Gamma-ray burst and Tidal Disruption Events with LSST

December 2018

Abstract

We aim at making predictions about the science potential of LSST regarding the observation and characterization of the populations of gamma-ray burst (GRB) orphan afterglows and of tidal disrution events (TDE). The said predictions can be used to optimize the survey strategies and to prepare the community to take the most out of the LSST data stream. Together with the INAF–OAR group led by E. Brocato, we are also part of a larger community of astronomers interested in the possibility of having target-of-opportunity (ToO) capabilities in LSST, specifically aimed at the electromagnetic follow-up of gravitational wave (GW) sources.

1 Quintuplet Information 2018

Sergio Campana (PI)
Giancarlo Ghirlanda (quiescent co-PI)
Paolo D'Avanzo (INAF researcher since 2017)
Andrea Melandri (INAF researcher since 2018)
Deborah Mainetti (PhD student until 14/3/18)
Om Sharan Salafia (PhD student until 14/3/18; postdoc since 2/5/18)

2 Quintuplet Information 2019

Giancarlo Ghirlanda (PI)
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Om Sharan Salafia (postdoc)

Scientific Collaborations:

1. Transients and Variable Stars (TVS)

3 Scientific Activity

Describe the scientific activity of the quintuplet (Limit: 1 page + 1 page for figures/tables.)

During 2018, we participated in writing a white paper (led by R. Margutti) to ask for the implementation of ToO capabilities in LSST, specifically focused on the GW electromagnetic follow-up. O. S. Salafia was one of the section leaders. O. S. Salafia also took part in the Flatiron Cadence Hackathon on NY, where he won a prize with his presentation "ToO Afraid?", with which he showed that the impact of the said ToOs on the other science cases is negligible.

We are currently working on a population synthesis approach (similar to G15) to predict the number and features of the long GRB (both orphan and on-axis) afterglow population to be detected by LSST. The population of events is based on a detailed modelling of prompt emission properties of long GRBs taking into account all observational constraints (similar to G16, with updated constraints and refined methods). The afterglow emission is modelled with a fast and reliable code developed within our group, which allows for the modelling of structured jets (among the other goals, we aim to assess the impact of jet structure on the observed population properties). Once the synthetic population is simulated, including realistic contributions of absorption on the optical afterglow emission and host galaxy and SN emission template, we will use the LSST metric analysis framework (MAF) to derive the rate and properties of the population to be observed by LSST. A similar approach will be followed for the predictions of the number and features of the short GRB population (starting from G16 and including the refinement of jet structure) that can be detected by LSST. Finally, a similar approach will be devoted to the predictions for the detection rate of TDEs.

The timeline of this project foresees a possible first publication devoted to the detection rates of pointed and off–axis long GRBs already during 2019. Preliminary results, once the implementation of the population code with the MAF is complete and after some consistency checks, will be presented to the LSST collaboration and in particular within the TVS science working group.

The development of the same study for the population of short GRBs will proceed in parallel and might be boosted towards completion also by the possible new constraints attainable during the next observing run (O3) of the gravitational wave interferometers. In the meanwhile, following an empirical approach, we collected all detections and upper limits in the optical/NIR bands for about 130 *Swift* short GRBs occurred from 2004 November to July 2017 and used this sample to study the average properties of short GRB optical/NIR afterglows in the observer and in the rest-frame. This sample can be used as a tool (and benchmark for simulations) to provide estimates of the expected rate of detections of on- and off-axis short GRB afterglows with LSST and to test the possibilities to disentangle any associated kilonova emission.

Population studies for TDE should start early in 2020.

4 Scientific and technical deliverables

- White paper "Target of Opportunity Observations of Gravitational Wave Events with LSST" led by R. Margutti, co-authored by M. G. Bernardini, P. D'Avanzo, G. Ghirlanda, A. Melandri and O. S. Salafia (section leader).
- Dedicated publication for the detection rates and properties of the population of long GRBs (to be completed and submitted by the end of 2019).
- MAF notebook and modified OpSim database to assess the impact of GW ToO on the other science cases.

List of attached documents:

1. white paper on GW ToO observations

5 Other information

- Participation in the LSST TVS Workshop inn Naples, April 2018 (O. S. Salafia)
- Partecipation in the LSSTEurope3 - Building Science Collaborations congress (June 2018) where P. D'Avanzo contributed a talk entitled "Short gamma-ray burst afterglows and kilonovae: perspectives with LSST"
- Partecipation in the "LSST Cadence Hackaton" (September 2018) held at the Flatiron Institute (NYC-USA), where O. S. Salafia won a prize with the talk entitled "ToO afraid?"
- Participatio in the Italian LSST meeting in Rome (December 2018), where O. S. Salafia will present the activities of our group

6 References

(G15) Ghirlanda, G.; Salvaterra, R.; Campana, S.; Vergani, S. D.; Japelj, J.; Bernardini, M. G.; Burlon, D.; D'Avanzo, P.; Melandri, A.; Gomboc, A.; Nappo, F.; Paladini, R.; Pescalli, A.; Salafia, O. S.; Tagliaferri, G., *Unveiling the population of orphan γ-ray bursts*, A&A 578 A71, 2015

(G16) Ghirlanda, G.; Salafia, O. S.; Pescalli, A.; Ghisellini, G.; Salvaterra, R.; Chassande-Mottin, E.; Colpi, M.; Nappo, F.; D'Avanzo, P.; Melandri, A.; Bernardini, M. G.; Branchesi, M.; Campana, S.; Ciolfi, R.; Covino, S.; Götz, D.; Vergani, S. D.; Zennaro, M.; Tagliaferri, G., *Short gamma-ray bursts at the dawn of the gravitational wave era*, A&A 594 A84, 2016