LUCI E OMBRE DI MARKARIAN180

un viaggio nel cuore di un blazar

Sluzhalo Marco, Iannucci Jacopo and Federico Elena

Liceo Scientifico **Telesi@**, Telese Terme

E-mail: sluzhalo.m.studente@iistelese.it
iannucci.j.studente@iistelese.it
federico.e.studente@iistelese.it

ABSTRACT

Markarian 180 (Mrk 180) is a Flat Spectrum Radio Quasar (FSRQ) blazar, located approximately 450 million light-years from Earth. It was first observed by the MAGIC telescope on August 26, 2006. By analyzing data from the Fermi and TeVcat catalogs, spectral energy distribution (SED) and light curve graphs were created, suggesting that Markarian 180 belongs to the second peak of the SED, in the high-frequency range such as optical, ultraviolet, and X-rays. Thanks to the MAGIC telescope, high-energy gamma-ray emissions were detected with a 5.5 σ significance. Its latitude is 131.91° and its longitude is 45.64°.

INTRODUCTION

1. Blazars are a class of highly energetic and luminous astrophysical objects that belong to the quasar category. They are characterized by rapid variability in their brightness and emit radiation across a broad spectrum of wavelengths, from radio waves to gamma rays (high energy). The radiation we observe is highly polarized, and their emissions can be dominated by two main peaks in the spectral energy distribution (SED): one at low energy (radio, optical, infrared) and one at high energy (X-rays and gamma rays).
2. Our journey began with participation in the International Cosmic Day at the Faculty of Physics of the University of Naples Federico II. During this event, we introduced the topic of cosmic rays, focusing specifically on studying the muon flux using the Cosmic Ray Cube. In the second meeting, held at our headquarters, we delved into the phenomenon of extragalactic sources, with a particular focus on blazars. We were provided with a detailed explanation on how to extract information about these sources using specific tools and catalogs, such as TeVcat and Fermi, as well as Google Colab for data analysis.
   Subsequently, the participants were divided into groups of three, with each group being assigned a specific source to analyze.

RESEARCH METHODS

The analysis of the Markarian 180 source was conducted by collecting data from various sources, including TevCat and Fermi. The processing phase was carried out using Google

Colab, through which the necessary lines of code were written to construct the SED (Spectral Energy Distribution) graph, after acquiring the CSV file via Firmamento.

```
import pandas as pd
```

```
df = pd.read_csv("/content/_1978832158_Sed.csv")
```

```
df.head()
```

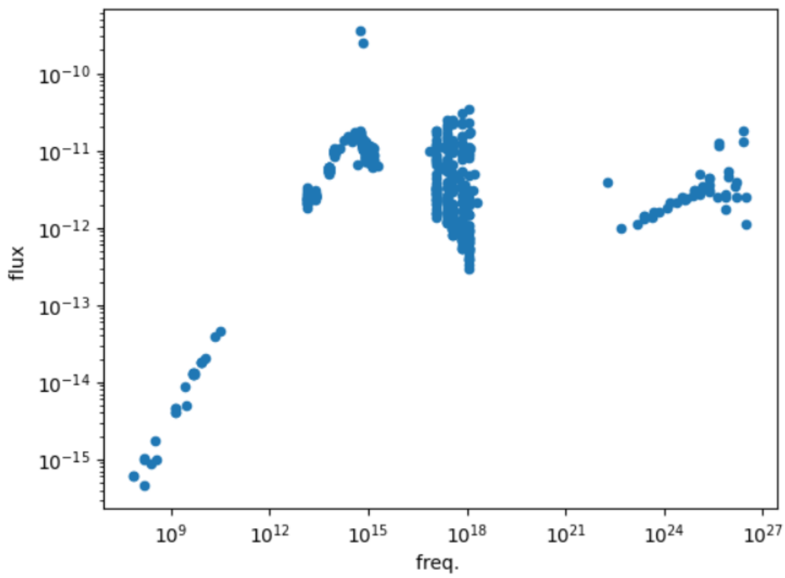
	freq.	flux	err_flux	MJD_start	MJD_end	flag	catalog	reference
0	3.000000e+09	5.073000e-15	2.300000e-17	55000.0	55000.0		VLASSQL	Gordon et al. 2021; ApJS; 255; 30
1	2.418000e+17	7.767000e-12	3.450000e-14	55000.0	55000.0		4XMM-DR13	Webb et al. 2020; A&A; 641; A136
2	2.418000e+17	1.127000e-11	1.210000e-12	55000.0	55000.0		XMMSL2	Saxton et al. 2008; A&A; 480; 611
3	2.418000e+17	1.566000e-11	1.510000e-12	55000.0	55000.0		XMMSL2	Saxton et al. 2008; A&A; 480; 611
4	2.418000e+17	2.489000e-11	4.150000e-13	55000.0	55000.0		RASS	Boller et al. 2016; A&A; 103; 1

```
df.plot("freq. ","flux ","scatter")
```

```
<Axes: xlabel='freq. ', ylabel='flux '>
```

```
[ ] import matplotlib.pyplot as plt
```

```
df.plot("freq. ","flux ","scatter")
plt.xscale("log")
plt.yscale("log")
```



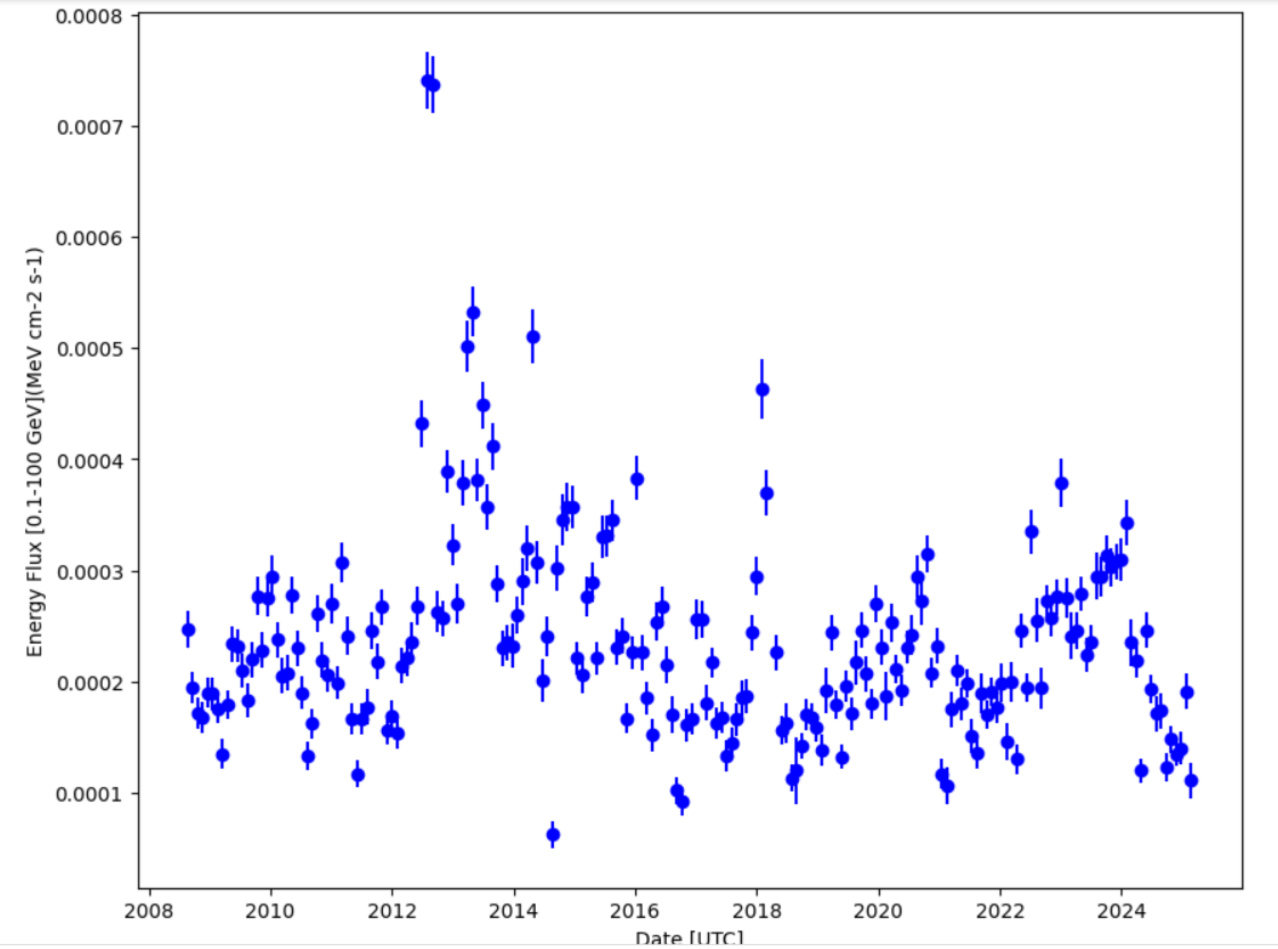

```
[ ] fig = plt.figure(figsize=(10,8))
    plt.errorbar(lcdf_nouplims["Date(UTC)"],lcdf_nouplims["Energy Flux [0.1-100 GeV](MeV cm-2 s-1)"],lcdf_nouplims["Energy Flux Error"],fmt="bo")
    plt.xlabel("Date [UTC]")
    plt.ylabel("Energy Flux [0.1-100 GeV](MeV cm-2 s-1)")
    plt.show()
```

The graph shows the spectral energy distribution of the source. In the last session, the light curve graph was developed using Python, resulting in the following output:

This graph represents the energy flux trend from 2008 to 2024. Significant variability is observed, with peaks occurring approximately every two years. Between 2015 and 2018, the energy flux underwent a sharp decrease, followed by a subsequent recovery. Markarian 180 thus proves to be a source of great interest for further studies on its activity.

The main difference compared to the SED case is that, instead of representing frequencies, the horizontal axis shows time, expressed in UTC dates.

To allow Pandas to correctly interpret the time data and display it on the graph, it is necessary to specify the format. As done previously, the plt.plot() function can be used to plot the light curve graph, which shows the flux trend as a function of time.



Scatter plot with data related to the astrophysical source Markarian 180.
On the X-axis, we have time (dates ranging from 2008 to 2024).
On the Y-axis, we have the energy flux (gamma band between 0.1 and 30 GeV).

RESULTS

The information obtained from the construction of the graph is consistent with the data provided by TevCat and Firmamento.

Markarian 180 (Mrk 180) is located in the constellation Draco, at the coordinates of right ascension 11h 36m 26.4s and declination +70° 09' 27", a position that allows observation of the source through various telescopes, both ground-based and space-based [1]. Its identification as a blazar was made possible through astronomical studies based on observations across different wavelengths of the electromagnetic spectrum. The characterization of the blazar was achieved through the use of radio and optical telescopes, which allowed for an in-depth analysis of its behavior and physical properties.

Markarian 180 is considered a potential candidate for the acceleration of high-energy cosmic rays. Recently, studies such as the one by Mondal et al. analyzed data from the Fermi telescope, which monitored Mrk 180 for 12.8 years, revealing stability in the gamma-ray flux. Data from other frequency bands, such as X-rays and visible light, were also examined to better understand the emission mechanisms of Mrk 180.

In March 2006, a sudden intensification of optical emission led to targeted observations with the MAGIC telescope, which revealed high-energy gamma rays with a flux equal to 11% of that of the Crab Nebula [6]. In 2008, further multiwavelength observation campaigns provided detailed light curves, showing how the emission of Mrk 180 varied over time.

A possible connection between Mrk 180 and the Telescope Array hotspot, where ultra-high-energy cosmic ray emission has been observed, was discussed. However, recent studies (He et al.) suggest that Mrk 180 is not a primary source of such cosmic rays.

Among the most significant observations, intense radio emission peaks were recorded in August 2023, indicative of a change in the source's activity. The measurements were made using the Very Long Baseline Array (VLBA), a system of radio telescopes distributed across various locations and known for its extremely high angular resolution.

REFERENCES

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