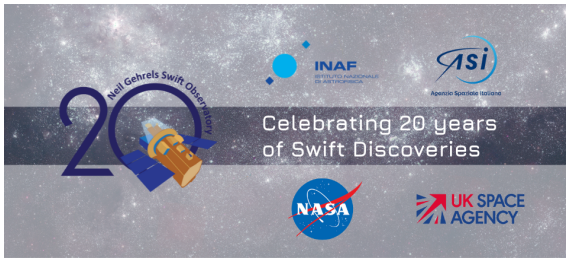

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First version of a Fink filter to identify Orphan Gamma-Ray Burst Afterglows among the Rubin LSST data

Tuesday 25 March 2025 14:29 (1 minute)

Gamma-Ray Bursts (GRBs) rank among the most energetic phenomena in the Universe. Thanks to the Swift and Fermi observatories, significant progress has been made in GRB science over the past decades, but one area of research that now requires exploration are the still elusive GRB orphan afterglows. We define orphan afterglows as GRB afterglows viewed off-axis, which have hence a negligible gamma-ray flux. They are promising candidates to learn more about GRB physics, jets and progenitors, as well as for the development of multi-messenger astrophysics with gravitational waves.

So far, only a few orphan afterglow candidates have been found, but the Rubin Observatory is expected to enhance the detection of these faint sources thanks to its large field of view, large mirror and survey mode operations. In this presentation, we will show our work done in order to find orphan afterglows in the Rubin wide, fast, deep survey. To identify orphan afterglows, we used the characteristic features of their light curves that we computed within the framework of the forward shock model associated with electron synchrotron emission. We first generated robust populations of GRBs based on Swift catalogues, and simulated their off-axis afterglow light curves using afterglowpy (Ryan et al., 2020). We simulated their detection by Rubin LSST in order to extract various light curve features. In addition, we designed a new method to fit the light curves with observations in multiple bands by renormalising the bands to the r-band. We developed a high-performance machine learning filter capable of discriminating these rare orphan-like events from all other variable objects.

We will present the performance of our filter as implemented in the Fink broker and tested on the ELAsTiCC (first simulation of Rubin LSST alerts, with millions of synthetic transient light curves and host galaxies) data set and our own Rubin observation simulations of orphan afterglows. Our code is open-source, implemented in Fink, and ready to receive the first Rubin data expected in the coming months.

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