AT2020mrf

The Most X-ray Luminous Cow-like Supernova

Yuhan Yao (Graduate Student, Caltech)
with Anna Ho (UC-Berkeley), Dan Perley (LJMU),
and the SRG team

yyao@astro.caltech.edu
AT2018cow: the “Cow” supernova

The death of a star shining across the electromagnetic spectrum!
Cow-like Supernovae

- A subclass of Fast Blue Optical Transients (FBOTs)
- Very dense material surrounding the star
  Excites a shock wave that travels at a velocity = 0.1 x speed of light
- Ongoing energy production from a central energy source (“engine”)
- Four objects known before

Rate of Massive Star Explosions

- Normal supernovae: ~90%
- FBOTs: ~10%
- Cow-like: ~0.1%
SRG discovers a new X-ray source

- *Spektrum-Roentgen-Gamma (SRG)*
  The 1st X-ray mission at the Sun-Earth L2 point
  8 all-sky surveys in 2020—2023
- In July 2020, discovered a new X-ray source
- Fast X-ray variability

![SRG Diagram](image-url)
Also detected in the optical as an FBOT

• In June 2020, a fast & blue **optical** transient was detected by the Zwicky Transient Facility (**ZTF**) optical survey at the Palomar Observatory.

• From a small star-forming galaxy $2 \times 10^9$ light years away.

• In 2021, detected in the **radio** by the NRAO’s Very Large Array (**VLA**) and uGMRT.

→ **AT2020mrf** is another Cow-like Event!
One year after the stellar death... still detected by Chandra!

- AT2020mrf’s X-ray is $\times 20$ brighter than AT2018cow at $\sim 1$ month since explosion

- *Chandra* observations in June 2021
  AT2020mrf’s X-ray is $>200$ brighter than AT2018cow at $\sim 1$ year since explosion

- 29 photons received in the 1st 6 hours, 10 photons received in the second 6 hours
  Fast X-ray variability persists

$\rightarrow$ *X-rays must be supplied by an active central engine*
Nature of the central engine

An actively accreting **black hole** or a rapidly spinning **neutron star**

*Credit: Bill Paxton, NRAO/AUI/NSF  Credit: Shanghai Astronomical Observatory, China*
What we have learnt from AT2020mrf?

1. The most luminous Cow-like supernova in the X-ray

2. Demonstrates the diversity of Cow-like events

3. Further established Cow-like events as an emerging class of stellar explosions that produce an active central “engine” (i.e., a black hole or a neutron star) that is mostly exposed to the observers.

Cow-like events will continue to be prime transients for X-ray telescopes. X-ray observatories provide an important window onto the birth of compact objects.
AT2020mrf

The Most X-ray Luminous Cow-like Supernova

Yuhan Yao (Graduate Student, Caltech)
with Anna Ho (UC-Berkeley), Dan Perley (LJMU),
and the SRG team

yyao@astro.caltech.edu