Multi-Messenger Astrophysics Parameter Estimation for GW and EM data channels

Benjamin Champion, Ofek Birnholtz & Richard O'Shaughnessy
Center for Computational Relativity and Gravitation, Rochester Institute of Technology

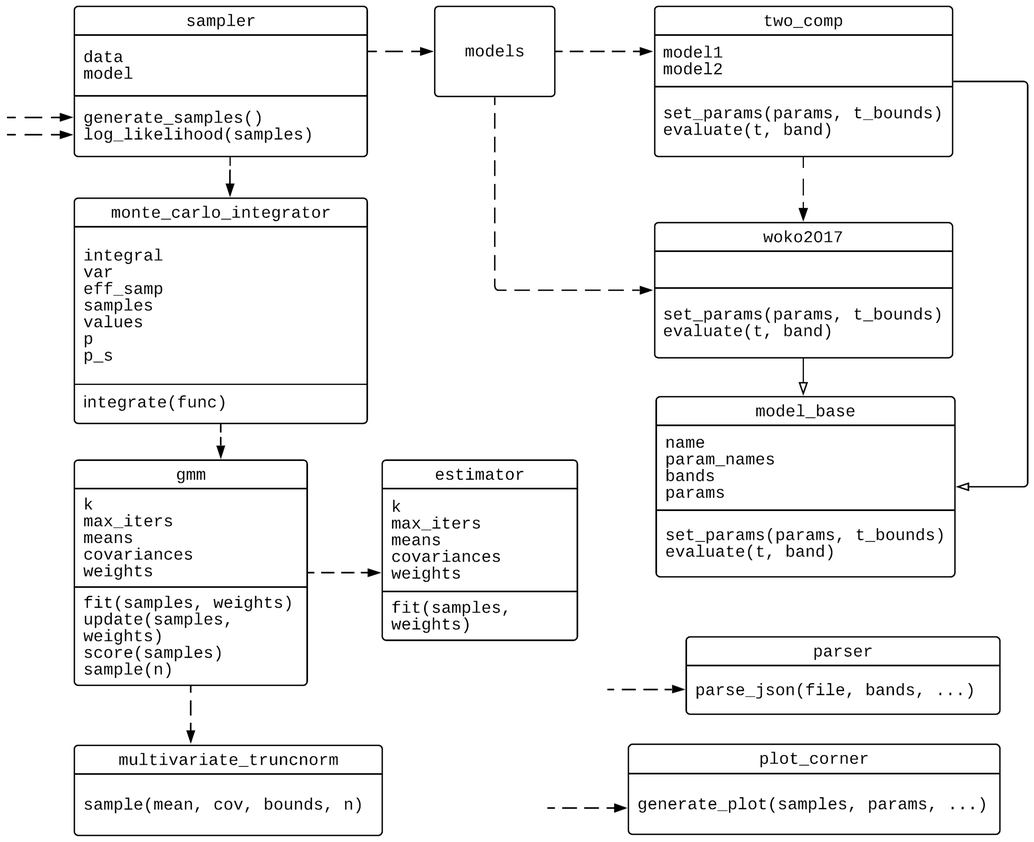
Overview

We automate generation of light-curves from astrophysical explosions to facillitate joint electromagnetic and gravitational-wave parameter estimation from multi-messenger sources. Features include:

1. Lightcurve generation across multiple bands in EM spectrum, leveraging various existing packages like [2]
2. Modular design enabling multi-component models
3. Open-source python implementation
4. Monte-Carlo Integrator (prototype for / similar to updated RIFT MC engine) and Gaussian Mixture Models used to perform parameter estimation
5. Also easily integrated with multiple PE frameworks (e.g., RIFT)

Code Design

Figure 1: code



Recovery of Injection

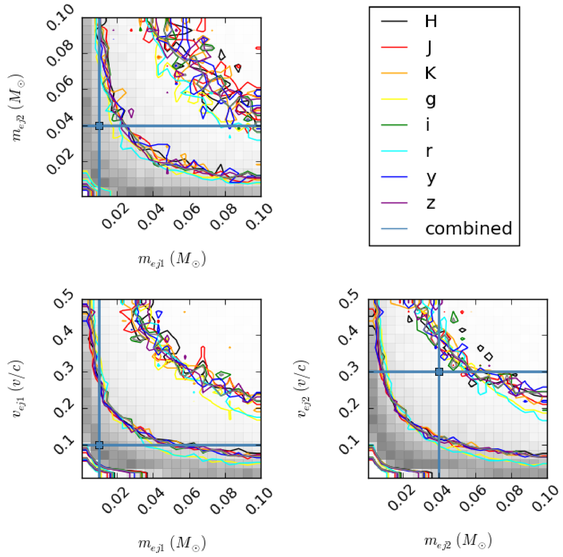


Figure 2: Recovery of injection across bands

Mock Light Curves

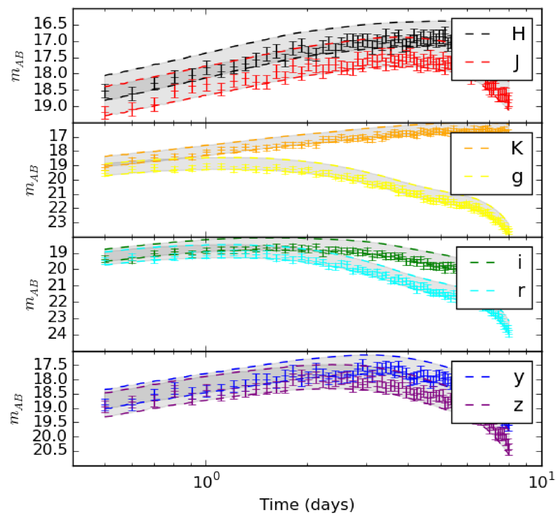


Figure 3: Synthetic lightcurves

Recovery of GW170817

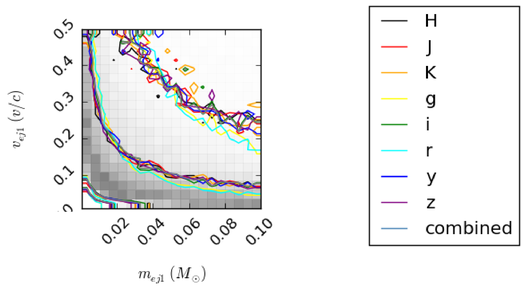


Figure 4: Recovery of GW170817 across bands

Real Light Curves

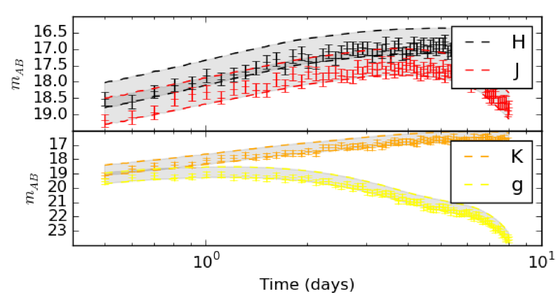


Figure 5: GW170817 lightcurves

Upcoming Developement

- Increase complexity of light curve models (e.g., orientation dependence; radio)
- optimize over sky position, orientation and lightcurve generation
- Run together with gravitational waveforms, for full multi-messenger parameter estimation!

References

[1] Open astronomy catalogs. https://astrocats.space.

[2] gwemlightcurves. https://gwemlightcurves.github.io/.

[3] Ryan T. Wollaeger and Oleg Korobkin et al. Impact of ejecta morphology and composition on the electromagnetic signatures of neutron star mergers. *Mon. Not. Roy. Astron. Soc.*, 478(3):3298–3334, 2018.

Contact Information

Web https://ccrg.rit.edu/
Email bwc3252@rit.edu
Phone +1 (585) 475 5943