A comparison between short GRB afterglows and kilonova AT2017gfo

- Andrea Rossi
- Istituto Nazionale di Astrofisica (INAF)
- Osservatorio di Astronomia e Scienze dello spazio (OAS) – Bologna (Italy)
Outline

- Discovery of the kilonova AT2017gfo
- Kilonovae associated with short GRBs
- Comparison between short GRB optical/NIR counterparts and AT2017gfo
Discovery of the AT2017gfo

Three-In-One Event: GW 170817, a short GRB, and a kilonova

RECORDS
- First GW from BNS: GW170817
- First EM counterpart: GRB 170817A
- First direct evidence of the nature of short GRBs
- First spectroscopic kilonova: AT2017gfo

Pian, et al., 2017, X-Shooter, FORS2
Blue and red components of AT2017gfo

Jet–ISM Shock (Afterglow)

Blue

Red

Metzger & Berger 2012

Pian, et al., 2017, X-Shooter, FORS2
Are there other kilonovae?

- Short GRB 130603B; z=0.356 (Tanvir +13)
- Other evidence:
  - Short GRB 050709; z=0.16 (Jin +16)
  - Short/long GRB 060614; z=0.125 (Yang +15)
  - Short GRB 080503 at unknown redshift (Perley +09; Gao +17)
  - Short GRB 160821B; z=0.16 (Jin +18; Kasliwal +17; Troja +19; Lamb +19)
  - Short GRB 150101B at z=0.134 (Troja +18)
What can we learn from short GRBs

- Kilonova emission can be found in short GRBs
- Be careful: the afterglow can dominate over the kilonova
- We can put constraints on the luminosity of the kilonova

Tanvir+2013

![Graph showing time vs. magnitude and time vs. X-ray flux for GRB 130603B, with typical afterglow power law decay highlighted.](image)
Sample of short GRBs with known redshift

39 short GRBs
within the redshift range $0.1 \leq z \leq 2.2$

- 33 short GRBs with redshift from Fong+15
- + 6 bursts between 2015 - 2018
- Updated the light curves and redshift
- 28 with redshift well defined

Rossi +19, arXiv:1901.05792
Comparison of AT017gfo and short-GRBs

Build a set of kilonova luminosity light curves for each $z_{GRB}$

- The comparison must be done in the same frame
- Cannot shift the GRBs lightcurves to avoid assumptions about the optical/NIR spectral behavior of the GRBs
- Put AT2017gfo spectra in rest-frame
- We built for each GRB a set of virtual rest-frame filter transmission curves at $z_{GRB}$
- We convolved the AT2017gfo luminosity spectra with the effective rest-frame filter
Comparison of AT017gfo and short-GRB

Filter transmission curves shifted at $z_{GRB}$

AT2017gfo rest-frame spectra

Optical/NIR light curves at $z(\text{GRB})$

Rossi +19, arXiv:1901.05792
Sample of optical counterparts with anomalous shallow decay

- A kilonova is expected to show a shallow evolution close to its maximum brightness.
- A standard afterglow has a constant power-law decay with index $\alpha > 0.75$
  \[ F_\nu(t) \propto t^{-\alpha} \]
- Counterparts with shallow decay are kilonova candidates

Rossi +19, arXiv:1901.05792
Constraints on the blue component

- Golden sample of 7 GRBs shallow decay or claimed KN and accurate redshift

- 050709: lower limit to luminosity: >0.8 AT2017gfo

- 130603B, 160821B, 150101B comparable to AT2017gfo blue component (<3 times AT2017gfo)

- Peculiar events: 060614 and 051221A are 15-40 times brighter, 061210 is 350 times brighter

Cases of shallow decay or known KN

- 050709
- 051221A
- 060614
- 061210
- 130603B
- 150101B
- 160821B
- 080905A
- 090515
- 150423A
- 150424A
- Golden sample

Rossi +19, arXiv:1901.05792
Interesting cases with not well defined redshifts

- 2 cases without shallow decay are >5 times fainter than AT2017gfo

- New kilonovae?

GRBs 080905A and 090515 both have a shallow decay

Rossi +19, arXiv:1901.05792
Constraints on the red component

- 160821B ~0.5 times AT2017gfo (but blue is similar)
- 050709 comparable to AT2017gfo
- 130603B 3 times AT2017gfo

Cases of shallow decay or known KN:

- 050709
- 080614
- 130603B
- 150101B

Rossi +19, arXiv:1901.05792
Summary

- 28% could not be compared (too early data)
- 33% afterglow dominated
- 4 new kilonovae? (too bright? wrong z?)
- 2 GRBs likely without an AT2017gfo-like kilonova (no shallow decay)
  - are >5 times fainter than AT2017gfo (wrong z?)
- A large range of Blue KN luminosity:
  Faintest blue KNe are similar to AT2017gfo
  But brightest could be > 10,100 times brighter
- All red Kilonovae are very similar

Rossi +19, arXiv:1901.05792
THANK YOU