UNIVERSITÀ DI FERRARA

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Scientific Collaboration with Brazil: status and prospects

A note by
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This collaboration started when Dr. João Braga, Vice-Director of INPE (Istituto National de Pesquitas Espaciais, Sao José dos Campos, Brazil) and Principal Investigator of the Brazilian small mission MIRAX, invited Filippo Frontera (former PI of the GRBM project aboard BeppoSAX) and his team to propose a payload devoted to GRBs for the MIRAX payload. The proposal was welcome. Indeed, since the early 2002, after the BeppoSAX mission conclusion, they were pursuing this goal.
An advanced GRBM study was already performed by FF and his team in Ferrara and in Bologna (reference person here Lorenzo Amati), for the phase A study of the LOBSTER mission, led by University of Leicester (PI George Frazer), aboard the International Space Station (ISS). Unfortunately, the mission was stopped by NASA following the decision by NASA to stop the visits to ISS.

Thus the Bologna-Ferrara GRBM team was happy to propose a payload devoted to GRBs for MIRAX. A proposal of such a payload, in collaboration with INAF-IASF Rome (reference person Marco Feroci), was then submitted to INPE. In occasion of a joint meeting held at INPE in San José dos Campos in June 2010, Italian proposal was long discussed and accepted by INPE.
The instrument proposed, with a broad passband from 2 keV to 20 MeV, included an array of Silicon Drift Chambers (SDC) surmounted by a coded mask, and a phoswich detector array in the successful configuration (PDS) launched aboard BeppoSAX. The SDCs were later proposed for the LOFT mission, approved by ESA for a Phase A study. In addition to this instrumentation, a hard X-ray (20-200 keV) monitor, based on CZT detectors, was added by Joao Braga to the Italian Payload. The science case of Italian payload devoted to GRBs is still very strong. It was reported to Scientific Board of ICRANET last year.

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Unfortunately ASI was not so timely in the decision of approving thy mission opportunity. The ASI President Enrico Saggese requested an evaluation of the mission to the Italian Institute of Astrophysics (INAF), that was given in May 2011. In the meantime an agreement was signed by INPE with the Center for Astrophysics (CFA) of the Harvard University and now MIRAX is going on with a different payload configuration in collaboration with CFA (responsible: Josh Grindlay).

Instead the collaboration with Brazil on GRBs was prosecuted, inviting Joao Braga to join us in GAME, a small mission proposed by us (PI Lorenzo Amati) to ESA (submission in June 2012) in response to the last call for small mission proposals to be launched in 2017, issued in March 2012.

GAME is a more advanced version of the payload proposed for MIRAX. Its science case is equally very strong (see Appendix).
Joao Braga was happy to join us and he contributed to the preparation of the proposal. He also got a preliminary endorsement letter by the Brazilian Space Agency (AEB), for contributing to the mission with the already developed Brazilian Multi-Mission Platform (PMM).
Unfortunately GAME has not been selected: the selected mission is CHEOPS, devoted to exo-planet search.
However we are convinced about the great potentiality of such a mission for GRB science and cosmology, and for all-sky X-ray monitoring.

Thus it is our intention to propose, in collaboration with Brazil, GAME or something better in future ESA calls for small missions. But we would also appreciate to propose GAME for any mission of opportunity, similar to MIRAX, that would come from Brazil. Indeed a program of small satellite missions is planned (or envisaged) by AEB. This opportunity would very exciting for proposing a payload like GAME or better.

Appendix

GAME science objectives

The proposed **GAME** mission has two main scientific objectives:

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a) measuring the photon spectrum and timing of the prompt emission of gamma ray bursts (GRBs) over a broad energy band, from ~1 keV to 20 MeV, combined with arcmin location accuracy;
b) monitoring the X-ray sky in the 1 – 200 keV band with a few arcmin source location accuracy and a few mCrab daily sensitivity over a large field of view
Concerning GRBs, GAME will give the answer to still several open questions of fundamental importance for the physics of the GRB phenomenon and for exploiting GRBs as cosmological rulers, among which:
1. to detect expected transient X-ray absorption column and absorption features for tens of medium/bright GRBs per year (see details in Section (e) below). These measurements are of paramount importance for the understanding of the properties of the Circum-Burst Matter (CBM) and hence the nature of GRB progenitors (a still fundamental open issue in the field). In addition, the detection of transient features can allow the determination of the GRB redshift to be compared, when it is the case, with that determined from the optical/NIR lines;
2. to perform unbiased measurements of time resolved spectra within single GRBs down to about 1 keV. This is crucial for testing models of GRB prompt emission (still to be settled despite the considerable amount of observations).
3. to provide a substantial increase with respect to the past and current missions) in the detection rate of X-Ray Flashes (XRF), a sub-class of soft / ultra-soft events which could constitute the bulk of the GRB population and could be the missing link between high luminosity hard bursts and the low luminosity/relatively soft GBRs with associated SN events.
4. to significantly increase the GRB detection up to very high redshift ($z > 8$), which is of fundamental importance for the study of evolutionary effects, the tracing of the star formation rate, ISM evolution, and possibly unveiling population III stars;
5. to perform an accurate determination of spectral peak energy, which is a fundamental quantity for the test and study of spectrum-energy correlations and the possible use of GRBs as cosmological probes;
6. to provide fast (within 1 min) and accurate (within 1-2 arcmin) location of the detected GRBs to allow their prompt multi-wavelength follow-up with ground and space telescopes, thus leading to the identification of the optical counterparts and/or host galaxies and to the estimate of the redshift, a fundamental measurement for the scientific goals listed above.
Concerning the all sky-monitoring, the scientific objectives of **GAME** include:
1. detection and localization within a few arcmin of Soft Gamma-ray Repeaters (SGR), X-ray bursts (XRB) and many other classes of galactic X-Ray Transients (XRT), like, e.g., Galactic low and high mass X-ray binaries in outburst, cataclismic variables, accreting ms pulsars, etc., for spectral and timing studies;
2. to trigger follow-up observations by ground and space observatories, a fundamental service for the world-wide community, in particular now that RXTE is stopping its activity;
3. to perform an all-sky survey in the hard X-ray band up to 200 keV, contemporary to that of eROSITA at lower energies.
The above science goals address fundamental questions of the ESA Cosmic Vision 2015-2025, like the following: what are the fundamental laws of the Universe? Which is the physics of matter in extreme conditions? how did the Universe originate and what is made

of? GRBs not only allow to investigate the physics of the most energetic phenomena, but are expected to be become, with the mission we are proposing, a new well established probe of cosmology theories.

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