

# THE CAPIGX Mission: Overview of the High-Energy Electromagnetic Mission for the 2030s

JOAN ALCAIDE-NÚÑEZ  <sup>1</sup>

CAPIBARA COLLABORATION<sup>a</sup>

<sup>1</sup> Ludwig-Maximilians Universität München, Fakultät für Physik, Geschwister-Scholl-Platz 1, 80539 München, Germany

## ABSTRACT

This is the abstract.

**Keywords:** Galaxies (573) — Cosmology (343) — High Energy astrophysics (739) — Interstellar medium (847) — Stellar astronomy (1583) — Solar physics (1476)

## 1. INTRODUCTION

Since the first detections of GRBs in the 1960s high-energy astrophysics has bloomed with multiple mission having been launched in order to obtain observations of these phenomena. These observations enable the pursuit of knowledge through the full electromagnetic spectrum, with  $\gamma$ - and X-ray representing the high-energy end of the spectrum. This is the side of the Universe where the physical limits are reached with black holes (BHs), Gamma-ray Bursts (GRBs), neutron stars (NS; including pulsars and magnetars, gravitational waves (GW) etc.

However, in the realm of high-energy transients there still are much more mysteries to unfold: the nature of high-energy transients (B. P. Gompertz et al. 2023) (M. E. Ravasio et al. 2024), the equation of state (EOS) of compact objects ((Z. Ji & J. Chen 2025), (W.-Z. Qiumu et al. 2025), particle acceleration mechanisms (L. Miroshnichenko & W. Gan 2012), among many other interrogations including high-energy events as cosmic probes (E. Abdalla et al. 2022), (M. Dainotti et al. 2023). Furthermore, high-energy events are key for multi-messenger astronomy, i.e. finding counterpart observations of gravitational waves (GW) (C. MISSING 2030) and neutrino ( $\nu$ ) radiation (C. MISSING 2030). Thus, and X-rays play a central role in this exploration, enabling the study of the Universe is all its aspects.

In order to advance in our understanding of the energetic Universe, we need observations, data to test and craft theoretical models and data to analyze the behav-

ior of these transient phenomena. Neither  $\gamma$ -ray nor X-ray radiation do penetrate Earth's atmosphere ??, thus making high-energy astrophysics only feasible via space-based observatories, which need to provide complete datasets, including prompt and afterglow emissions ?. It is true that very high-energy (VHE)  $\gamma$ -ray and ultra high-energy (UHE) cosmic rays (CR, ionic particles) can be detected using ground-based Cherenkov Telescopes C. MISSING (2030) (CTA, CTAO), which observe the Cherenkov light emitted from relativistic particles from particle showers. However, the electromagnetic radiation emitted by high-energy astrophysical transients does not fall within this energy range C. MISSING (2030).

In this paper, after reviewing the current status of available high-energy transient observational capabilities, I present the CAPIGX mission. The time-domain, multi-messenger mission to cover the hard X-ray to soft  $\gamma$ -ray range in the 2030s. Describing its goals and capabilities and outlining the plans of the CAPIBARA Collaboration to bring this concept to life.

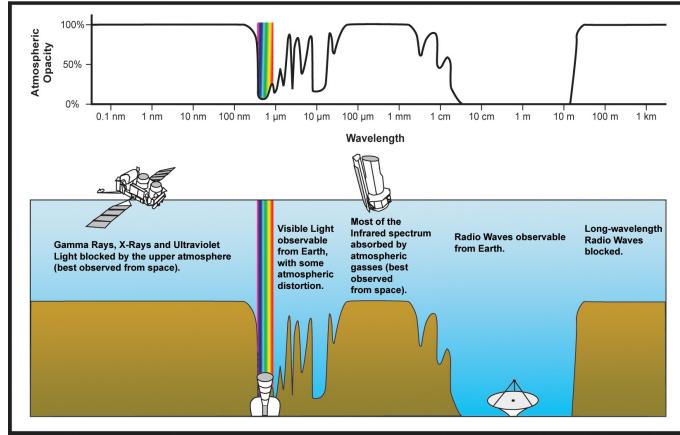
## 2. OVERVIEW OF CURRENT STATUS

Since the 2000s, there are two major missions still active: the Neil Gehrels Swift X-ray Observatory C. MISSING (2030) and the FERMI Gamma-ray Telescope C. MISSING (2030). Both having transient monitoring instruments covering relatively wide energy ranges. Since then, multiple telescopes have been launched: NICER C. MISSING (2030) (2017, soft X-ray), XRISM C. MISSING (2030) (202X), Einstein Probe C. MISSING (2030) (2023, soft X-ray), SVOM C. MISSING (2030) (202X), and HERMES (202X).

INTEGRAL, an observatory of the European Space Agency (ESA) launched 2002 was recently turned offline

Email: capibara-mission@outlook.com

<sup>a</sup> Collaboration for the Analysis of Photonic and Ionic Bursts and Radiation



**Figure 1.** Atmospheric opacity by wavelength (credit: NASA, Public Domain via Commons)

in March 2025. Additionally, changes in the NASA budget will lead to shutting down Swift and Fermi before 2026. The Compton Spectroscopy Instrument mission (COSI) targeting the 1–5 MeV range was also canceled due to funding. Continued high-quality observations are not granted. In this context, space agencies and scientific institutions have taken action, with new X-ray and  $\gamma$ -ray missions being proposed and planned, as seen in table ??

- 2.1. *Recently Launched Missions*
- 2.2. *GECAM-A/B*
- 2.3. *XRISM*
- 2.4. *Einstein Probe*
- 2.4.1. *SVOM*

The Space-based multi-band astronomical Variable Objects Monitor (SVOM) mission is a Franco-Chinese space mission launch on June 22, 2024 with the aim to study the most distant explosions of stars, Gamma-ray Bursts (GRBs) (?). It features four instruments three X-ray to instruments, to detect GRBs along the high-energy spectrum: ECLAIRs for GRB localisation (4–250KeV), MXT for microchannel X-ray observations (0.2–10keV) and GRM to measure the spectrum of GRBs (15keV–1MeV); and a visible telescope to observe the immediate afterglow. Space-based observations are also supported with two optical, ground-based telescopes to accurately measure GRB coordinates and to detect the visible part of the GRB radiation. SVOM is the result of a collaboration between China National Space Administration (CNSA) and Centre National d'Études Spatiales (CNES), as well as the Institute of Research into the Fundamental Laws of the Universe (IRFU), the Research Institute of Astrophysics and Planetology (IRAP), the National Astronomical Observatory (NAO) and the Beikng High Energy Institute (IHEP).

#### 2.4.2. *HERMES*

HERMES-SP (High Energy Rapid Modular Ensemble of Satellites – Scientific Pathfinder) is a mission concept based on a constellation of nano-satellites in low Earth orbit (LEO), hosting new miniaturized detectors to probe the X-ray temporal emission of bright high-energy transients such as Gamma-Ray Bursts (GRB) and the electromagnetic counterparts of Gravitational Wave Events (GWE) – hence playing a pivotal role in multi-messenger Astrophysics of the next decade.

HERMES-SP goal is to design and implement the first Gamma-Ray Burst localisation experiment through a distributed space architecture realized by a 3+3 CubeSat federation. Each CubeSat will be equipped with a novel miniaturised detector to gain a wide deep space coverage, and demonstrate capabilities in precisely localising GRB events in space. 11 partners from 5 European countries form the HERMES-SP Consortium.

#### 2.5. *Proposed Future Missions*

##### 2.5.1. *COSI (cancelled)*

The COSI (Compton Spectrometer and Imager) mission is a  $\gamma$ -ray survey telescope designed to probe the origins of Galactic positrons, uncover the sites of nucleosynthesis in the Galaxy, perform pioneering studies of polarization, and find counterparts to multi-messenger sources (?). It will cover the soft range between 0.2 MeV and 5 MeV. COSI combines improvements in sensitivity, spectral resolution, angular resolution, and sky coverage to contribute to the astrophysics field. The space telescope is currently scheduled for launch in 2027. The COSI mission is developed by the University of California, Berkeley's Space Sciences Laboratory; the University of California, San Diego; the Naval Research Laboratory, NASA's Goddard Space Flight Center, and Northrop Grumman.

### 2.5.2. THESEUS

The Transient High Energy Sky and Early Universe Surveyor (THESEUS) is a mission concept selected by ESA for launch in 2032. It is designed to increase the discovery space of the high energy transient phenomena over the cosmic history. Addressing open questions about the Early Universe and multi-messenger interferometry. Its main goals are deep sky monitoring in a broad energy band (0.3keV - 20 MeV), leveraging focusing capabilities and high angular resolution in the soft X-ray band, and on board near-IR capabilities for immediate transient identification and redshift determination. (?) (?). THESEUS is a mission coordinated by the Istituto Nazionale di Astrofisica (INAF-OAS) at Bologna, Leicester University, Commissariat à l'énergie atomique at the University of Saclay, the Institut für Astronomie und Astrophysik Tübingen, and the University of Geneva. It is very important to emphasize,

what missions are ready for launch/tuning in soon, or are concepts studied for launch in the  $\gtrsim$ 2030 era

### 2.5.3. HiZ-GUNDAM

The High-z Gamma-ray bursts for Unraveling the Dark Ages Mission (HiZ-GUNDAM) is a mission that will search for evidence of the first generation of stars (also population I stars) through the detection of gamma-ray burst (GRB) afterglows in the ancient Universe ( $z > 7$ ). The mission will also contribute to multi-messenger astronomy comparing the X-ray and Infrared (IR) observations of neutron star (NS) mergers with gravitational wave data (?). HiZ-GUNDAM will feature a wide-field X-ray detector to capture GRB phenomena as well as an infrared telescope to quickly observe the afterglow and measure the redshift of the corresponding celestial body. The wide-field X-ray detector of HiZ-GUNDAM should cover an energy range between 0.1 and 150 keV HiZ-GUNDAM the Japanese Aerospace Exploration Agency (JAXA) and the Institute of Space and Astronautical Science (ISAS).

Name	Status	Launch	Energy Range	Mission Type	Key Capabilities	Primary
<b>Launched</b>						
INTEGRAL	Terminated 2025	2002	3 - 150 keV 150 keV - 10 MeV	-	-	-
FERMI	Not granted in 2026	2004	NaI: 8 keV - 1 MeV BGO: 150 keV - 30 MeV	-	-	-
SWIFT	Not granted in 2026	2008	BAT: 15 - 150 keV XRT: 0.2 - 10 keV	-	-	-
NICER	Active	2017	0.2 - 12 keV	-	X-ray timing	-
GECAM-A/B	Active	2020	6 keV - 5 MeV	-	-	-
XRISM	Active	2023	-	-	-	-
Einstein Probe	Active	2023	WXT: 0.5 - 4 keV	-	-	-
SVOM	Active	2024	ECLAIRS: 4 - 120 keV GRM: 50 keV - 5 MeV	-	-	-
HERMES	Active	2025	2 keV - 5 MeV	-	-	-
<b>Proposed</b>						
COSI	Cancelled	-	200 keV - 5 MeV	-	-	-
THESEUS	Proposed	2037	-	-	-	-
HiZ-GUNDAM	Proposed	-	-	-	-	-
DAKSHA	Proposed	-	1 keV - 1 MeV	-	-	-
MoonBEAM	Proposed	-	-	-	-	-
CATCH	Proposed	-	-	<sup>2</sup>	-	-
STAR-X	Proposed	2028	0.2 - 6 keV + UV	-	-	-
NewAthena	Proposed	2037	0.1 - 12 keV	<sup>3</sup>	-	-
CAPIGX	Proposed	2030–2035	1 - 150 keV 150 keV - 1 MeV or 150 keV - 5 MeV	-	Transient Monitoring	-

<sup>2</sup> X-ray constellation concept

<sup>3</sup> Large X-ray observatory

---

3. THE CAPIGX MISSION CONCEPT  
 3.1. *Scientific Goals*  
 3.2. *Detector Design*  
 3.3. *Optimized Orbit for Intensity Interferometry*  
 3.4. *Expected Detection Rates*

ACKNOWLEDGMENTS

AUTHOR CONTRIBUTIONS

*Facilities:*  
*Software:*

APPENDIX

REFERENCES

- Abdalla, E., Abellán, G. F., Aboubrahim, A., et al. 2022, Journal of High Energy Astrophysics, 34, 49
- Dainotti, M., Lenart, A. L., Chraya, A., et al. 2023, Monthly Notices of the Royal Astronomical Society, 518, 2201
- Gompertz, B. P., Ravasio, M. E., Nicholl, M., et al. 2023, Nature Astronomy, 7, 67
- Ji, Z., & Chen, J. 2025, <https://arxiv.org/abs/2502.05513>
- Miroshnichenko, L., & Gan, W. 2012, Advances in Space Research, 50, 736
- MISSING, C. 2030
- Qiumu, W.-Z., Chen, M.-H., Chen, Q.-H., & Liang, E.-W. 2025, <https://arxiv.org/abs/2501.19305>
- Ravasio, M. E., Salafia, O. S., Oganesyan, G., et al. 2024, Science, 385, 452