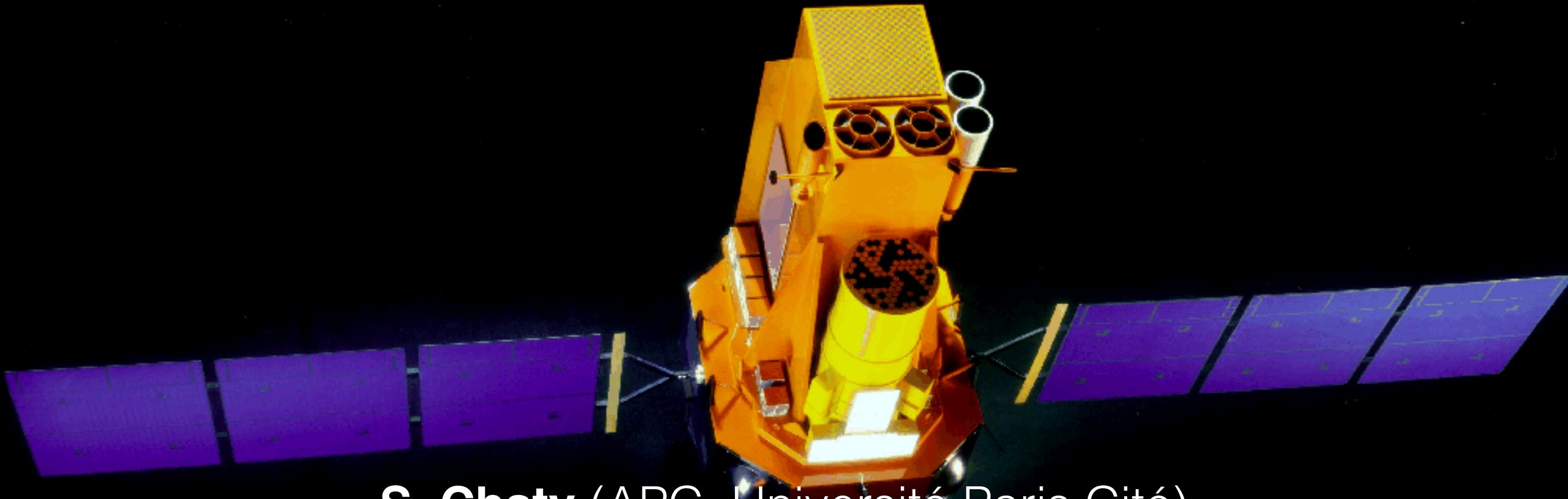


# **MINE: Multi-wavelength *INTEGRAL* NEtwork:** Identification & study of *INTEGRAL* sources



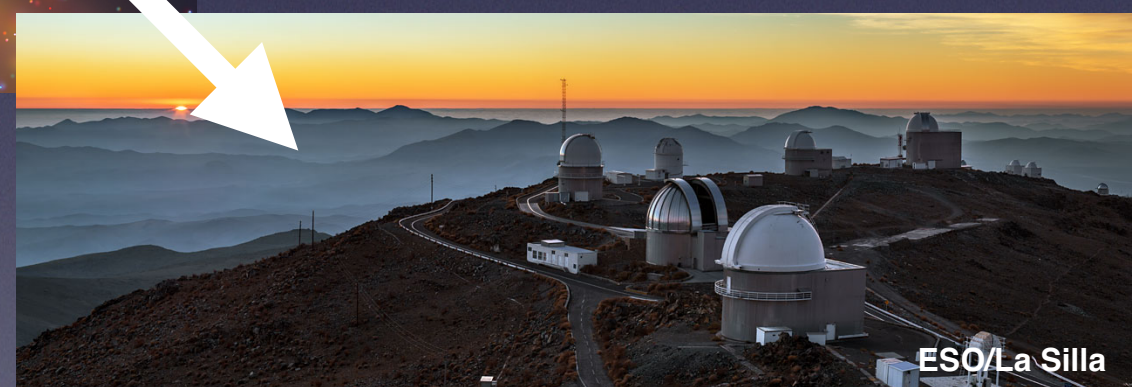
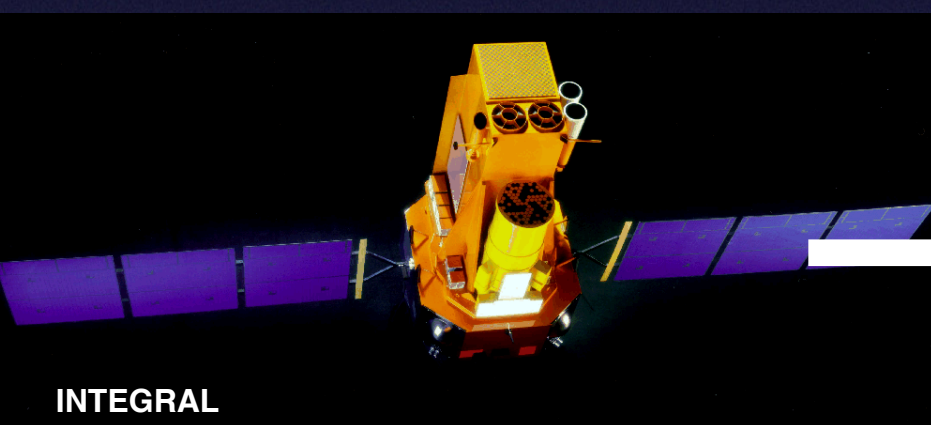
**S. Chaty** (APC, Université Paris Cité)

T. Courty (APC), F. Fortin (IRAP, France), I. Negueruela (U. Alicante), Q. Liu (PMO-CSA, China), J.A. Tomsick (Berkeley, USA)

Visite CNES@APC, 30/01/2026



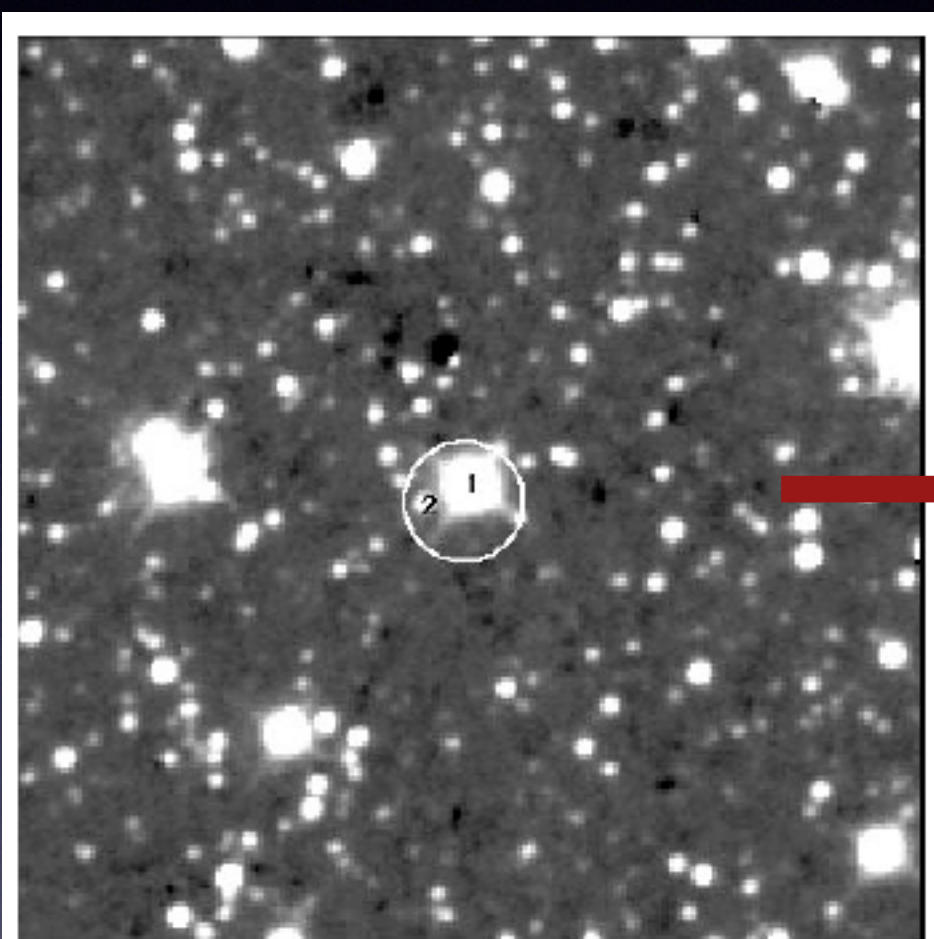
# Multi-wavelength study of *INTEGRAL* sources (1/3)



- *INTEGRAL* discovery -> *Chandra/XMM/Swift* localization -> ESO phot/spec

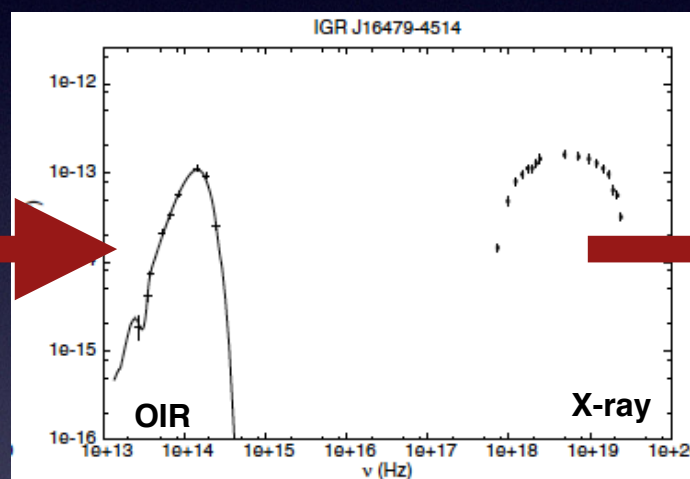


# Multi-wavelength study of *INTEGRAL* sources (2/3)

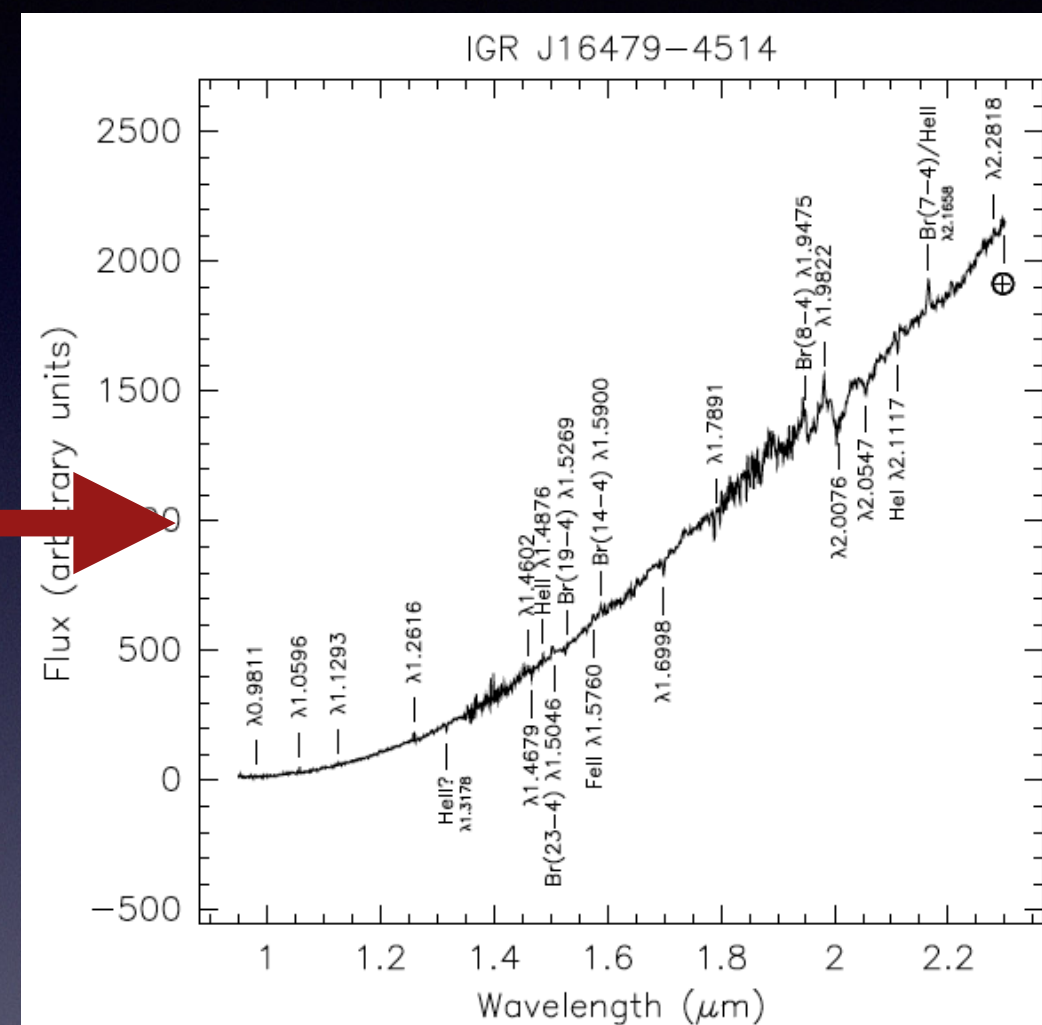


(e) IGR J16479-4514 (4'' XMM-Newton)

Identification



SED

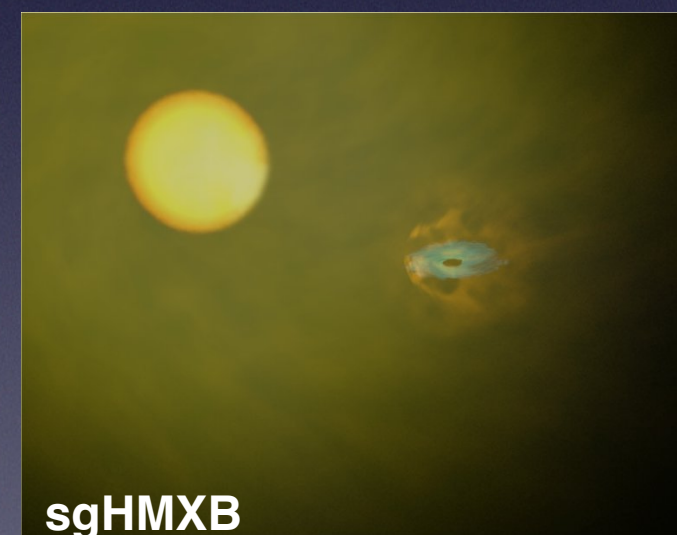
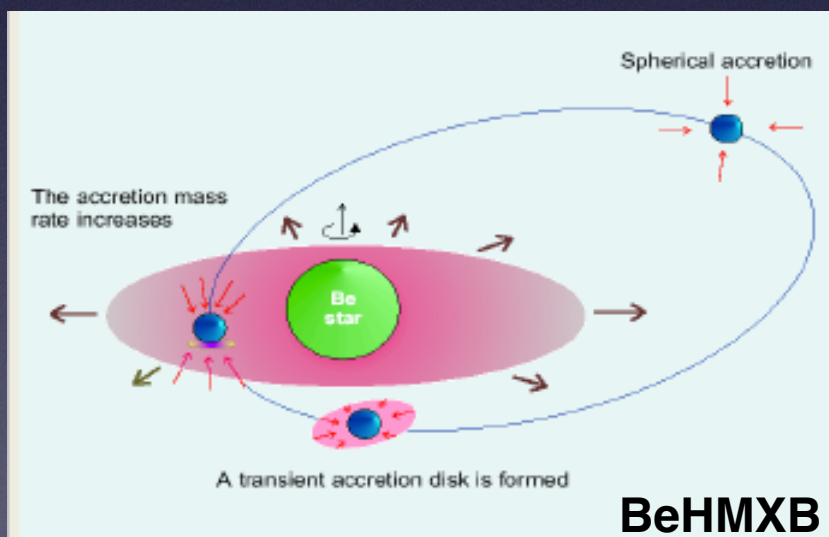
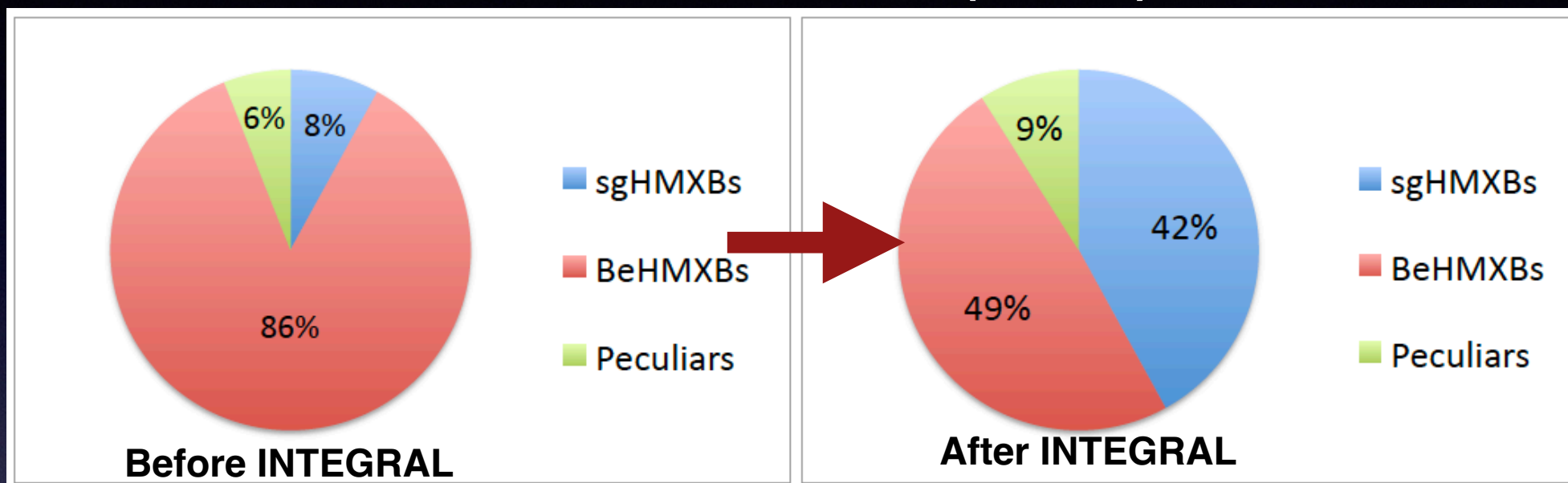


Spectroscopy

- **Facilities: ESO (La Silla & Paranal) observatories** optical/infrared photometric + spectroscopic campaigns to identify new IGR sources



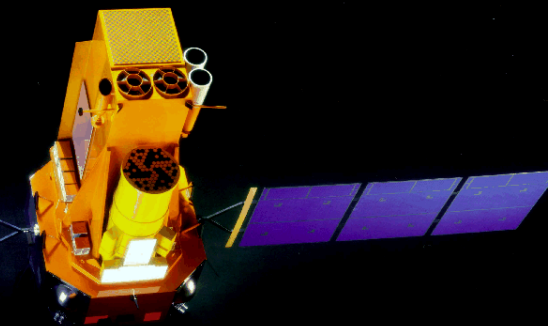
# Multi-wavelength study of *INTEGRAL* sources (3/3)



- Thanks to multi-wavelength follow-up (id+study) of *INTEGRAL* sources -> number of sgHMXB increased by factor 5 !



# Building of HMXB catalogue (1/2)



A&A 671, A149 (2023)  
<https://doi.org/10.1051/0004-6361/202245236>  
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**Astronomy  
&  
Astrophysics**

## A catalogue of high-mass X-ray binaries in the Galaxy: from the INTEGRAL to the *Gaia* era<sup>★,★★</sup>

Francis Fortin<sup>1</sup>, Federico García<sup>2</sup>, Adolfo Simaz Bunzel<sup>2</sup>, and Sylvain Chaty<sup>1</sup>

<sup>1</sup> Université Paris Cité, CNRS, Astroparticule et Cosmologie, 75013 Paris, France  
e-mail: fortin@apc.in2p3.fr

<sup>2</sup> Instituto Argentino de Radioastronomía (CCT La Plata, CONICET; CICPBA; UNLP), C.C.5, (1894) Villa Elisa, Buenos Aires, Argentina

Received 17 October 2022 / Accepted 28 January 2023

### ABSTRACT

**Context.** High-mass X-ray binaries (HMXBs) are a particular class of high-energy sources that require multi-wavelength observational efforts to be properly characterised. New identifications and the refinement of previous measurements are regularly published in the literature by independent teams of researchers and might, when they are collected in a catalogue, offer a tool for facilitating further studies of HMXBs.

**Aims.** We update previous instances of HMXB catalogues in the Galaxy and provide the community easy access to the most complete set of observables on Galactic HMXBs. In addition to the fixed version that is available in Vizier, we also aim to host and maintain a dynamic version that can be updated upon request from users. Any modification will be logged in this version.

**Methods.** Using previous HMXB catalogues supplemented by listings of hard X-ray sources detected in the past 20 yr, we produced a base set of HMXBs and candidates by means of identifier and sky coordinate HMXBs. We searched for as many hard X-ray, soft X-ray, optical, and infra known catalogues and compiled their coordinates. Each HMXB was subjected measurements and the original reference.

**Results.** We provide a catalogue of 152 HMXBs in the Galaxy with their best star, systemic radial velocities, component masses, orbital period, eccentricity, coordinates and identifiers for each counterpart we found from hard X-rays to recent *Gaia* DR3 catalogue.

**Key words.** stars: massive – binaries: general – catalogs

**Acknowledgements.** We thank the anonymous Referee for their insightful remarks that helped us improving both this paper and the online catalogue. The authors were supported by the LabEx UnivEarthS: Interface project I10 “Binary rEvolution: from binary evolution towards merging of compact objects”. SC is grateful to the CNES (Centre National d’Études Spatiales) for the funding of MINE (Multi-wavelength INTEGRAL Network). FG is CONICET researcher. FG acknowledges support by PIP 0113 (CONICET), PICT-2017-2865

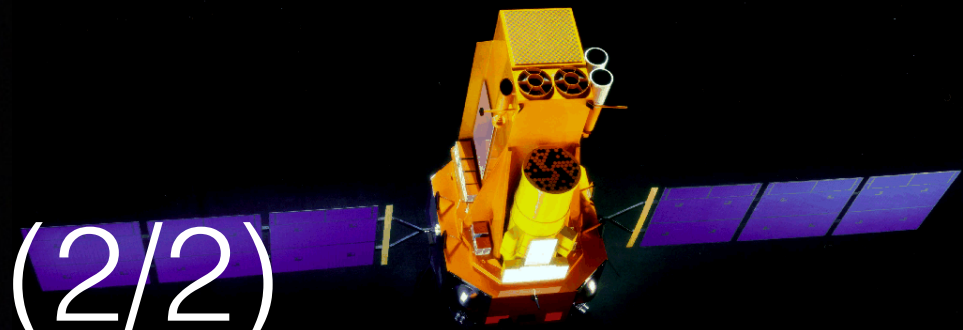
85 citations!

- A new and updated catalogue of Galactic HMXB : including all *INTEGRAL* sources, with new *Gaia* parameters !

Fortin, Garcia, Simaz Bunzel, Chaty, A&A, 2023, 671, A149



# Building of HMXB catalogue (2/2)



## Binary rEvolution

From evolving binaries to the merging of compact objects

Maintained by  
@Binary-rEvolution



## A Catalogue of High-Mass X-ray Binaries in the Galaxy

From the *INTEGRAL* to the *Gaia* era

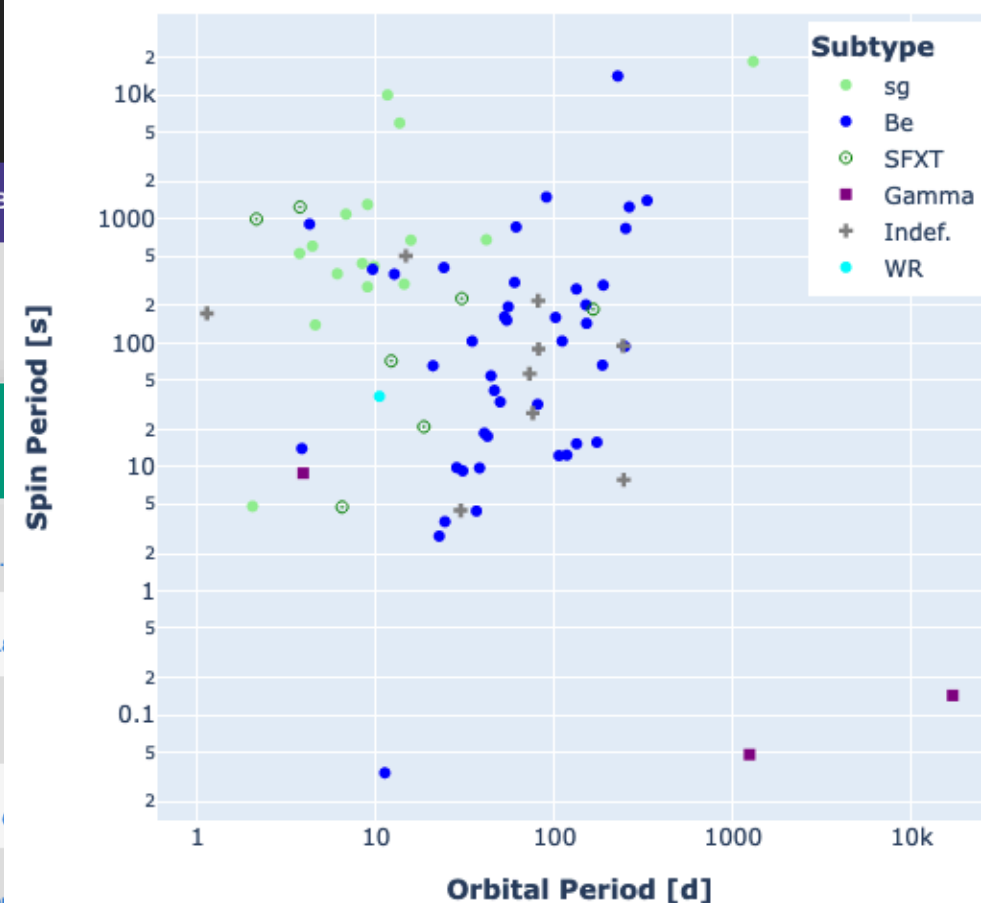
HOME HMXB CATALOGUE NOTES DOWNLOADS CONTRIBUTING SWITCH TO LMXB

Search HMXB:

Query tip: any identifier known by Simbad will work !

<input type="checkbox"/>	Main ID [Field of View]	Spectral type	Class	Right Ascension [J2000]	Declination [J2000]	Error radius [mas]	Distance [pc]	Mx [Msun]	Mo [Msun]
<input type="checkbox"/>	IGR J00370+6122 [FoV]	BN0.7 Ib 2014A&A...566A.131G	sg	9.29013	61.3601	0.008	3401 (-171,+186)		22.0 2014A&A...563A...
<input type="checkbox"/>	gam Cas [FoV]	B0.5IVpe 2011ARep...55...31S	Be	14.17745	60.7167	1.8			13.0 2000A&A...364L...
<input type="checkbox"/>	EM* AS 14 [FoV]	B2 1960IzKry...24...160B		18.99604	59.1539	0.011	2592 (-140,+156)		
<input type="checkbox"/>	2S 0114+650 [FoV]	B1Iae 2015A&A...579A.111K	sg	19.51123	65.2916	0.007	4475 (-183,+217)		16.0 +/- 2.0 2017ApJ...844...1
<input type="checkbox"/>	4U 0115+634 [FoV]	B0.2Ve 2001A&A...369..108N	Be	19.63319	63.7425	0.011	5787 (-453,+817)		17.5 1996MNRAS.280...
<input type="checkbox"/>	IGR J01363+6610 [FoV]	B1Ve 2005A&A...440..637R	Be	23.95772	66.212	0.007	5816 (-407,+413)		12.5 1996MNRAS.280L...31P 2010ATel.3079....1C

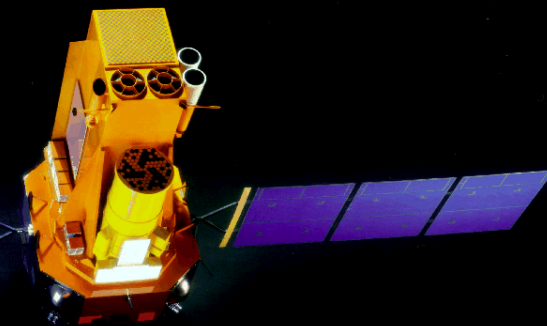
## Corbet diagram of Galactic HMXBs



- A new and updated catalogue of Galactic HMXB :  
accompanied by on-line catalogue on github

Fortin, Garcia, Simaz Bunzel, Chaty, A&A, 2023, 671, A149





# Building of LMXB catalogue (1/2)

A&A, 684, A124 (2024)  
<https://doi.org/10.1051/0004-6361/202347908>  
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Astronomy  
&  
Astrophysics

## A catalogue of low-mass X-ray binaries in the Galaxy: From the INTEGRAL to the *Gaia* era<sup>★</sup>

F. Fortin<sup>1,2</sup>, A. Kalsi<sup>3,4</sup>, F. García<sup>5</sup>, A. Simaz-Bunzel<sup>5</sup>, and S. Chaty<sup>2</sup>

<sup>1</sup> IRAP, Université de Toulouse, CNRS, CNES, UPS, 31401 Toulouse, France  
e-mail: francis.fortin@irap.omp.eu

<sup>2</sup> Université Paris Cité, CNRS, Astroparticule et Cosmologie, 75013 Paris, France

<sup>3</sup> Delhi Technological University, Delhi 110042, India

<sup>4</sup> Department of Physics and Astronomy “Galileo Galilei”, University of Padua, Padua, Italy

<sup>5</sup> Instituto Argentino de Radioastronomía, CCT La Plata, CONICET, CICPBA, UNLP, C.C.5, 1894 Villa Elisa, Buenos Aires, Argentina

Received 8 September 2023 / Accepted 22 January 2024

### ABSTRACT

**Context.** Low-mass X-ray binaries (LMXBs) are high-energy sources that require multi-wavelength follow-up campaigns to be fully characterised. New transients associated with LMXBs are regularly discovered, and previously known systems are often revisited by astronomers to constrain their intrinsic parameters. All of this information compiled into a catalogue may build a useful tool for subsequent studies on LMXBs and their population.

**Aims.** We aim to provide an update on past LMXB catalogues dating back 16 yr and propose to the community a database on Galactic LMXBs with the most complete, manually curated set of parameters and their original references. On top of a fixed version accessible through Vizier, we propose hosting the catalogue independently on our GitHub collaboration, side-by-side with our previous catalogue on high-mass X-ray binaries. The database will be regularly updated based on new publications and community inputs.

**Methods.** We built a working base by cross sources detected over the past 20 yr. We cross search in the literature to retrieve important information directly from literature searches. Counterparts of information presented on the LMXB Catalogue are presented on the LMXB Catalogue.  
**Results.** We present a catalogue of 339 LMXBs with their position, velocity, component masses and compact object identifiers of counterparts at various wavelengths.

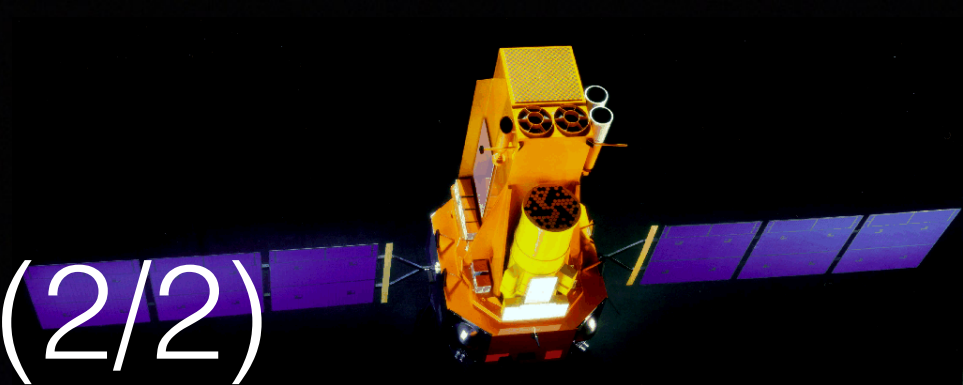
**Key words.** catalogs – binaries: general – X-ray: binaries

**Acknowledgements.** The authors were supported by the LabEx UnivEarthS: Interface project I10 “Binary rEvolution: from binary evolution towards merging of compact objects”. S.C. is grateful to the CNES (Centre National d’Études Spatiales) for the funding of MINE (Multi-wavelength INTEGRAL Network). F.G. is a CONICET researcher and acknowledges support from PIP 0113 and

32 citations

- A new and updated catalogue of Galactic LMXB : including all *INTEGRAL* sources, with new *Gaia* parameters !





# Building of LMXB catalogue (2/2)

**Binary rEvolution**  
From evolving binaries to the merging of compact objects

**UnivEarthS**

## A Catalogue of Low-Mass X-ray Binaries in the Galaxy

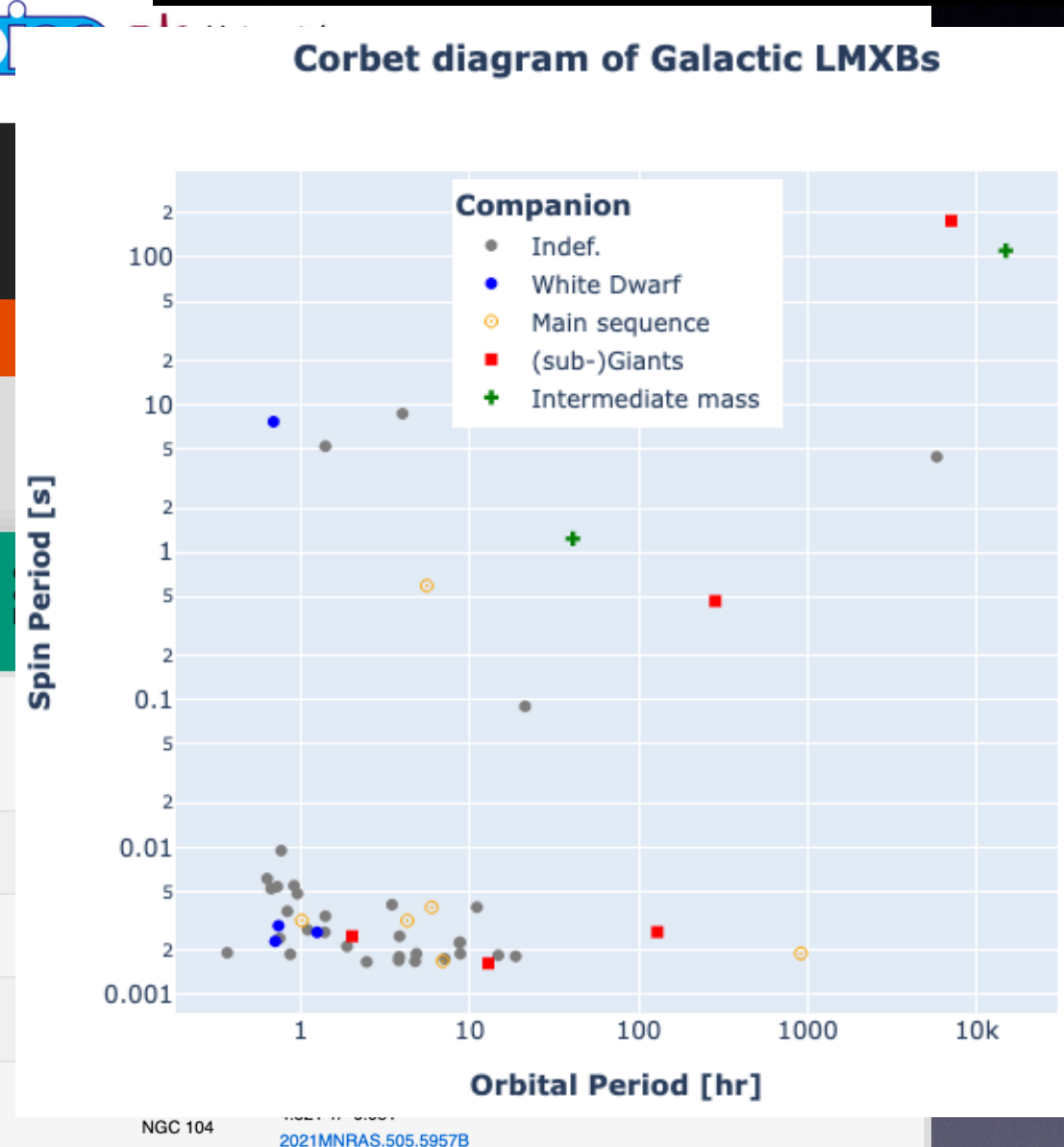
From the *INTEGRAL* to the *Gaia* era

HOME LMXB CATALOGUE NOTES DOWNLOADS CONTRIBUTING

Search LMXB:

Query tip: any identifier known by Simbad will work !

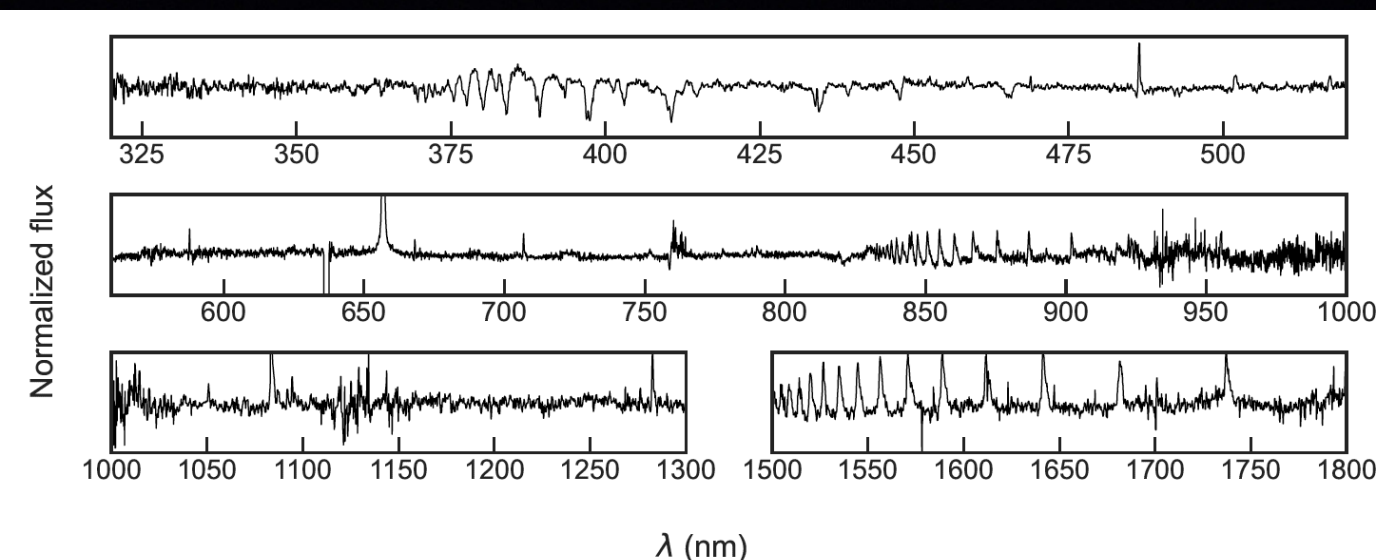
<input type="checkbox"/>	Simbad Main ID [click for more details]	Popular IDs	Status	Spectral type	Compact object	Right Ascension [J2000]	Declination [J2000]	Error radius [mas]
<input type="checkbox"/>	CXOGlb J002353.9-720350	NGC 104 125 47 Tuc X-4 CXOGlb J002353.9-720350	confirmed		NS (!) 2005ApJ...622..556H	5.9749	-72.0639	14
<input type="checkbox"/>	CXOGlb J002400.9-720453	47 Tuc X-5	candidate		NS (!) 2003ApJ...588..452H	6.00413	-72.0814	7
<input type="checkbox"/>	CXOGlb J002403.4-720451	47 Tuc X-7	candidate		NS (!) 2003ApJ...588..452H	6.01468	-72.0811	710
<input type="checkbox"/>	47 Tuc X-9	47 Tuc X-9	confirmed		BH (!!) 2017MNRAS.467.2199B	6.01777	-72.0828	100
<input type="checkbox"/>	CXOGlb J002404.9-720451	NGC 104 37 47 Tuc W37 CXOGlb J002404.9-720451	confirmed		NS (!!) 2005ApJ...622..556H	6.02042	-72.0808	600



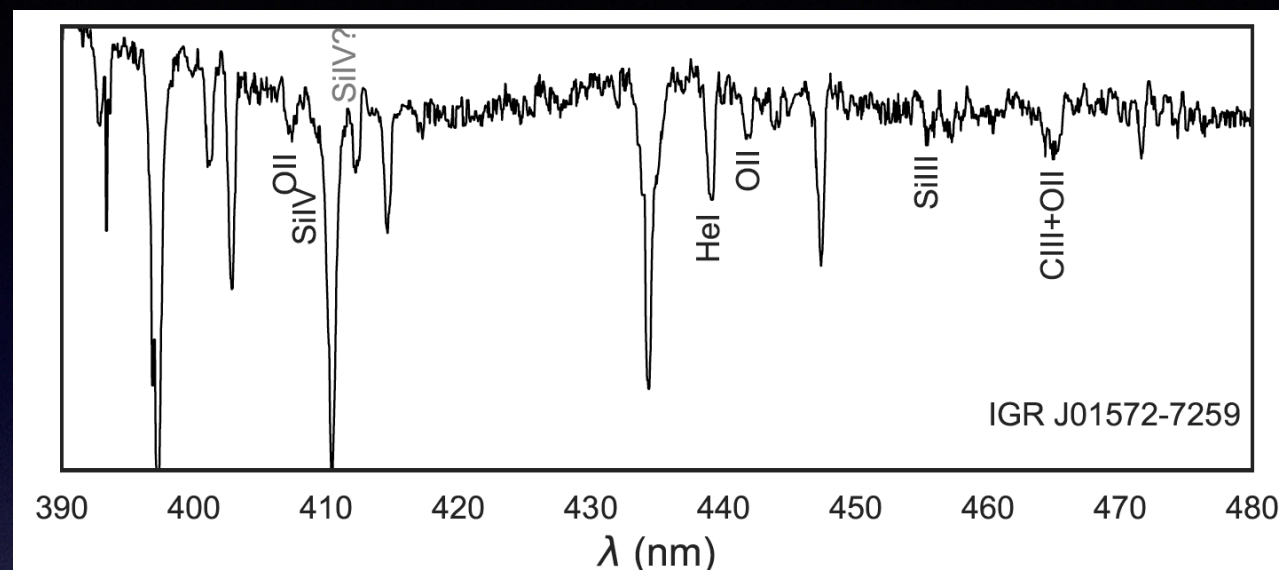
- A new and updated catalogue of Galactic LMXB :  
accompanied by on-line catalogue on github



# New study: Multi- $\lambda$ study of LMC and Magellanic bridge sources



O9Ve (Van Jaarsveld et al. 2018), B2III (Masetti et al. 2006)  
 H emission line = Be?

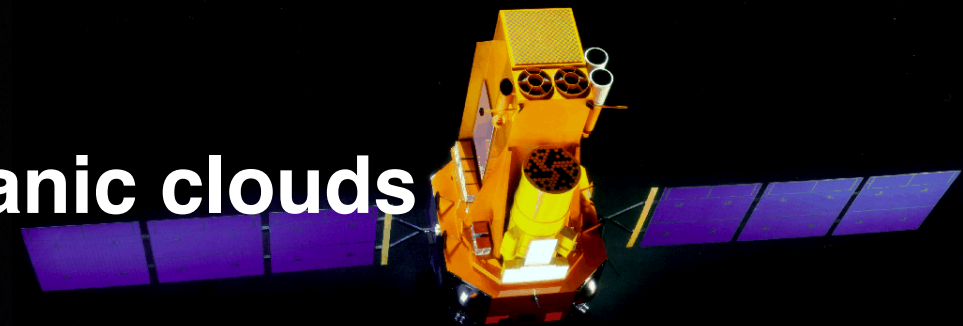


Consistent with B1-1.5 IV based on SiIV 4088 and OII (Evans 2004) and SiIII  
 4553/HeI 4387 (Walborn 1990)

- Multi- $\lambda$  study of IGR J05007-7047** : Be system within LMC ( $1/2 \odot$  metallicity) > O9Ve,  $P_{\text{orb}} = 30.77 \pm 0.01$  d
- Classification of donor star with X-shooter spectra, data reduction with Esoreflex and correction of telluric lines with Molecfit
- IGR J01572-7259**: Be system within Magellanic bridge/SMC ( $1/5 \odot$  metallicity): no prior literature on this source, B 0-0.5 V, higher luminosity or B1-1.5 IV;  $P_{\text{orb}} = 35.6 \pm 0.5$  d and  $P_{\text{spin}} = 11.58208(2)$ s



# Building of binary catalogue within Magellanic clouds (in prep.)



## Binary rEvolution

From evolving binaries to the merging of compact objects



Maintained by  
[@Binary-rEvolution](#)

## A Catalogue of High-Mass X-ray Binaries in the Galaxy

From the *INTEGRAL* to the *Gaia* era

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[SWITCH TO LMXB CATALOGUE](#)  [ABOUT](#)

Search HMXB:

Show:

10

...



Query tip: any identifier known by Simbad will work !

<input type="checkbox"/>	Main ID [Field of View]	Spectral type	Class	Right Ascension [J2000]	Declination [J2000]	Error radius [mas]	Distance [pc]	Mx [Msun]	Mo [Msun]	Period [d]	Super period [d]
<input type="checkbox"/>	IGR J00370+6122 <a href="#">[FoV]</a>	BN0.7 lb <a href="#">2014A&amp;A...566A.131G</a>	sg	9.29013	61.3601	0.008	3401 (-171,+186)		22.0 <a href="#">2014A&amp;A...563A...1G</a>	15.6649 +/- 0.0014 <a href="#">2021PASJ...73.1389U</a>	
<input type="checkbox"/>	gam Cas <a href="#">[FoV]</a>	B0.5IVpe <a href="#">2011ARep...55...31S</a>	Be	14.17745	60.7167	1.8			13.0 <a href="#">2000A&amp;A...364L..85H</a>	203.371 +/- 0.089 <a href="#">2012A&amp;A...537A..59N</a>	
<input type="checkbox"/>	EM* AS 14 <a href="#">[FoV]</a>	B2 <a href="#">1960IzKry..24...160B</a>		18.99604	59.1539	0.011	2592 (-140,+156)				
<input type="checkbox"/>	2S 0114+650 <a href="#">[FoV]</a>	B1Iae <a href="#">2015A&amp;A...579A.111K</a>	sg	19.51123	65.2916	0.007	4475 (-183,+217)	16.0 +/- 2.0 <a href="#">2017ApJ...844...16H</a>		11.5983 +/- 0.0006 <a href="#">1985ApJ...299..839C</a>	30.76 <a href="#">2013A</a>
<input type="checkbox"/>	4U 0115+634 <a href="#">[FoV]</a>	B0.2Ve <a href="#">2001A&amp;A...369..108N</a>	Be	19.63319	63.7425	0.011	5787 (-453,+817)	17.5 <a href="#">1996MNRAS.280L..31P</a>		24.3174 +/- 0.0004 <a href="#">2010MNRAS.406.2663R</a>	
<input type="checkbox"/>	IGR J01363+6610 <a href="#">[FoV]</a>	B1Ve <a href="#">2005A&amp;A...440..637R</a>	Be	23.95772	66.212	0.007	5816 (-407,+413)	12.5 <a href="#">1996MNRAS.280L..31P</a>		159.0 +/- 2.0 <a href="#">2010ATel.3079....1C</a>	

- **A new catalogue of binaries within Magellanic clouds:** scientific motivation is : 3 times more BeHMXB in MC than in MW wrt mass, low metallicity environment similar to galaxies where are detected GW mergers



# PhD & Post-docs

- **PhD (4):**

- Farid Rahoui (2006-09); Alexis Coleiro (2010-13); Francis Fortin (2016-19); Julien Marchioro (2020-23), Théo Courty (2025-28)

- **Post-docs (8):**

- Marc Ribo (2002-2005); Juan Antonio Zurita Heras (06/2006-01/2009); Farid Rahoui (2009); Peter A. Curran (2010-2012); Mathieu Servillat (2012-2013); Alicia Lopez Oramas (01/2015-01/2017); Federico Garcia (09/2017-08/2019); Francis Fortin (10/2020-09/2023)

# Impacts sociétaux

- **Conférences :**

- Fête de la science, nuit européenne des chercheurs, RCE, Observatoire de Juvisy, Associations, etc

- **Festival :**

- FICE Festival International du Ciel et de l'Espace (Fleurance, membre de l'organisation et intervenant chaque année)

# Budget CNES

- **Budget 2026:** reconduction demandée :

- Equipement: 4 k€ (achat station de travail pour simulations d'évolution de binaires, stage étudiant M2->Thèse)
- Missions: 4 k€ (missions Europe COSPAR 2026 Firenze session E1.2 organisée par S Chaty et I. Dvorkin)



# Publications (2023-25)

- **Chaty S., Fortin F.,** García F., Liu Q.Z., 2026, A&A in prep., A catalogue of HMXB in the Magellanic clouds: from the INTEGRAL to the Gaia era
- **Courty T., Chaty S.,** Negueruela I., 2026, A&A in prep., Multi- $\lambda$  study of LMC and Magellanic bridge sources
- Fogantini F.A., **García F.,** Combi J.A., **Chaty S.,** Marti J., Luque-Escamilla P., 2023, A&A, 669, 149, A NuSTAR view of SS433: Precessional evolution of jet-disk system
- **Fortin F., García F.,** Simaz Bunzel A., **Chaty S.,** 2023, A&A, 671, A149, A catalogue of HMXB in the Galaxy: from the INTEGRAL to the Gaia era
- **Fortin F.,** Kalsi A., **García F.,** Simaz Bunzel A., **Chaty S.,** 2024, A&A, 684, 124, A catalogue of LMXB in the Galaxy: from the INTEGRAL to the Gaia era
- **Marchioro J., Chaty S.,** Coleiro A., **Fortin F.,** Simaz Bunzel A., 2023, A&A, 670, 88, Interaction of an HMXB with the ISM through stellar wind, the case of GX 301-2
- Simaz Bunzel A., **García F.,** Combi J.A., **Chaty S.,** 2023, A&A, 670, 80, Evolution of eccentric high-mass X-ray binaries. The case of GX 301-2
- Simaz Bunzel A., **García F.,** Combi J.A., **Fortin F., Chaty S.,** 2023, A&A, 670, 45, Impact of tides on non-coplanar orbits of progenitors of High-Mass X-ray Binaries