Thesis subject

Name of the laboratory: LAM

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Subject's title: **Panchromatic analysis from the X-ray to the optical to characterize GRB and their hosts: SVOM/COLIBRI synergy**

Subject description: Gamma Ray Bursts (GRBs) are the most violent explosions occurring in the universe. They are astronomical transients probing advanced high energy astrophysics. They also provide unique beacons of light to probe the interior of star-forming galaxies, up to very high redshift with the most luminous bursts. The future space mission SVOM will reveal GRBs occurring in galaxies over a very large range of redshifts. A first challenge is to estimate as quickly as possible the redshift of these sources to optimize the follow-up observations.

The measure of this redshift is performed with the observation of the synchrotron emission emitted during the remanent phase, hereafter called the afterglow. The photons of the afterglow interact with the interstellar medium of the host galaxy and with the intergalactic medium, and these interactions imprint its spectral emission. The redshift is determined by searching for the imprint of these resulting features in the spectrum of the afterglow emission. The GRBs also deliver a unique information on the properties of the interstellar medium of galaxies along their line of sight and up to the very high redshifts because of their extreme luminosity. The afterglow probes a single line of sight in the host galaxy, and gas, heavy elements and dust present in the interstellar medium leave specific marks in its spectrum. Therefore, the observation and modelling of the afterglow emission of the GRB soon after the burst is crucial to characterize both the GRB and its host galaxy.

GRBs can also be interesting high-energy accelerators. Recently, a few sources have been detected up to the very high-energy gamma-ray band, probing the efficient acceleration of electrons in the jet, with high-energy neutrinos potentially produced as secondary processes. Despite intensive searches around the detected gamma-ray bursts, up to now no signal has been identified, probably because of the low target density in the jets. SVOM with the low energy threshold of ECLAIRs should be able to detect jets crossing much larger densities. These events must be confirmed with a near-infrared follow-up.

The French Ground Follow-up Telescope, named COLIBRI, will provide the optical and near infrared observations needed to get a first determination of the photometric redshift of GRBs detected onboard SVOM a few minutes after the burst. A redshift can be estimated with COLIBRI data only as demonstrated (Corre, 2018). The addition to COLIBRI data of X-ray data from the MXT instrument on board of the SVOM satellite will provide a crucial information to fit the light curve of the afterglow. The intrinsic synchrotron emission is modelled as simple power-laws, and the effect of the interstellar medium on photometric data is described by an extinction curve which depends only on dust properties (Zafar et al. 2011) This dust extinction does not reduce the X-ray emission which is only affected by photoelectric absorption due to gas along the line of sight. Therefore, the combination of X-ray measurements with optical and NIR photometric data will break degeneracies in parameter estimation and lead to both more reliable photometric redshifts and key properties of the interstellar medium of the host galaxy (global amount of extinction, extinction curve, hydrogen column density). This combined analysis of SVOM and COLIBRI observations will improve the performance of SVOM to identify particularly interesting events, as GRB's jets possibly producing high-energy neutrinos.

The proposed thesis will start few months before the launch of SVOM scheduled between December 2022 and February 2023, with the first data arriving few weeks after the launch.. It is a perfect timing to finalize the follow-up program and data analysis tools, and work on the first datasets. Moreover, it offers the advantage of highlighting instruments developed by France for the mission, while developing very original and promising techniques never implemented until now.

The first year will be dedicated to the modification of the existing code to analyse the afterglow emission with the addition of the X-ray data, and to implement the characterization of the interstellar medium with the estimation of key parameters. The performance of the code will be first tested on realistic simulated data of SVOM and COLIBRI data.
The second year will be dedicated to the first exploitation of SVOM and COLIBRI data, and to test the code on real data. The code will be mainly used to select rare GRB events as high-z GRBs or highly extinguished GRBs which will deserve deeper follow-up studies to probe their physics and surrounding environment conditions. The PhD student will also take part to the follow-up campaigns on larger telescopes through international collaborations and . optimized observing strategies.

The candidate will have to be familiar with Python. The implementation of machine learning methods to improve the statistical analyses will be investigated.

If the launch is delayed, the analysis of simulated data can be easily extended and a database of already observed GRBs by several GRB missions and followed-up by hundreds of ground-based optical/IR/radio telescopes

Bibliography:
Corre, D. PhD thesis , http://www.theses.fr/24093685X

Zafar et al. 2011, A&A, 532, 143 , 10.1051/0004-6361/201116663