Relativistic Fluids around Compact Objects (RFCO2025)

Machine-Learning Enhanced Photometric Analysis of the Extremely Bright GRB 210822A

NASA

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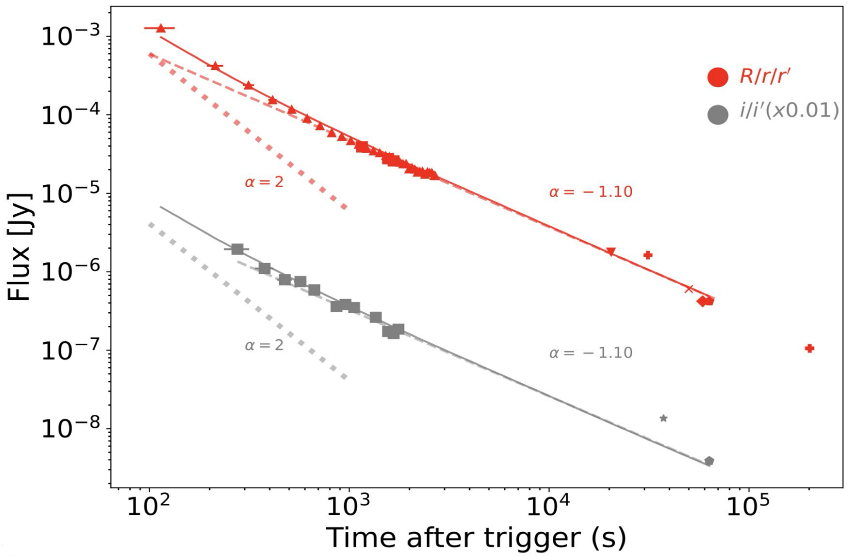
Warsaw, Poland, May 5th 2025

GRB 210822A (T90 = 186 s)

Temporal Analysis

- We analysed the temporal evolution of the afterglow in the ***r*** and ***i*** bands
- We fitted a function $F_\nu \propto t^{-\alpha}$ to each band
- Better fit when a **reverse shock** (RS) component is considered
- RS suggests a matter-dominated shell, implies low level of magnetisation



Spectral Analysis

- Light curves and spectra from UKSSDC in the 0.3-10 keV range.
- Optical and X-ray data are well fit by a function $F_\nu \propto \nu^{-\beta}$, considering reddening and dust absorption.
- Our β yields a p = 2.52 ± 0.12 and a value $F_\nu \propto t^{-1.14 \pm 0.09}$ consistent with the temporal decay found previously.

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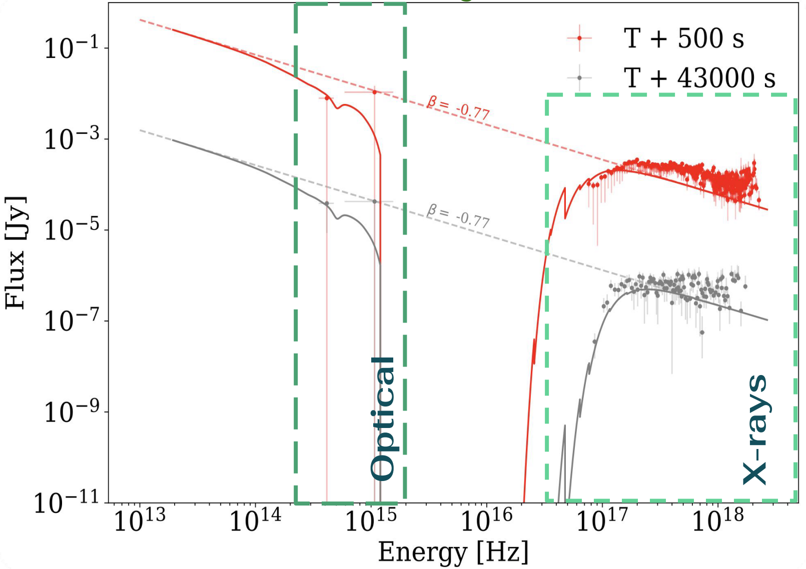

Machine-Learning Method (Applied to GRB 210822A)

- We scaled the optical flux to a common frequency, considering $\nu^{-0.77}$
- ML model trained on 30k AFTERGLOWPy light curves
- Neural Network evaluated with observed GRB data to obtain parameter estimates

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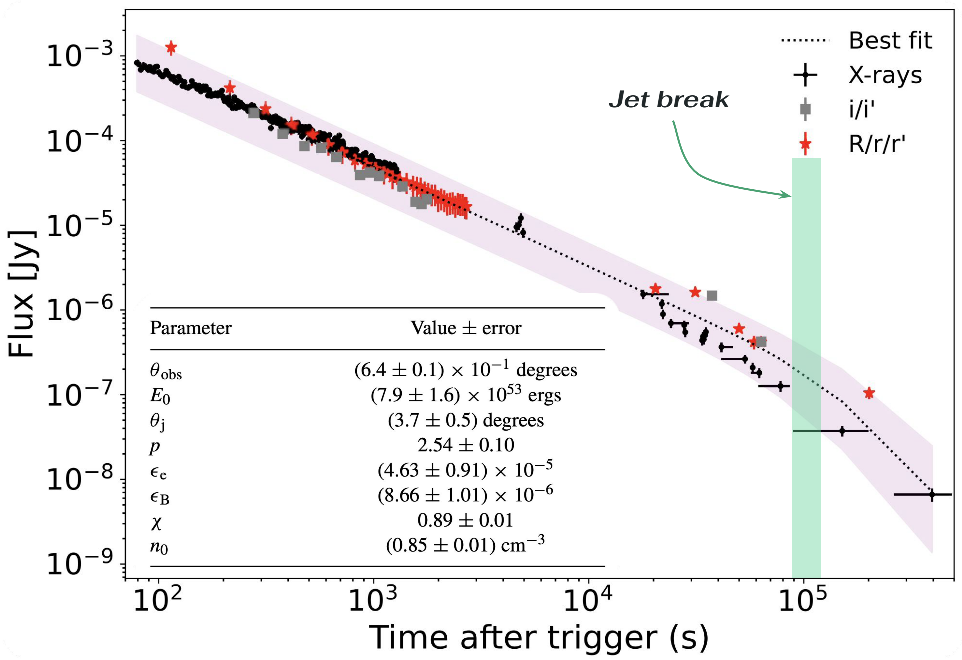

Parameter	Value ± error
θ_{obs}	$(6.4 \pm 0.1) \times 10^{-1}$ degrees
E_0	$(7.9 \pm 1.6) \times 10^{53}$ ergs
θ_j	(3.7 ± 0.5) degrees
p	2.54 ± 0.10
ϵ_e	$(4.63 \pm 0.91) \times 10^{-5}$
ϵ_B	$(8.66 \pm 1.01) \times 10^{-6}$
χ	0.89 ± 0.01
n_0	(0.85 ± 0.01) cm^{-3}

Jet Break

- The presence of two different power-law segments seems to indicate a jet break
- Using typical values we obtain θ_j = **3-5° ± 0.5** in a constant ISM
- Angles consistent with the lower limits on the GRB samples (Berger 2014) and similar to the values observed through the ML model

$$\theta_j = 0.07 \text{ rad } \left(\frac{t_b}{1 \text{ day}}\right)^{3/8} \left(\frac{1+z}{2}\right)^{-3/8} \left(\frac{E_{K,iso}}{10^{53} \text{ ergs}}\right)^{-1/8} \left(\frac{n}{0.1 \text{ cm}^{-3}}\right)^{1/8}$$

Wang et al. 2018

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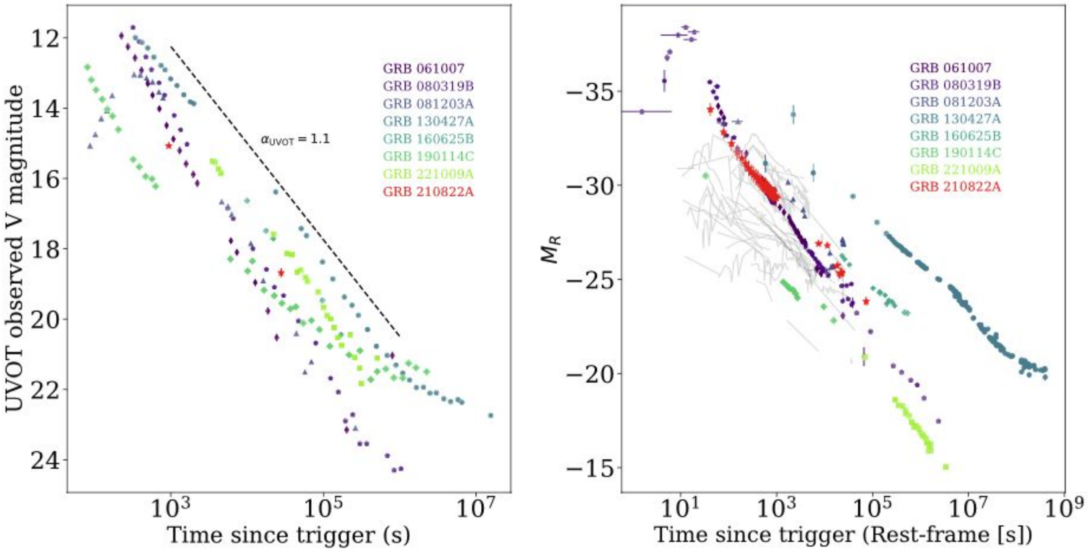
GRB 210822A

In the context of other GRBs

UV and Optical

- Oates (2023) presented an analysis of the brightest long GRBs detected by Swift/UVOT
- We compared UV photometry of GRB 210822A with these GRBs
- Considering that redshifts, duration and opening angles are in similar ranges, we suggest a similarity in the origin and evolution of GRB 210822A.
- Presence of a RS component in GRBs 080319B, 130427A, 160625B, 190114C, y 221009A
- Multi-frequency observations are needed for a complete understanding of each GRB.



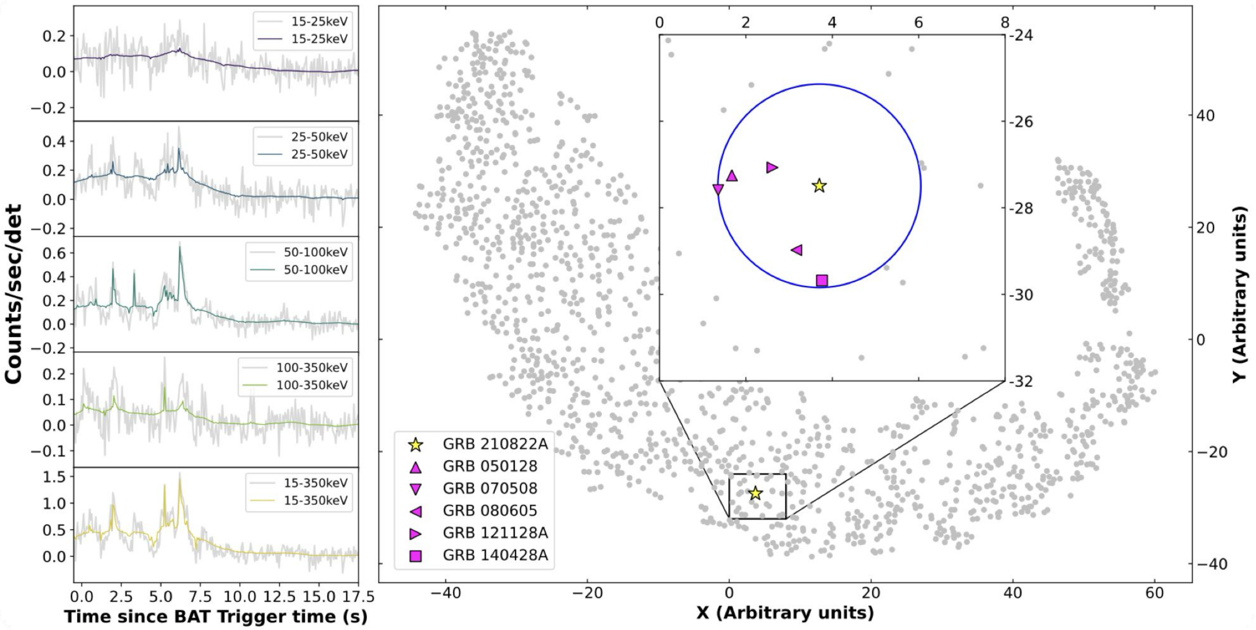
Event	T_{90} [s]	z	θ_j [°]
GRB 061007	75.7 ± 2.5	1.26	0.8 - 4.7
GRB 080319B	124.9 ± 3.1	0.94	0.2 - 4.6
GRB 081203A	223.0 ± 89.9	2.05	...
GRB 130427A	244.3 ± 4.7	0.34	2.5 - 7.0
GRB 160625B[4]	$460.0 \pm$ ...	1.41	2.0 - 12
GRB 190114C	361.5 ± 11.7	0.42	7.0 - 32
GRB 221009A	1068.4 ± 13.3	0.15	0.7 - 2.0
GRB 210822A	185.8 ± 46.6	1.74	3.0 - 5.0

GRB 210822A

In the context of other GRBs

Gamma-rays

We used the ***ClassiPyGRB*** *(see Rosa's talk)* (Garcia-Cifuentes et al. 2023b) library to find the GRBs with the most similar gamma-ray emission as GRB 210822A



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None of these GRBs share a significant gamma-ray brightness, optical and gamma-ray emission have different origins.

GRB	T_{90} (s)	Redshift
GRB 050128[a]	28.0 ± 9.1	1.67
GRB 070508	20.9 ± 0.7	0.82
GRB 080605	18.1 ± 0.9	1.64
GRB 121128A	23.4 ± 1.7	2.20
GRB 140428A	17.4 ± 5.9	4.70

GRB 210822A

Summary

- We presented the analysis of the optical photometry of the afterglow of the bright GRB 210822A.
- We identified a RS component in the optical bands at T < 300s and a jet break between T + 80,000 s and T + 100,000 s.
- We implement a novel neuronal network technique to model the LC and constrain the intrinsic parameters of the GRB.
- We showed the similarity of GRB 210822A with other events that are extremely bright in the optical/UV.

Angulo-Valdez, C. *Machine-Learning Enhanced Photometric Analysis of the Extremely Bright GRB 210822A*, MNRAS, Volume 527, Issue 3, January 2024, Pages 8140-8150

Thank you!

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