Very Early Optical & UV Observations of Kilonovae are Important

Here’s Why

Iair ("ya-eer") Arcavi
UC Santa Barbara & Las Cumbres Observatory
(soon: Tel Aviv University)
Compilation from: Arcavi 2018


Retrieved via: kilonovae.space
Single component radioactive decay can not explain all bands.

Compilation from: Arcavi 2018


Retrieved via: kilonovae.space
Three component radioactive decay model gives a better fit (10 parameters).

Compilation from: Arcavi 2018


Retrieved via: kilonovae.space
Different emission components can come from different ejecta components.
Different ejecta components constrain different physics.
Different Models for the Blue $\rightarrow$ Red Emission

Multi-component radioactive decay
Villar et al. 2017

Single-component radioactive decay
(time-varying opacity) Waxman et al. 2017

Boosted relativistic ejecta
(early blue-emission) Kasliwal et al. 2017, see also Nakar & Piran 2017, Gottlieb et al. 2017

Shock cooling
(early blue-emission) Piro & Kollmeier 2017
Boosted / Shock Cooling = Evidence of Cocoon

Kasliwal+ 2017
Piro & Kollmeier 2017
see also Nakar & Piran 2017, Gottlieb+ 2017
Polar Ejecta = Constraint on the Viewing Angle

LIGO & Virgo Collaborations et al. 2017, Nature
Boosted emission provides good fit, but can it have a rise time of ~1d?

Compilation from: Arcavi 2018


Retrieved via: kilonovae.space
Adding shock cooling can also improve the fit, but contradicts peak time of ~1d.

Data from Las Cumbres Observatory identifies the peak thanks to sub-day cadence!
Adding shock cooling can also improve the fit, but contradicts peak time of ~1d.

Data from Las Cumbres Observatory identifies the peak thanks to sub-day cadence!
Would Have Solved With LIGO Localization 1h Earlier

Arcavi et al. 2017a, Nature
UV - Optical Discovery Time Difference Was Critical

Arcavi 2018
Predicted One-Hour Time Scale Blue Emission

Metzger et al. 2015
Early Optical-UV Kilonova Observations Are Crucial

What is the source of the early blue emission?
Radioactive decay from low opacity ejecta, radioactive decay from boosted high velocity ejecta, shock cooling, or combinations thereof?

This is important: Various ejecta components potentially constrain NS EOS, nucleosynthesis, jet launching, cocoon forming, inclination angle (→ Hubble Constant).

Early data critical! Distinguishing between emission models requires optical-UV observations starting few hour/s after merger (10 hours is too late) with sub-day cadence.
Technical Topics for Discussion

Are Fermi localizations going to be in the same format as LVC ones? Our search was delayed in order to adjust our pipeline to use the GRB170817 Fermi localization.

Are there going to be joint Fermi-LVC localization maps? In case one GW detector is offline, combining maps could significantly narrow the search region.

Is there going to be an API to report and query EM search locations? A first step for coordinating followup and avoiding duplications.