

## Riccardo Arcodia



### Title

X-ray blasts from awakening massive black holes

### Abstract

Quasi-Periodic Eruptions (QPEs) are high-amplitude bursts of X-ray radiation recurring every few hours and provide a new channel to study how massive black holes are activated in low-mass galaxies. Previously, only two such sources were known, classified as hosting an actively accreting black hole. I will present the detection of QPEs in two further galaxies, obtained with a blind and systematic search during the first year of operations of the eROSITA X-ray telescope (Arcodia et al., Nature 2021). The optical spectra of these galaxies show no signature of black hole activity, indicating that a pre-existing accretion flow typical of active nuclei is not required to trigger these events. I will give a state-of-the-art overview of QPEs' multi-wavelength observational properties and possible origin scenarios. What we currently suggest is that QPEs might be driven by the presence of one (or more) orbiting body (-ies) with stellar mass. This could make QPEs a viable candidate for the electromagnetic counterparts of the so-called extreme mass-ratio inspirals, with considerable implications for the future of multi-messenger astrophysics and cosmology.

# Riccardo Arcodia

## Curriculum Vitae

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### Employment

- 2021–present **Postdoc**, *Max Planck Institute for Extraterrestrial Physics*.  
Scientific exploitation of eROSITA data and Einstein Probe scientific support.

### Education

- 2017–2021 **PhD *summa cum laude* in Astrophysics**, *Max Planck Institute for Extraterrestrial Physics*.  
Supervisors: Andrea Merloni, Kirpal Nandra  
Defense date: 30 September 2021  
Thesis Title: *Accretion onto black holes across the mass scale*
- 2015–2017 **Master's Degree *magna cum laude* in Astrophysics and Space Physics**, *Università degli Studi di Milano-Bicocca*.  
Thesis Title: *X-ray absorption study of high-redshift blazars: a way to probe the intergalactic medium*  
Supervisors: Sergio Campana, Gabriele Ghisellini  
- Two semesters of classes  
- Nine months of thesis with defence
- 2012–2015 **Bachelor's Degree in Physics**, *Università degli Studi di Milano-Bicocca*.  
Thesis Title: *Study of the X-ray absorption of a complete sample of Swift GRBs*  
Supervisors: Sergio Campana, Monica Colpi  
- Six semesters of classes  
- Two months of thesis with defence

### Research experience

#### Approved proposals as Principal Investigator

- 2020-2021 – XMM-Newton A020 Large Programme : *A systematic search for X-ray Quasi-Periodic Eruptions in the eROSITA era* - four 130 ks-long anticipated ToOs allocated by the panel. Not triggered yet.
- NICER Cycle 3 : *NICER follow-up of a future eROSITA QPE* - Anticipated ToO monitoring for a total of  $\sim 48$  ks. Not triggered yet.
- NICER Cycle 3 : *Tracking the period evolution of QPEs* - Allocated for a total of  $\sim 120$  ks. Ongoing.

- MeerKAT radio telescope - 4h DDT observations allocated in Sept. 2021. Observed, to be published.
- Parkes radio observatory 2021Apr - 8h observations allocated. Observed, to be published.
- Chandra Cycle 22 : *The hunt for Quasi-Periodic Eruptions in the eROSITA era* - two 75 ks-long anticipated ToOs allocated by the panel. Not triggered yet.
- 2019-2020 - NICER Cycle 2 : *The hunt for Quasi-Periodic Eruptions in the eROSITA era* - Intense ToO/DDT monitoring for a total of  $\sim 186$  ks. Published.
- XMM-Newton A019 : *The hunt for Quasi-Periodic Eruptions in the eROSITA era* - two 90 ks-long anticipated ToOs allocated by the panel, one 90 ks-long DDT approved by the XMM-Newton PS. Published.
- 2018-2019 - XMM-Newton A018 : *Dissecting the Intergalactic Medium through deep blazar observations* - 123 ks allocated by the panel with priority C, not observed.

### Conferences

- 07/2021 *Sixteenth Marcel Grossmann Meeting* - Virtual - Oral contribution.
- 06/2021 *European Astronomical Society 2021* - Virtual - Two oral contributions.
- 11/2019 *AGN Spectral States - Unification of Black Holes across the mass scale* - Prague - Oral contribution.
- 09/2019 *X-ray Astronomy 2019 - Current challenges and new frontiers in the next decade* - Bologna - Oral contribution.
- 08/2019 *Quasars in crisis 2019* - Edinburgh - Flash talk and e-Poster.
- 07/2019 *From the Dolomites to the event horizon: sledging down the black hole potential well* - Sexten - Oral contribution.
- 06/2019 *Supermassive Black Holes: environment and evolution* - Corfu - Oral contribution.

### Colloquia - Invited Seminars

- 10/2021 *INAF/IASF Milano* - virtual seminar
- 09/2021 *MPE/OPINAS group* - virtual seminar
- 08/2021 *Hebrew University of Jerusalem* - virtual seminar
- 06/2021 *National Astronomical Observatories, China* - virtual seminar
- 06/2021 *Bologna Univ.* - virtual seminar
- 06/2020 *Southampton Univ.* - virtual seminar
- 05/2020 *Astronomical Institute, Prague* - virtual seminar

### Peer reviewer

- 2020- MNRAS

## Press Releases

- 2021 EAS 2021 Conference: eROSITA press release. Speaker.
- 2021 MPE press release - "eROSITA witnesses the awakening of massive black holes". Writing.

The content related to this press release was shared, according to Nature metrics, by 44 tweets (divided in 80% from the public and 20% from scientists, including "Nasa Universe") and more than 9 between news and blogs of 5 different languages (including "Vice Science").

## Pre-Doctorate Research

- 2017 Nine-months stage at the Brera Observatory (INAF-OAB) in Merate to work on my Master's Degree thesis work, under the supervision of Sergio Campana and Gabriele Ghisellini.
- 2015–2016 Occasionally joined the Brera Observatory (INAF-OAB) in Merate to work on the publication of a scientific article based on my Bachelor's Degree graduation thesis, while attending the first year of Master's Degree classes.
- 2015 Two-months stage at the Brera Observatory (INAF-OAB) in Merate to work on my Bachelor's Degree graduation thesis, supervised by Sergio Campana.

## Outreach Activities

- 2016 Co-organizer of a stand on Gravitational Waves at the 2016 European Researchers Night event MEETmeTONIGHT, in Milan.
- 2016 Staff member at Pint of Science 2016, in Milan.

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## Publications

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### First authored publications

- 1 *X-ray quasi-periodic eruptions from two previously quiescent galaxies*  
**R.Arcodia**, A. Merloni, K. Nandra et al.; *Nature*, 592, 704 (2021)
- 2 *Do stellar-mass and super-massive black holes have similar dining habits?*  
**R.Arcodia**, G. Ponti, A. Merloni, K. Nandra; *A&A*, 638, A100 (2020)
- 3 *Testing the disk-corona interplay in radiatively-efficient broad-line AGN*  
**R.Arcodia**, A. Merloni, K. Nandra, G. Ponti; *A&A*, 628, A135 (2019)
- 4 *X-ray absorption towards high-redshift sources: probing the intergalactic medium with blazars*  
**R.Arcodia**, S. Campana, R. Salvaterra, G. Ghisellini; *A&A*, 616, A170 (2018)
- 5 *The dependence of gamma-ray burst X-ray column densities on the model for Galactic hydrogen*  
**R.Arcodia**, S. Campana, R. Salvaterra; *A&A*, 590, A82 (2016)

## Other Publications and related contribution

- *Extreme ultra-soft X-ray variability in an eROSITA observation of the Narrow-Line Seyfert 1 Galaxy 1H 0707-495*  
T. Boller, T. Liu, P. Weber, **R. Arcodia**, . . . , A&A, 647, A6 (2021). *Contribution*: analysis of XMM-Newton optical monitor data and part of the eROSITA data; interpretation, some plotting and writing.
- *Discovery of eRASSt J192932.9-560346: a bright, two-pole accreting, eclipsing polar*  
A. Schwobe, . . . , **R. Arcodia** et al., arXiv:2106.14540 (2021). *Contribution*: development of analysis/plotting methods.
- *First constraints on the AGN X-ray luminosity function at  $z \sim 6$  from an eROSITA-detected quasar*  
J. Wolf, . . . , **R. Arcodia** et al., A&A, 647, A5 (2021). *Contribution*: X-ray data analysis.
- *The eROSITA Final Equatorial-Depth Survey (eFEDS): A multiwavelength view of WISE mid-infrared galaxies/active galactic nuclei*  
Y. Toba, . . . , **R. Arcodia** et al., arXiv:2106.14527 (2021). *Contribution*: testing/development of analysis/plotting methods.
- *The eROSITA Final Equatorial-Depth Survey (eFEDS): The first archetypal Quasar in the feedback phase discovered by eROSITA*  
M. Brusa, . . . , **R. Arcodia** et al., arXiv:2106.14525 (2021). *Contribution*: testing/development of analysis/plotting methods.
- *The eROSITA Final Equatorial-Depth Survey (eFEDS): The AGN Catalogue and its X-ray Spectral Properties*  
T. Liu, . . . , **R. Arcodia** et al., arXiv:2106.14522 (2021). *Contribution*: testing/development of analysis/plotting methods.
- *The eROSITA Final Equatorial-Depth Survey (eFEDS): Identification and characterization of the counterparts to the point-like sources*  
M. Salvato, . . . , **R. Arcodia** et al., arXiv:2106.14520 (2021). *Contribution*: visual inspection of SDSS-IV/V spectra.
- *The eROSITA Final Equatorial-Depth Survey (eFEDS). An X-ray-bright, extremely luminous infrared galaxy at  $z = 1.87$*   
Y. Toba, . . . , **R. Arcodia** et al., A&A, 649, L11, (2021). *Contribution*: testing/development of analysis/plotting methods.
- *The 16th Data Release of the Sloan Digital Sky Surveys: First Release from the APOGEE-2 Southern Survey and Full Release of eBOSS Spectra*  
R. Ahumada, . . . , **R. Arcodia**, . . . , APJS, 249, 3 (2020). *Contribution*: visual inspection of SDSS-IV spectra.

- *The final SDSS-IV/SPIDERS X-ray point source spectroscopic catalogue*  
J. Comparat, . . . , **R. Arcodia**, . . . , A&A, 636, A97 (2020). *Contribution:* visual inspection of SDSS-IV spectra.
- *Exploring the diversity of Type 1 active galactic nuclei identified in SDSS-IV/SPIDERS*  
J. Wolf, . . . , **R. Arcodia**, . . . , MNRAS, 492, 3580 (2020). *Contribution:* visual inspection of SDSS-IV spectra, discussions/editing.

## Technical Experience

OS	Linux/Unix, Windows, Mac OS X
Programming	Python; some experience with C++ and Idl
Typesetting	L <sup>A</sup> T <sub>E</sub> X, Microsoft Office
Facilities	XMM-Newton, eROSITA, Swift-XRT, NICER, NuSTAR
Data red.	XMM-Newton SAS for EPIC and OM instr., eROSITA eSASS
Data analysis	X-rays: Xspec, BXA, Ultranest, Sherpa, HeaSoft; TopCat, SAOimage ds9

## Languages

Italian	Native speaker
English	Fluent
German	Good command
French	Good command

*A2/B1 course*  
*High school second language*