The most complete optical GRB catalogue

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On behalf of a large collaboration: M. G. Dainotti et al., 2024, MNRAS
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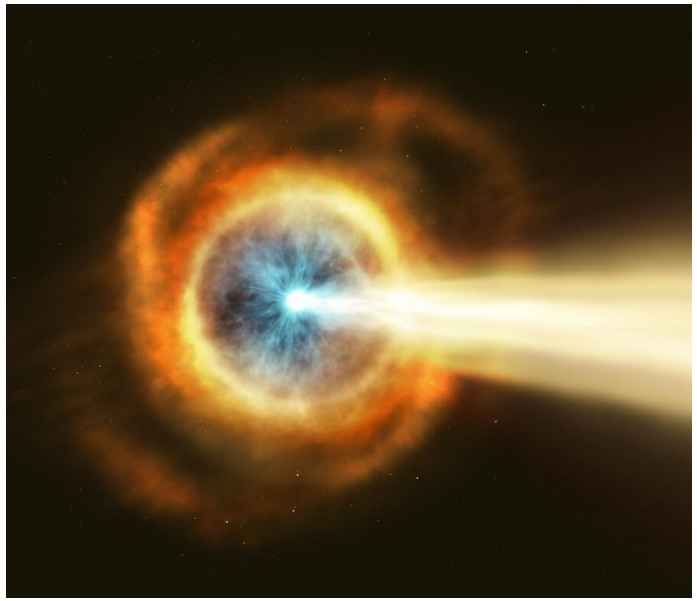
Outline

- Introduction to GRBs and why we need this catalogue
- Steps involved in compiling the catalogue
- Colour evolution analysis
- Rescaling
- Introducing the GRBLC webtool

Introduction to GRB

- Flashes of high energy photons in the sky (typical duration is few seconds)
- The greatest amount of energy released in a short time, not considering Big Bang
- Cosmological origin. Furthest GRBs observed z ~ 9.4
- X-rays, optical, and radio radiation observed after days/months (afterglows), distinct from the main γ-ray events (the prompt emission).
- Observed spectrum non-thermal.
- GRBs are important for their energy emission mechanisms.



Why do we need an optical catalogue of GRBs?

GRB morphology

- Emerging of features (e.g. plateau emission)

Population studies

- Beyond the long-short dichotomy

Machine learning

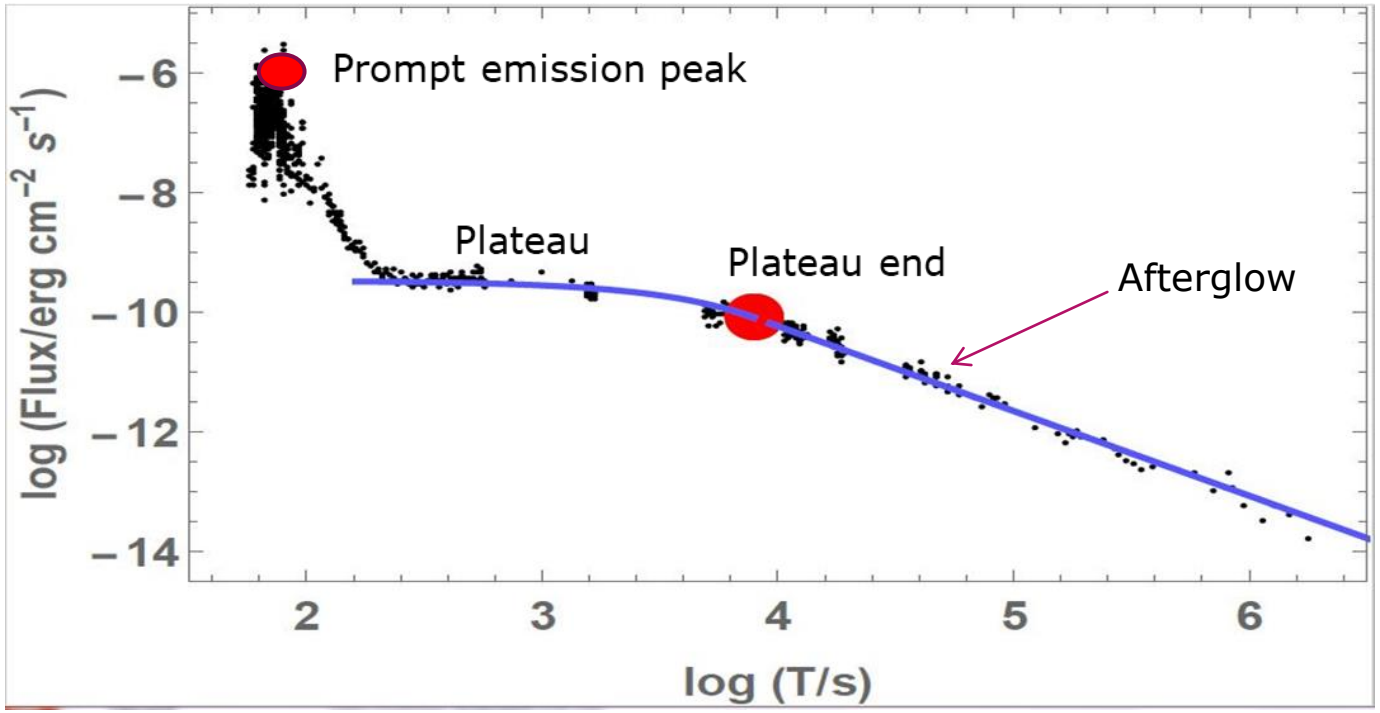
- Lightcurve reconstruction
- Redshift estimation

Towards the early universe…

- Population III stars cosmology

The community needs a uniform format for GRB optical data

Good data coverage is necessary for highlighting key LC features

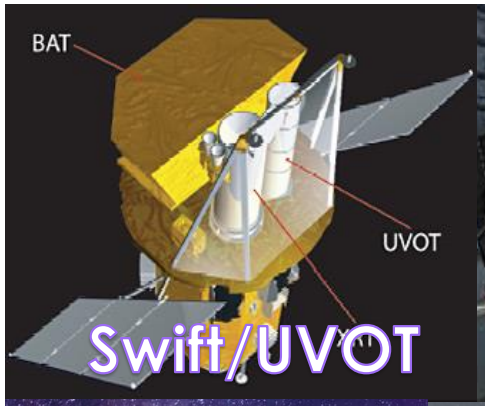


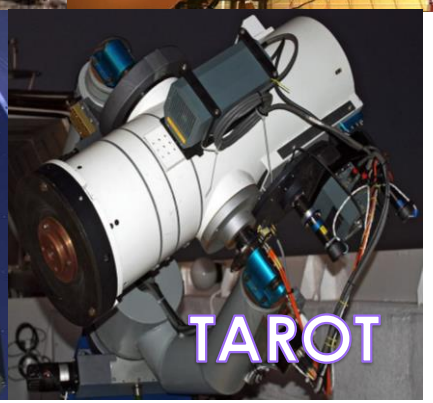
- Important features of a well-sampled GRB light curve observed by Burst Alert Telescope+ X-Ray Telescope +Swift (2004-ongoing). The blue line is the phenomenological Willingale model. (R. Willingale et al. 2007)

Pipeline for building the GRB catalogue

- **Data collection** — GCNs, papers, ATel, private communications etc…
- **Homogenising sample** — shifting in AB system and applying Galactic extinction correction and, where possible, the K-correction and host galaxy correction
- **Colour evolution and rescaling** — Fitting of the rescaling factors vs log10 time
- **Division into three groups** — Agreement and Disagreement with literature, Undetermined by us

535 GRBs with determined redshfift
Swift + 570 instruments!





AND MORE …

Japanese telescopes in our catalogue

Homogenising the sample

Correct for galactic reddening
using Schafly et al. (2011) dust map or ASIAGO database (ADPS)

$$mag_{AB,gal} = mag^{*} - A_{\lambda,gal}$$

We shift the magnitudes in the AB system
(overcoming fluctuations of the filters' zeropoint)

$$mag_{AB,gal} = mag^{*} - A_{\lambda,gal} + shift_{Vega \rightarrow AB}$$

We apply the K-correction (if the spectral index is available)

$$mag_{corr} = mag_{AB,gal} - k$$

We apply the host correction using Pei (1992) extiction curves

$$mag_{corr} = mag_{AB,gal} - k - A_{\lambda,host}$$

Providing a uniform format for GRB optical data

- Example data gathered for 050904A

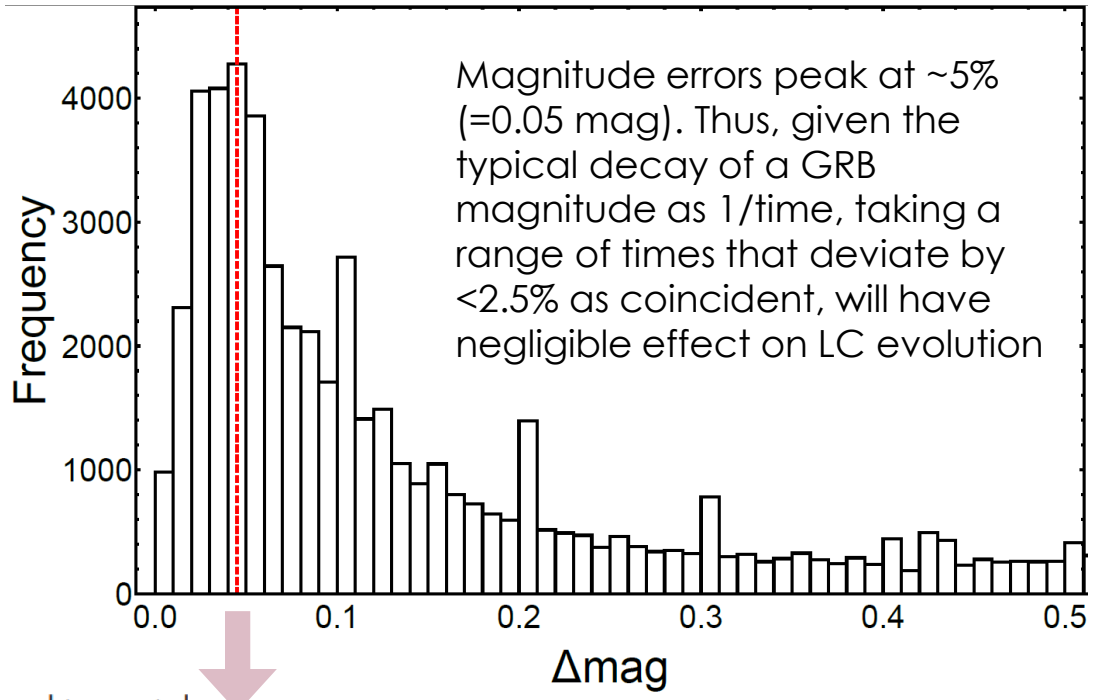
Time(s)	Mag	MagErr	Filter	System	Observatory/Telescope/Instrument	GalExtCorr	Source	Flag
115	17.981	0	R	AB	LSO/TAROT-S(25cm)/ANDOR-IKON-DW-436-N	y	3917	yes/X/Z
519	13.951	0.24	Ic	AB	Calern/TAROT(25cm)/ANDOR-IKON-L936-BEX2-DD	y	Boer2006	no
786.5	15.381	0	Ic	AB	Calern/TAROT(25cm)/ANDOR-IKON-L936-BEX2-DD	y	Boer2006	no
2402	20.698	0	UVW1	AB	NGSO/Swift/UVOT	y	3923	no
2481.5	20.812	0	UVW2	AB	NGSO/Swift/UVOT	y	3923	no

The rescaling factor

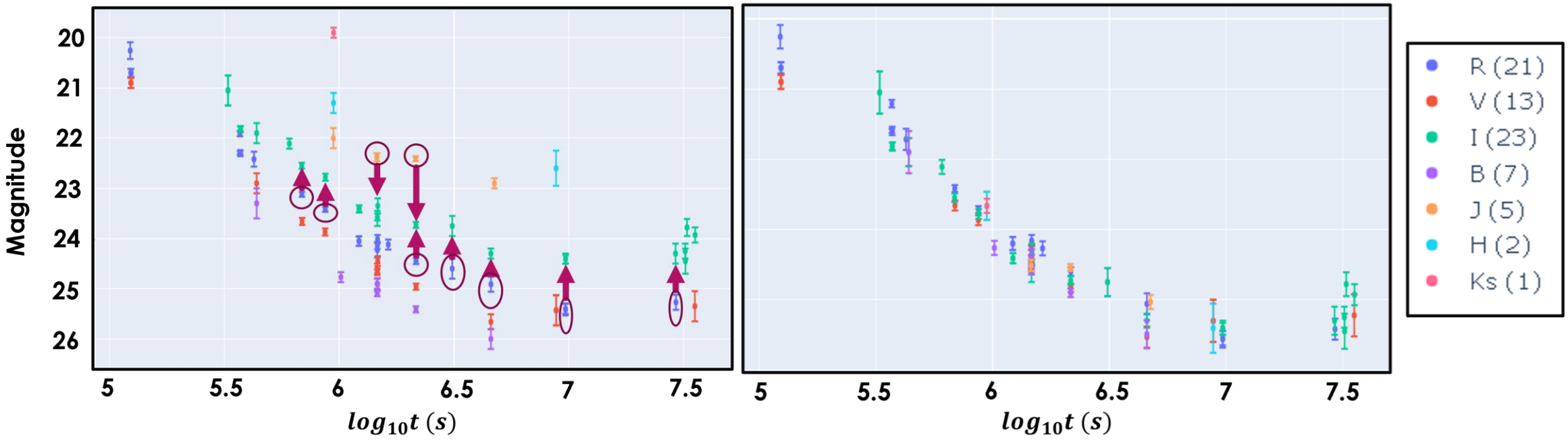
Given a GRB with magnitudes in the filters f and g, the rescaling factor is defined as the difference between the magnitude of the f filter and g filter at coincident epochs.

We chose f to be the most numerous filter in the given GRB

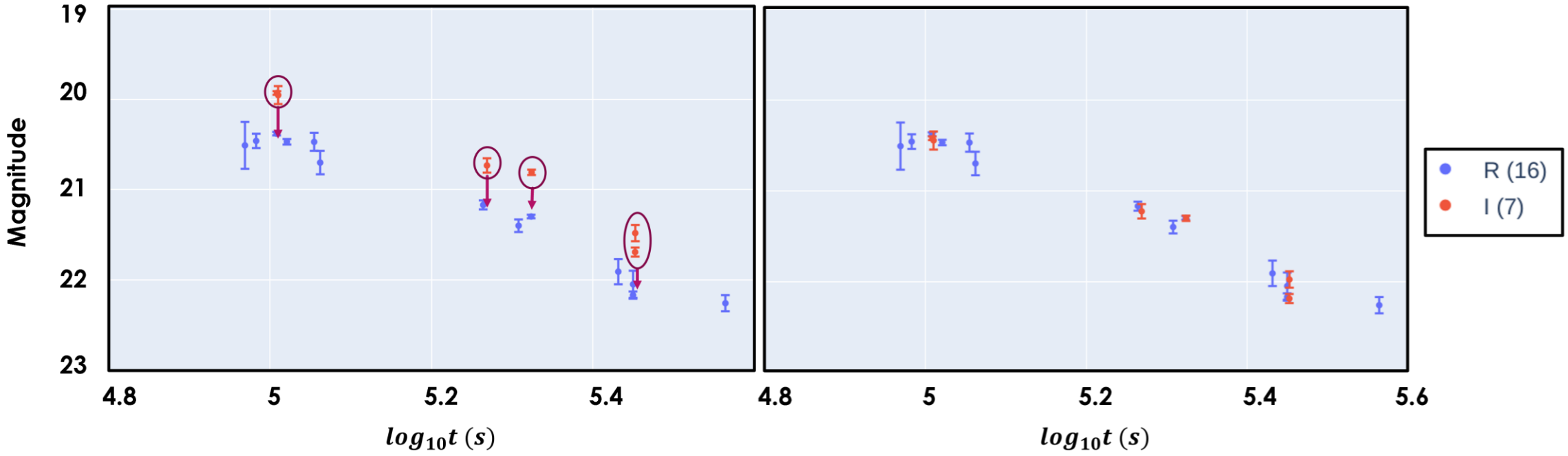
$$rf_{f,g} = (\mathrm{mag}_f - \mathrm{mag}_g)_{\mathrm{coincident}}$$



Rescaling: Example of GRB 000911A



Rescaling: Example of GRB 030323A



Colour evolution: Fitting $rf_{f,g} = a * \log_{10}(t_f) + b$

using Levenberg–Marquardt algorithm

a set to 0

variable a

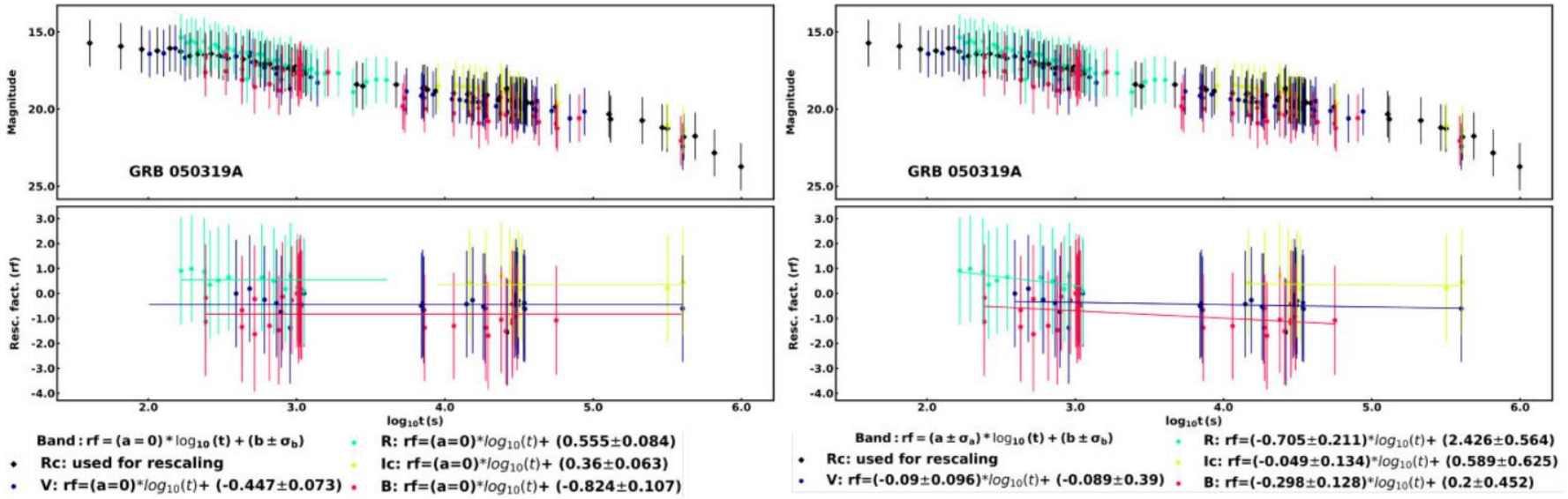
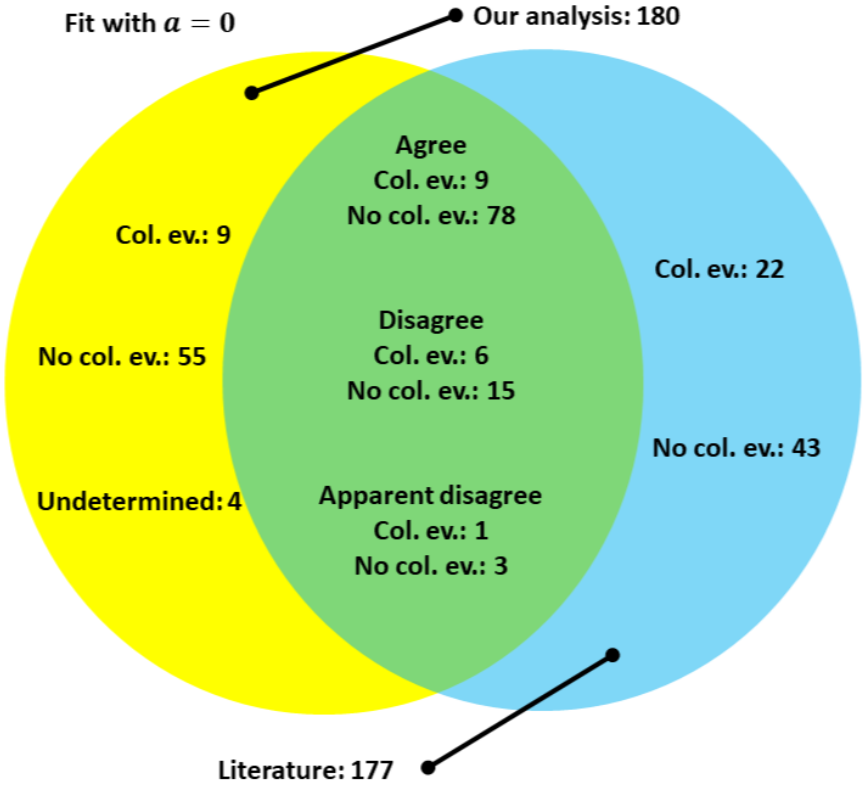
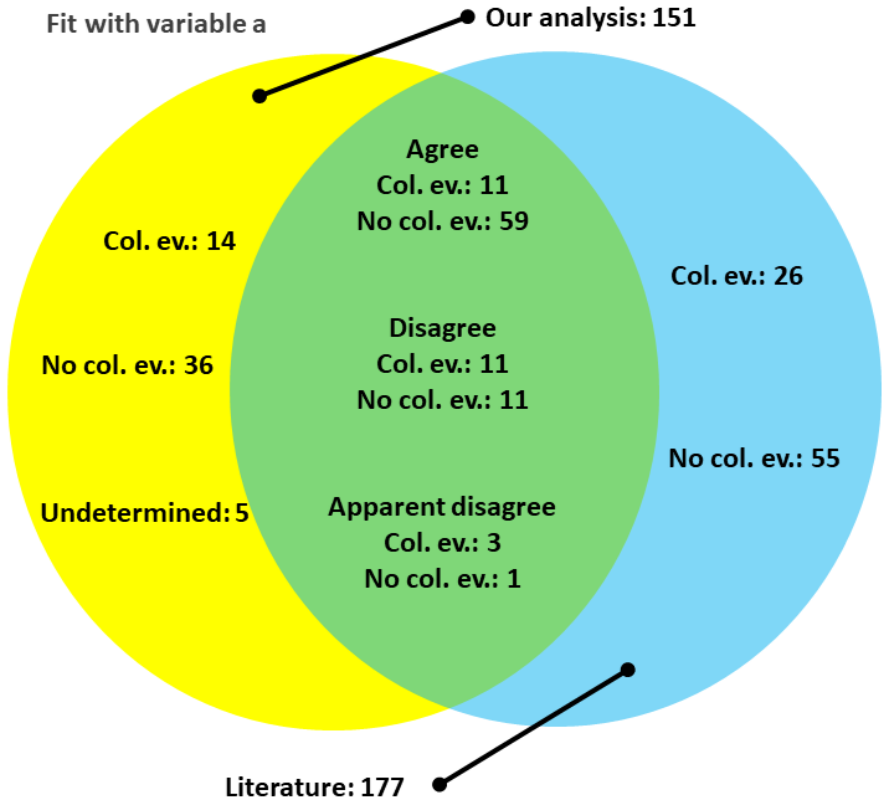


Figure 9. A comparison of the $a = 0$ fitting (left panel) and the variable slope fitting (right panel) for GRB 050319A. For both panels, the upper half shows magnitudes versus times, while in the lower half we report the rescaling factors versus time with their fitting functions.

Colour evolution: Results





Colour evolution: Results

Fit with fixed a=0

- Agreement: 84 (49%)
- Disagreement: 23 (13%)
- Determined only by us: 66 (39%)

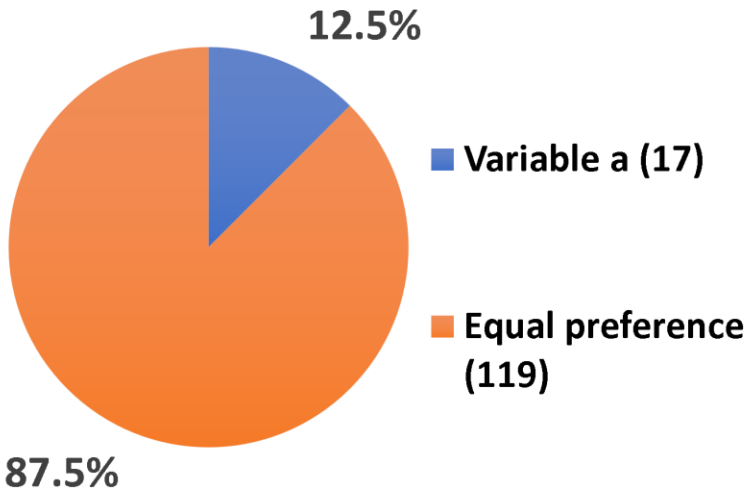
Total number: 173

Fit with variable slope

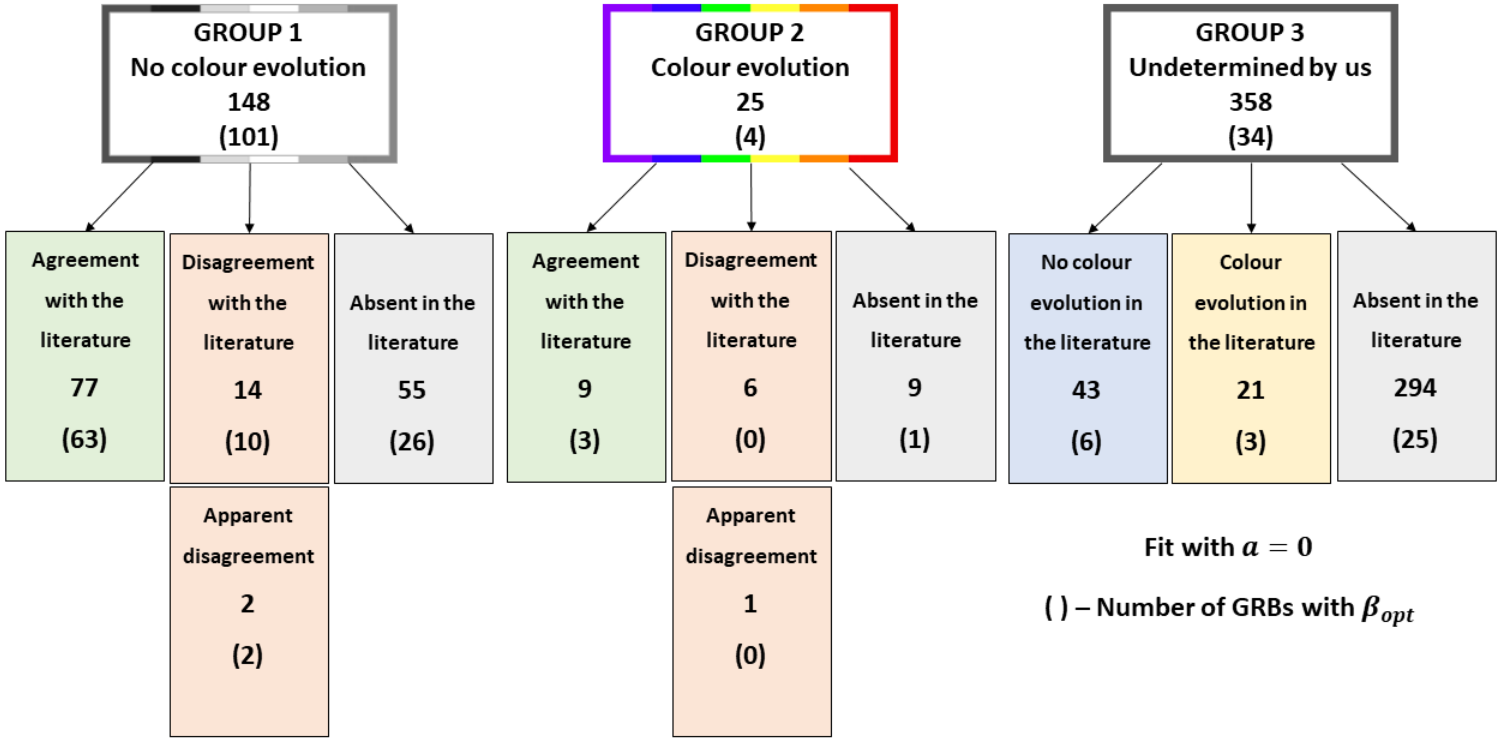
- Agreement: 66 (47%)
- Disagreement: 24 (17%)
- Determined only by us: 51 (36%)

Total number: 141

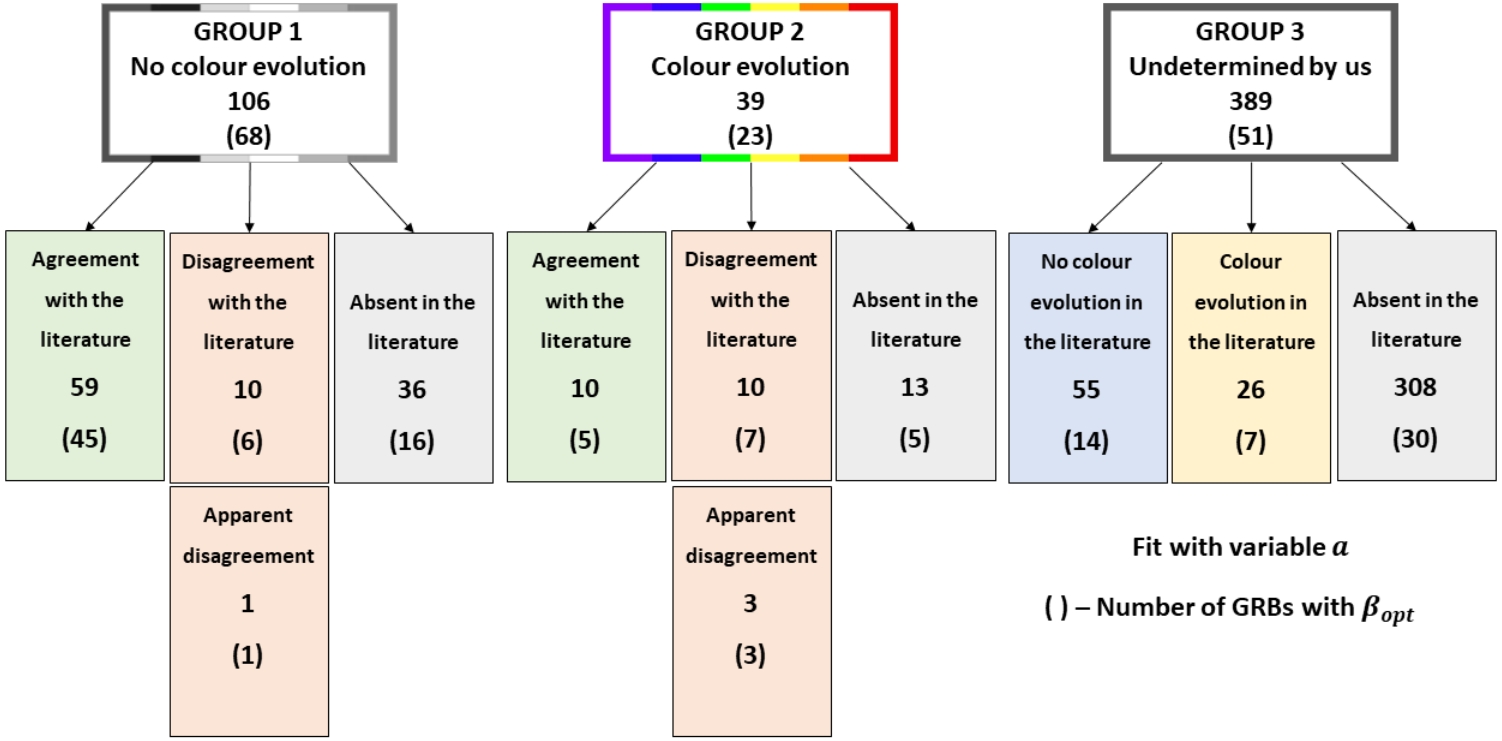
Best model (BASED ON BIC)



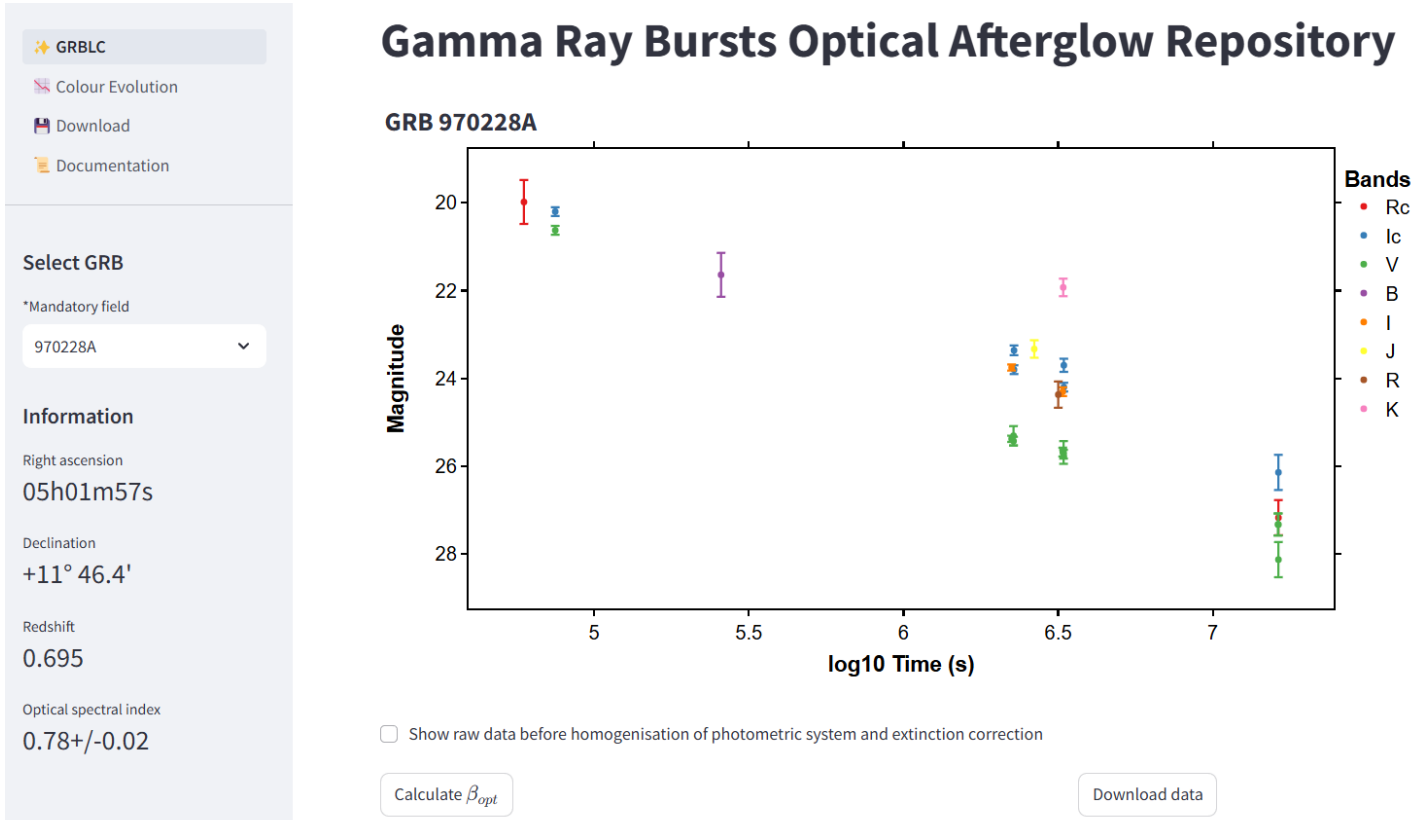
Division of Groups: a=0 model



Division of Groups: variable a model



One web-tool to include them all…



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JOURNAL ARTICLE ACCEPTED MANUSCRIPT

An optical gamma-ray burst catalogue with measured redshift PART I: Data release of 535 gamma-ray bursts and colour evolution

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Your contributions are welcome!

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