# Flaring Activity from S5 0836+71 (4C71.07): What Can We Learn with Limited Multiwavelength Coverage?

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Abstract

After a long period of quiescence in gamma rays, blazar S5 0836+71 (4C71.07) flared in the Spring of 2011. We found only limited multiwavelength coverage of the source. An indication of correlated optical/gamma-ray variability is not surprising for a FSRQ like this one. Radio observations at high frequencies, however, had seen a flare in 2010, well offset from possible gamma-ray activity. The 2011 gamma-ray activity comes during a period of rising radio emission, a pattern that has been seen since the EGRET era, e.g. Valtaoja & Teräsranta 1995.

## Introduction

The luminous high-redshift (z=2.218) quasar S5 0836+710 (also known as 4C71.07 or 0836+710) is characterized by a flat radio spectrum (α=-0.33,(Kuhr 1981)). It hosts a powerful radio jet emerging from the core and extending up to kiloparsec scales (Hummel et al. 1992). VLBI (Very Long Baseline Interferometry) images of 0836+710 show a very complex motion pattern, with one-sided jet components moving from apparent subluminal ($\beta_{app}$ = 0.5) to superluminal ($\beta_{app}$ = 25) velocities (β = v/c, $H_0$ = 100 km/s/Mpc) (Otterbein 1998; Lister et al 2009). Internal structure of the jet in quasar S5 0836+710 has been investigated at 1.6 and 5 GHz using observations with VSOP (VLBI Space Observatory Programme, (Perucho et al. 2007)). These observations revealed that three major oscillations in the jet can be described the helical surface mode and combination of the helical and elliptic body modes. These modes are represented by the longest observed wavelength of 100 milliarcsecond (mas) and two shorter ones (7.7 mas and 4.6 mas), respectively. See also the MOJAVE summary page for this blazar:
http://www.physics.purdue.edu/astro/MOJAVE/sourcepages/0836+710.shtml.

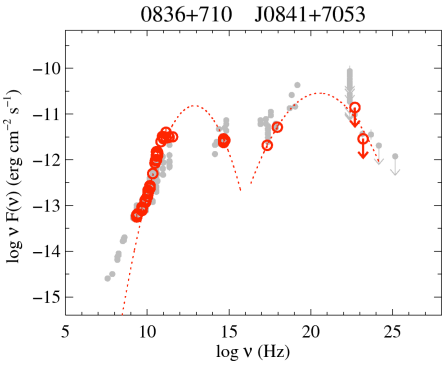
The quasar S5 0836+710 was also subjected to several X-ray studies and multiwavelength modeling (Fang et al. 2001; Foschini et al. 2006; Gianni et al. 2011).

## Gamma-ray Observations

Quasar S5 0836+710 was detected by COMPTEL (3-10 MeV band, (Collmar 2006)) and EGRET (Thompson et al. 1993; 3EG J0845+7049, Hartman et al. 1999). This source was not bright enough to be included in the *Fermi*-LAT Bright Source List (Abdo et al. 2009), however, it was associated with 1FGLJ0842.2+7054 in the First LAT Catalog (1FGL)(Abdo et al. 2010). Regular gamma-ray montoring by *Fermi*-LAT showed that the source was not active until recently. An exceptional outburst from the source on 2011 April 3 was noted by the *Fermi*-LAT (Ciprini 2011). Preliminary analysis of observed gamma-ray flare indicates that S5 0836+71 was in a bright state with an average daily flux of $F_{E>100MeV}$ =(1.2±0.3)x10$^{-6}$ photons cm$^2$s$^{-1}$. The reported flux is order of magnitude greater than the average flux value in the 1FGL catalog. Its 2FGL name is 2FGL J0841.6+7052 (Abdo et al. 2011).

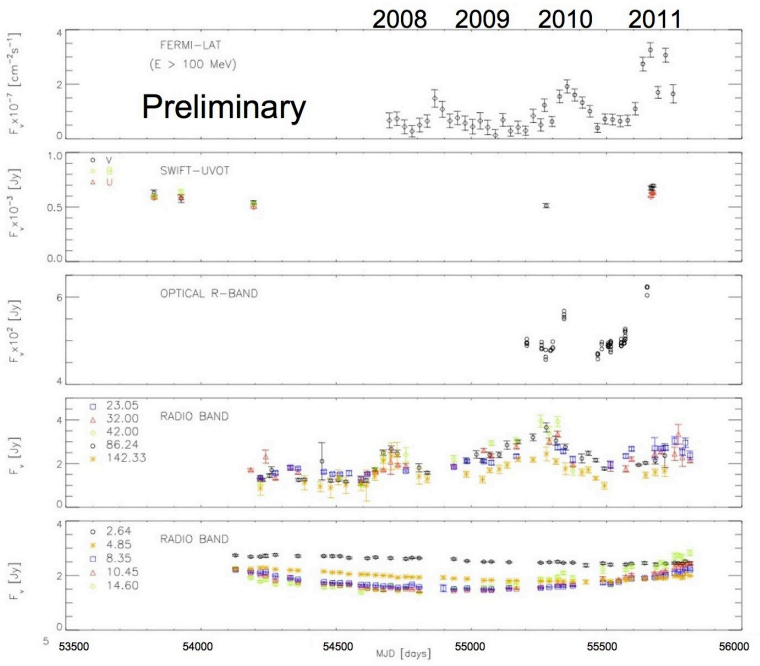
Its gamma-ray spectrum is steep, with a photon power-law index of 2.95±0.07 in 2FGL.

## Spectral Energy Distribution




The 0836+71 SED shown here is from the early Planck results (Planck Collaboration, 2011, Early Results 15, arXiv:1101.2047). During the simultaneous observations of Planck and Fermi (shown in red), the gamma-ray flux was not detectable. Historical results (gray) show that this blazar has its synchrotron and Compton peaks at relatively low frequencies.

## Long-term Multiwavelength Light Curve




**Key features of the long-term light curves:**

1. The coverage is sparse except for gamma rays and radio, so the emphasis is on long-term trending rather than short-term correlations. The Swift X-ray Telescope observations (not shown) show fading X-ray emission following the bright April 2011 gamma-ray flare.
2. The optical shows correlation with the gamma-ray flaring in both 2010 and 2011. The correlation establishes identification but coverage is not detailed enough for short-term correlations.
3. The high-frequency (> 23 GHz) radio observations show variability, but it is not obviously strongly correlated with the gamma rays. Some features:
   a. There is a long-term increasing trend during and already at the beginning of the LAT LC and activity.
   b. If the 2010 radio peak is associated with the gamma-ray peak that same year, then the radio would have to lead the gamma-ray emission by a significant amount (months), and even longer between the 2008-09 radio peak and the gamma-ray maximum.
   c. The stronger gamma-ray flaring activity in 2011 does appear to coincide with a rising flux in the radio
   d. There are also 3 (sub-) flares similar to gamma, though the cross-band relative timing and correspondence (1:1 correlation) is unclear at the moment.

A recent paper, Nieppola et al, http://arxiv.org/abs/1110.5267, found that this type of blazar (low-polarization FSRQ) showed the least correlation with the mm band. 0836+71 seems to be an example of this lack of strong correlation.

**On Nov. 1, 2011, S5 0836+71 flared in gamma rays to a flux above 100 MeV greater than 3 x 10$^{-6}$ ph cm$^{-2}$ s$^{-1}$, nearly 40 times brighter than the average flux in the 2FGL catalog. The rise was a factor of 5 in 24 hours or less.**