medium around

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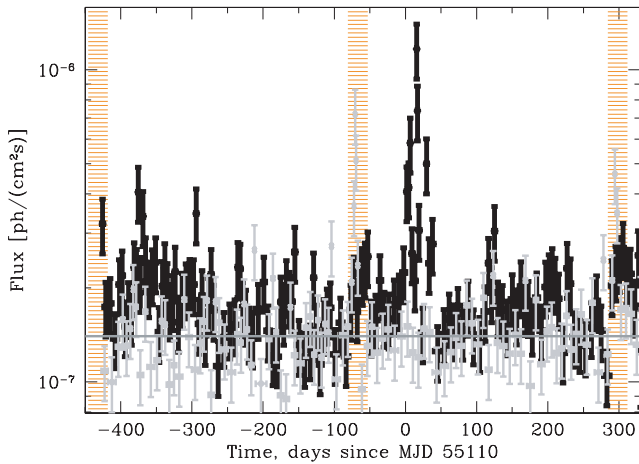


Figure 1. 2008 August–2010 January light curve of OJ 287 (black) and background region (grey). Hatched bands (orange in the online article) mark periods of passage of the Sun through the observation region.

the $1.3 \times 10^8 M_{\odot}$ black hole provides a unique possibility for studying the response of the jet to changes in the properties of the accretion flow and the external medium in which the jet propagates. In this respect, the OJ 287 system provides a scaled-up analogue of Galactic γ -ray-loud binaries, in which orbital modulation of γ -ray emission enables the study of the response of a relativistic outflow from a compact object (a neutron star or a black hole) to changes in the properties of the external medium (stellar wind and radiation field of the companion star) (see e.g. Zdziarski, Neronov & Cheryakova 2010).

2 FERMI OBSERVATIONS

In order to study the variability of the γ -ray signal during flaring activity, we have processed publicly available data from the Large Area Telescope (LAT) instrument, using the *Fermi* Science Tools provided by the *Fermi* Science Support Centre. The data were selected using the *GTSELECT* tool. The light curves were produced with the help of *GTBIN* and *GTEXPOSURE* tools, as is explained in the *Fermi* data Analysis Threads.¹

Fig. 1 shows the long-term light curve of the source at energies above 0.1 GeV over the period 2008 August–2010 September binned to achieve a signal-to-noise ratio $S/N = 5$ per time bin. Photons were collected from a circle 2° in radius and centred on OJ 287. The flaring activity period, which started on 2009 October 5, could be readily identified. The detailed light curve of the flaring period shown in Fig. 2 reveals several well-separated flares. The brightest flare, which happened on 2009 October 22, was reported by Ciprini et al. (2009). Follow-up observations of the October 22 flare by *Swift*/XRT have revealed an increase of the X-ray flux accompanying the γ -ray flare (D’Ammando et al. 2009).

The direction toward OJ 287 is situated close to the plane of the ecliptic. The light curve of the source could be affected by the passage of the Sun through the field of view of the telescope. The periods of the Sun’s passage within the region of radius 15° centred on OJ 287 (the sky region chosen for the analysis) are shown by the hatched strips in Fig. 1 (orange in the online article). The possible effect of the Sun’s passage on the source light curve is most clearly seen in the light curve collected from the region of radius 2°

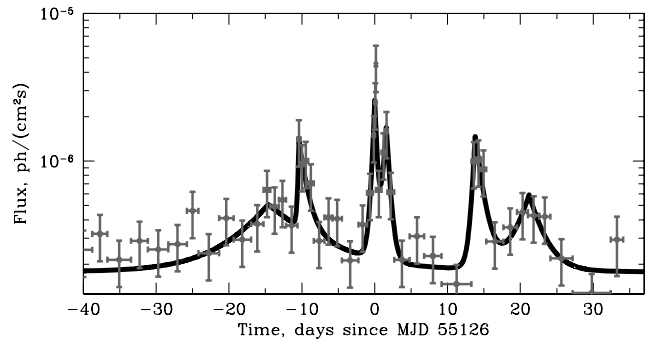


Figure 2. Light curve of the 2009 October–November flare of OJ 287 in the $E > 0.1$ GeV energy band, binned in time bins with S/N ratio equal to 3. The black curve shows the model fit to the light curve (equation 1) with the parameters given in Table 1.

displaced by $\sim 5^{\circ}$ from the position of OJ 287 to the position RA = 127.11, Dec. = 19.89. No source is detected at this position, so the light curve collected from this region (shown by grey data points in Fig. 1) could be considered as a measure of the diffuse background level close to the position of OJ 287. One might notice a flare in the background light curve associated with the Sun’s passage close to the background extraction region. The effect of the Sun’s passage on the light curve of OJ 287 is less pronounced (see Fig. 1), because the source is situated higher above the ecliptic plane compared with the background region.

Analysis of the images of the γ -ray sky around OJ 287 show that, apart from OJ 287, the region of radius 15° centred on OJ 287 contains several other sources (most clearly visible in the 1–300 GeV band image in panel c of Fig. 3). However, these sources are rather weak, so that they are not detected on the one-month exposure time-scale corresponding to the duration of the flaring activity of OJ 287 (see the right panel of Fig. 3). The absence of strong sources near

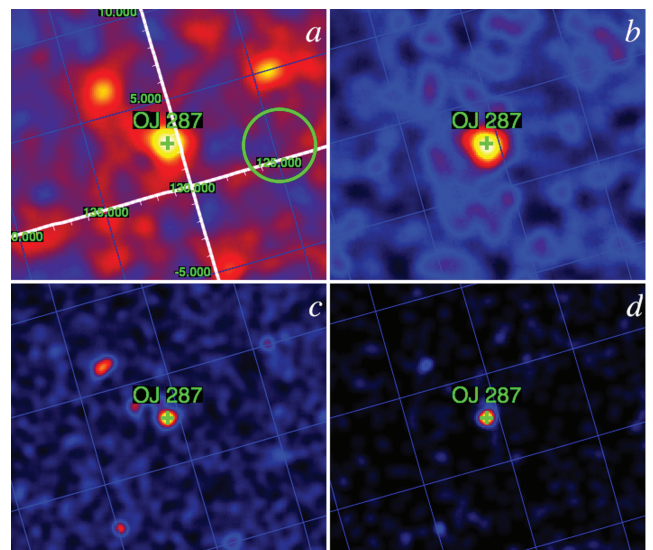


Figure 3. Images of the sky region around OJ 287. Panels (a) and (c) show 0.3–1 GeV and 1–300 GeV band images for the entire observation period. Panels (b) and (d) show 0.3–1 GeV and 1–300 GeV band images during the flaring activity of OJ 287. The coordinate grid shows ecliptic coordinates. The circle (green in the online article) shows the region from which the background light curve was extracted. Images in the 0.3–1 GeV band are smoothed with a Gaussian of width 1° . Images in the 1–300 GeV band are smoothed with a Gaussian with 0.5° width.

¹ <http://fermi.gsfc.nasa.gov/ssc/data/analysis/scitools/>

Table 1. Parameters of the model fit (see equation 1) to the light curve of the γ -ray flare of OJ 287, together with their 68 per cent confidence ranges.

| k | t_k (d) | t_{rk} (d) | t_{dk} (d) | A_k ($\times 10^{-6} \text{ cm}^{-2} \text{ s}^{-1}$) |
|---|-------------------------|------------------------|------------------------|--|
| 1 | 1.4 ± 0.5 | $5.0^{+10.0}_{-2.5}$ | $7.0^{+4.0}_{-3.5}$ | $0.33^{+0.07}_{-0.08}$ |
| 2 | $5.6^{+0.2}_{-0.3}$ | $0.15^{+0.37}_{-0.14}$ | $1.0^{+0.6}_{-0.4}$ | $1.0^{+0.4}_{-0.3}$ |
| 3 | $16.02^{+0.05}_{-0.07}$ | $0.33^{+0.19}_{-0.09}$ | $0.30^{+0.15}_{-0.1}$ | $2.3^{+0.6}_{-0.6}$ |
| 4 | $17.6^{+0.18}_{-0.15}$ | $0.5^{+0.4}_{-0.25}$ | $0.46^{+0.25}_{-0.18}$ | $1.5^{+0.5}_{-0.5}$ |
| 5 | $29.8^{+0.4}_{-0.3}$ | $0.4^{+0.3}_{-0.23}$ | $1.0^{+0.5}_{-0.4}$ | $1.3^{+0.3}_{-0.3}$ |
| 6 | $37.2^{+1.3}_{-1.0}$ | $2.0^{+1.8}_{-1.0}$ | $1.9^{+0.9}_{-2.2}$ | $0.41^{+0.14}_{-0.12}$ |

OJ 287 ensures that the observed variability of the signal from the source during the flaring period is not affected by possible variable emission from a nearby source, for which the tail of the point-spread function overlaps with that of OJ 287.

The $E > 0.1$ GeV light curve of the flare consists of several well-separated pulses with a rather sharp rise and decay. To find the rise and decay times we have fitted the light curve with a phenomenological model of the sum of exponentially rising and decaying pulses:

$$F(t) = B + \sum_{k=1}^3 \begin{cases} A_k \exp[(t - t_k)/t_{rk}], & t < t_k, \\ A_k \exp[-(t - t_k)/t_{dk}], & t > t_k, \end{cases} \quad (1)$$

where $B = \text{constant}$ is the background level. The background level was found from the circle of radius 2° displaced by 5° from the source position. Parameters of the model function (1), derived from the fitting, are given in Table 1.

One can see from Fig. 2 and Table 1 that brightest flares are characterized by rather sharp rises and decays, with rise/decay times of several hours. At this time-scale, measurement of the rise/decay times of the flares is complicated by the fact that the *Fermi*/LAT telescope observes a given patch of the sky once in 3.2 h (once per two rotation periods of $\simeq 96$ min). This is clear from Fig. 4, in which the light curve for a time interval of several hours around the brightest flare from the source is shown in more detail. The upper panel of the figure shows the $E \geq 0.1$ GeV light curve of the source. The lower panel shows the energies of photons collected from the circle of radius 2° centred on the source (black points) and photons collected from a background extraction circle of the same radius displaced by 5° from the source position. Photons from the source and background regions arrive only within periodic time intervals spaced by 3.2 h, marked by vertical grey strips in the two panels of the figure. It is clear that the *Fermi*/LAT pointing pattern does not allow us to constrain the rise/decay time of the flares to better than 3.2 h. The apparently abrupt end of the flare (12 photons from the source are detected between $t = \text{MJD } 55126.0 + 3 \text{ h}$ and $t = \text{MJD } 55126.0 + 4 \text{ h}$, while no photon is detected within the subsequent observation period $\text{MJD } 55126.0 + 6.2 \text{ h} < t < \text{MJD } 55126.0 + 7.2 \text{ h}$) limits the decay time of the flare to be less than 3.2 h. Assuming that the source flux did not change in the time interval following the peak of the flare, one could estimate the chance probability of detecting zero photons in this time bin to be 7×10^{-4} , taking into account the exposures in the two adjacent time intervals with maximal and zero count rates, $3.3 \times 10^6 \text{ cm}^2 \text{ s}$ and $2 \times 10^6 \text{ cm}^2 \text{ s}$, respectively.

To summarize, both fitting of the light-curve profile with a phenomenological exponential rise/exponential decay model and direct photon counting in individual 1-h *Fermi* exposures indicate that the flux from the source is significantly variable on time-scales shorter than or comparable to 3–10 h. This fact has important impli-

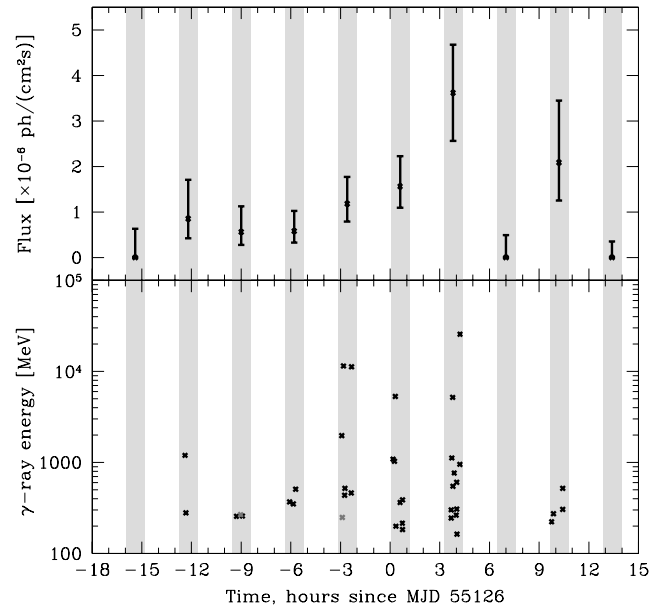


Figure 4. Upper panel: light curve of the brightest episode of the 2009 October–November flare of OJ 287 in the $E > 0.1$ GeV energy band. Lower panel: energies and arrival times of γ -rays from the source (black points) and from the background region (grey points). Vertical grey strips show the periods during which the source was in the field of view of the LAT.

cations for the physical model of the origin of γ -ray emission from the OJ 287 system.

3 ORIGIN OF THE RELATIVISTIC JET IN OJ 287

The constraint on the variability time-scale of the γ -ray flares $T_{\text{var}} = \min(t_{rk}, t_{dk}) \leq 3.2 \text{ h}$ derived above enables us to identify the γ -ray emission site within the binary black hole system of OJ 287.

It is commonly accepted that γ -ray-emitting jets are generated by the AGN ‘central engines’, supermassive black holes, on distance scales of the order of the gravitational radius of a supermassive black hole:

$$R_g = \frac{G_N M_{\text{BH}}}{c^2} = 2 \times 10^{11} \left[\frac{M_{\text{BH}}}{1.3 \times 10^8 M_\odot} \right] \text{ cm}, \quad (2)$$

where M_{BH} is the black hole mass. The minimal variability time-scale of electromagnetic emission originating from the AGN central engine is expected to be no shorter than the light-crossing time of the supermassive black hole,

$$T_{\text{lc}} = (1 + z)2R_{\text{BH}}/c = 2(1 + z) \left(R_g + \sqrt{R_g^2 - a^2} \right) / c \simeq \begin{cases} 0.5 [M_{\text{BH}}/1.3 \times 10^8 M_\odot] \text{ h}, & a = R_g, \\ 0.9 [M_{\text{BH}}/1.3 \times 10^8 M_\odot] \text{ h}, & a = 0, \end{cases} \quad (3)$$

where R_{BH} is the size of the black-hole horizon and $0 < a < R_g$ is the black-hole rotation moment per unit mass. Variability of the X-ray emission at a time-scale $T \sim T_{\text{lc}}$ is observed in X-ray emission from Galactic sources powered by black holes with masses $M_{\text{BH}} \sim 10 M_\odot$ (Remillard & McClintock 2006). Variability at a time-scale $T_{\text{var}} \sim T_{\text{lc}}$ is also observed in γ -ray emission from blazars, a special type of AGN with jets aligned along the line of sight (Aharonian et al. 2006, 2007; Gaidos 1996; Albert et al. 2007; Neronov & Aharonian 2007; Neronov et al. 2008a).

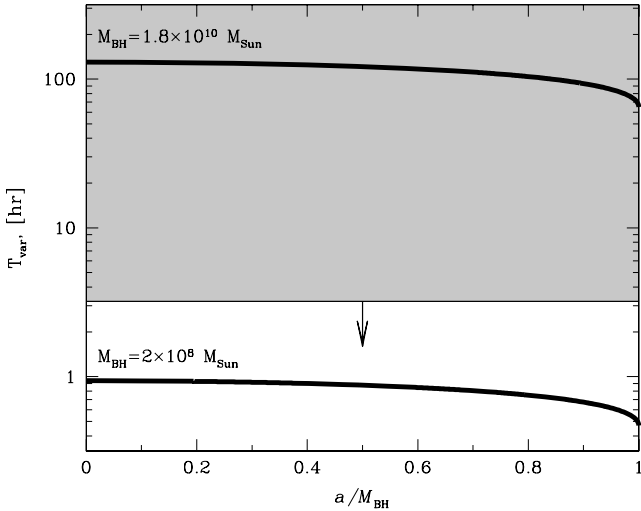


Figure 5. Comparison of the upper bound on the variability time-scale of OJ 287 flares (grey shaded region) with the light-crossing times of the two supermassive black holes in the system.

Fig. 5 shows a comparison of the upper limit $T_{\text{var}} \leq 3.2$ h on the variability time-scale of the flares from OJ 287 with the light-crossing time of the two supermassive black holes in the OJ 287 system. One can see that the upper bound is much lower than the light-crossing time of the more massive black hole with $M_{\text{BH}} \simeq 1.8 \times 10^{10} M_{\odot}$, independently of the black-hole rotation moment a . At the same time, the limit on the variability time-scale is larger than the light-crossing time of the smaller black hole. This implies that the observed γ -ray emission is generated by the jet emitted by the lower mass companion black hole in the system.

Note that the above result does not depend on the assumptions about relativistic motion of the γ -ray emission region. Indeed, the minimal possible time-scale ΔT_{min} of emission from a relativistic jet moving with bulk Lorentz factor Γ does not depend on Γ and is instead determined by the size of the non-moving ‘central engine’ that ejected the jet (Celotti et al. 1998; Neronov et al. 2008a; Neronov, Semikoz & Sibiryakov 2008b). In the jet comoving frame, the minimal variability time-scale $\Delta T'_{\text{min}} \sim \Gamma \Delta T_{\text{min}}$ is the light-crossing time of the smallest size γ -ray emitting ‘blobs’, $\Delta T'_{\text{min}} \sim R'_{\text{min}}/c$. γ -ray emitting blobs that were ejected by the jet’s ‘central engine’ of size R_{CE} could not have a size smaller than $R'_{\text{min}} \geq R_{\text{CE}}\Gamma$ in the comoving frame. This implies that $\Delta T_{\text{min}} \sim \Delta T'_{\text{min}}/\Gamma \sim R'_{\text{min}}/c\Gamma \geq R_{\text{CE}}/c$, independently of Γ .

At first sight, such a conclusion looks counterintuitive. Indeed, since the two black holes accrete matter from the same reservoir, the accretion rate on to the more massive black hole should be much higher. In general, a higher accretion rate should lead to production of a more powerful jet.

However, the above argument does not take into account possible relativistic beaming effects, which are normally very significant in BL Lacs. The γ -ray flux from a relativistically beamed jet moving with bulk Lorentz factor Γ at an angle θ with respect to the line of sight is boosted by a factor δ^4 , where $\delta = [\Gamma(1 - \beta \cos \theta)]^{-1}$ is the Doppler factor and β is the bulk velocity of the jet. A constraint on the bulk Lorentz factor of the jet produced by the $M_{\text{BH}} \simeq 1.3 \times 10^8 M_{\odot}$ black hole could be found under the assumption that the observed X-ray emission from the system (Seta et al. 2009) originates from the same jet region as the GeV emission.

The highest energy of γ -ray photons coming from the source is $E_{\gamma, \text{max}} \geq 30$ GeV (see Fig. 4). γ -rays of such energies can produce

e^+e^- pairs in interactions with X-ray photons of energies

$$E_X \geq \frac{\Gamma^2 m_e^2 c^4}{(1+z)^2 E_\gamma} \simeq 0.5 \left[\frac{\Gamma}{4} \right]^2 \left[\frac{E_{\gamma, \text{max}}}{30 \text{ GeV}} \right]^{-1} \text{ keV}, \quad (4)$$

where we have assumed that typical collision angles for photons emitted from the jet are $\alpha \simeq \Gamma^{-1}$. The apparent (relativistically beamed) luminosity of OJ 287 in the soft X-ray band is $L_{\text{app}} \simeq 3 \times 10^{44} \text{ erg s}^{-1}$, which corresponds to the observed flux $F_X \simeq 10^{-12} \text{ erg cm}^{-2} \text{ s}$ (Seta et al. 2009). Calculating the optical depth of a γ -ray emission region of comoving size $R' \simeq \delta c T_{\text{var}}/(1+z)$ and luminosity $L' \simeq \delta^{-4} (1+z)^2 L_X$, one finds

$$\tau_{\gamma\gamma} \simeq 0.5 \left[\frac{\delta}{4} \right]^{-6} \left[\frac{L_X}{10^{44} \text{ erg s}^{-1}} \right] \left[\frac{T_{\text{var}}}{3.2 \text{ h}} \right]^{-1}. \quad (5)$$

High energy γ -rays could escape from the source if $\tau_{\gamma\gamma} < 1$. This condition imposes a restriction on the Doppler factor $\delta \gtrsim 4$.

Thus, the observed γ -ray flux from the jet is Doppler-boosted by at least a factor $\delta^4 \gtrsim 3 \times 10^2$. It is interesting to note that even if emission from the higher mass black hole is not relativistically beamed toward an observer on Earth, it might be noticed in the spectrum of the source. Indeed, assuming a simple Eddington-like scaling of the accretion rate and jet luminosity with the black hole mass, $L_i \sim M_{\text{BH}i}$, one finds that the relativistically beamed luminosity of the jet from the lighter black hole $L \sim \delta^4 L_1 \geq 10^2 L_1$ could, in fact, be comparable to the overall luminosity of the heavier black hole, $L_2 \sim (M_{\text{BH}2}/M_{\text{BH}1}) L_1 \simeq 1.4 \times 10^2 L_1$. Fast variability of emission could therefore serve as a tool for identification of the contribution of emission from the lighter black hole to the overall source spectrum.

A common feature of all models of jet production by black holes is that matter ejection into the jet is associated with rotation of matter around the black hole and/or with rotation of the black hole (Blandford & Znajek 1977; Blandford & Payne 1982). This implies that the characteristic time-scale at which the properties of the jet could change is given by the period of rotation of the black hole itself or of the accretion flow on to the black hole. The period of rotation around a circular orbit at a distance r from the black hole is given by (Bardeen, Press & Teukolsky 1972)

$$P(r) = 2\pi(1+z) \frac{r^{3/2} \pm a R_g^{1/2}}{c R_g^{1/2}}. \quad (6)$$

The + (−) sign corresponds to the prograde (retrograde) orbit. Stable circular orbits exist only down to a certain distance r_{ms} from the BH. The period of rotation along the last prograde stable orbit at distance r_{ms} is

$$P(r_{\text{ms}}) \simeq \begin{cases} 3 \left[\frac{M_{\text{BH}}}{1.3 \times 10^8 M_{\odot}} \right] \text{ h}, & a = R_g, \\ 22 \left[\frac{M_{\text{BH}}}{1.3 \times 10^8 M_{\odot}} \right] \text{ h}, & a = 0. \end{cases} \quad (7)$$

The upper bound on the variability time-scale $T_{\text{var}} \leq 3.2$ h is much shorter than the period of rotation around a non-rotating black hole and is comparable to or smaller than the period of rotation around a maximally rotating black hole with $a = R_g$. This means that relativistic ejections into the jet, responsible for the observed flares, are produced by matter moving in the direct vicinity of the black hole horizon, well inside the $R = 6R_g$ radius of the last stable orbit around a non-rotating black hole.

4 CONCLUSIONS

To summarize, we find that observations of OJ 287 in the $E > 0.1$ GeV energy band constrain the minimal time-scale of flux

variations of the source to be shorter than 3.2 h. The upper limit on the minimal variability time-scale imposes a restriction on the size of the jet formation region. We find that the size of the jet formation region in the OJ 287 system is much smaller than the size of the horizon of the more massive black hole in the binary black hole system powering the source. This means that the observed γ -ray emission is produced by the jet ejected from the smaller mass black hole. The higher apparent luminosity of the smaller mass companion is explained by the effects of relativistic beaming of γ -ray emission. Combining X-ray and γ -ray data, we find a restriction on the Doppler factor of the γ -ray-emitting part of the jet, $\delta \gtrsim 4$. The observed variability time-scale indicates that the relativistic jet from the smaller mass black hole is formed close to the black hole horizon, well inside the last stable orbit around a non-rotating supermassive black hole.

The γ -ray data provide a new insight into the physical model of the unique binary supermassive black hole system in OJ 287. The γ -ray flaring activity is produced in connection with the passage of the smaller mass black hole through the accretion disc around the larger mass black hole during periods of close approach of the two black holes in the periastron of the binary orbit. Interaction of the smaller mass black hole with the larger mass black hole accretion disc leads to transient episodes of ejection into the relativistic jet from the smaller mass black hole. It appears that the transient jet from the small-mass black hole happens to be aligned along the line of sight, a fact responsible for the BL Lac type appearance of the source. It is not clear *a priori* whether the jet from the smaller mass black hole forms only during periastron passage or exists throughout the binary orbit. If the jet is powered by transient accretion on to the black hole, it would be natural to expect that the the small-mass black-hole jet (and the associated γ -ray emission) should disappear soon after periastron passage on the characteristic time-scale of accretion. Otherwise, if the jet is powered by the rotation energy stored in the small-mass black hole, it is natural to expect that the jet and the γ -rays from the jet would be persistent throughout the binary orbit. Systematic monitoring of the source evolution in γ -rays on the orbital (11.7 yr) time-scale, which is now possible with *Fermi*, might clarify this question. It is interesting to note that if the jet from the smaller mass black hole is directed along the black-hole spin axis, its alignment with the line of sight might be destroyed by the precession of the black-hole spin axis (see Valtonen et al. (2006) for a detailed discussion of the orbital evolution of the system). This would mean that the BL Lac appearance of the source might be time-dependent. An immediate consequence of the misalignment of the smaller black hole jet with the line of sight

should be the loss of the strong Doppler boosting of the flux. In the absence of Doppler boosting, the emission from the smaller mass black hole might become subdominant compared with the emission from the larger mass black hole. Study of the details of the overall time evolution and of the short time-scale variability properties of the source along the orbit and from periastron to periastron should clarify the transient/permanent nature of the BL Lac appearance of the source.

ACKNOWLEDGMENTS

This work was supported by the Swiss National Science Foundation grant PP00P2_123426.

REFERENCES

- Aharonian F. et al., 2006, *Sci*, 314, 1424
 Aharonian F. A. et al., 2007, *ApJ*, 664, L71
 Albert J. et al., 2007, *ApJ*, 669, 862
 Bardeen J. M., Press W. H., Teukolsky S. A., 1972, *ApJ*, 178, 347
 Blandford R. D., Payne D. G., 1982, *MNRAS*, 199, 883
 Blandford R. D., Znajek R. L., 1977, *MNRAS*, 179, 433
 Celotti A. L., Fabian A., Rees M., 1998, *MNRAS*, 293, 239
 Ciprini S., Gasparrini D., Reyes L. C., Tanaka Y. T., Tosti G., Vilatta M., Raiteri C. M., Takalo L. O., 2009, *Astron. Tel.*, 2256
 D'Ammando F., Gehlers N., Hoversten E., Romano P., Vercellone S., 2009, *Astron. Tel.*, 2267
 Gaidos J. A., 1996, *Nat*, 383, 319
 Harris D. E., Krawczynski H., 2006, *ARA&A*, 44, 463
 Lehto H. J., Valtonen M. J., 1996, *ApJ*, 460, 207
 Neronov A., Aharonian F., 2007, *ApJ*, 671, 85
 Neronov A., Semikoz D., Sibiryakov S., 2008a, *MNRAS*, 391, 949
 Neronov A., Semikoz D., Sibiryakov S., 2008b, in Aharonian F. A., Hofmann W., Rieger F., eds, *AIP Conf. Proc. Vol. 1085, High Energy Gamma-Ray Astronomy*. Am. Inst. Phys., New York, p. 545
 Remillard R. A., McClintock J. E., 2006, *ARA&A*, 44, 49
 Seta H. et al., 2009, *PASJ*, 61, 1011
 Sillanpää A., Haarala S., Valtonen M. J., Sundelius B., Byrd G. G., 1988, *ApJ*, 325, 628
 Stickel M., Fried J. W., Kuehr H., 1989, *A&AS*, 80, 103
 Valtonen M. J. et al., 2006, *ApJ*, 646, 36
 Valtonen M. J. et al., 2008, *Nat*, 452, 851
 Valtonen M. J. et al., 2009, *ApJ*, 698, 781
 Zdziarski A., Neronov A., Cheryakova M., 2010, *MNRAS*, 403, 1873

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