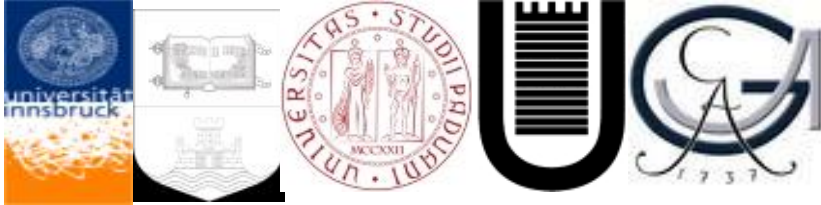




# AstroMundus

ERASMUS MUNDUS JOINT MASTERS COURSE  
in Astronomy and Astrophysics

**Dragana Ilic**  
(Faculty of Mathematics, University of Belgrade)  
on behalf of the Astromundus Consortium



## Joint Master Degree of 5 partners:

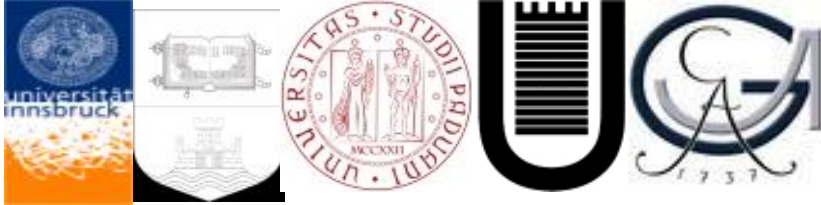


- University of Innsbruck (Coordinating institution)
- University of Belgrade
- University of Göttingen
- University of Padova
- University of Rome Tor Vergata

# Astromundus are people...



Meeting of Edition 1 and 2 students in 2012

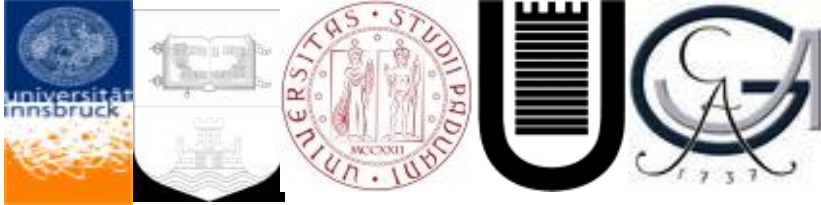


# Consortium: Partners



- University of Innsbruck (Coordinating institution)
- University of Belgrade
- University of Göttingen
- University of Padova
- University of Rome Tor Vergata





# Consortium: Associates



- Astronomical Observatory Belgrade
- INAF = Istituto Nazionale di Astrofisica
  - Astronomical Observatory of Padova (INAF-OAPd)
  - Astronomical Observatory of Rome (INAF-OAR)
- Gran Sasso Science Institute
- Max Planck Institute for Solar System Research (MPS)





# Astromundus Objectives

- **Main objective:** provide top-ranked students with excellent background in astrophysics
- But also:
  - introduce students to the world of modern astrophysical research
  - application of modern techniques
- **number of students ~120 (8 Editions)**
  - Exchange of scholars (among partners, but also from other institutions)



# Cooperation agreement

took a while to reach

- “ due to different laws in different countries
- “ different regulations in different universities

**But: no major obstacles, full support from administration and management bodies**



## Difference to regular/singular Master programmes:

- “ a special curriculum was issued
- “ students can be selected
- “ very intense tutoring
- “ career and study path advice



... a few features that we are proud of



# Study Path

Institution	1st semester	2nd semester	3rd semester	4th semester
Innsbruck	x			x
Padova		x		x
Rome		x	x	x
Göttingen			x	x
Belgrade			x	x

**All students are together in the first semester!**

- “ students are being brought to the same level
- “ necessary for the following, more specialised courses in the following semesters
- “ bringing the students of one edition together, so that they are really acting as a group

**We can recommend this!**



# This is to certify, that

in view of the Addendum 1 of the Consortium Agreement of Jan 22<sup>nd</sup> 2010  
between the members of the AstroMundus Consortium

[redacted]  
born [redacted] in [redacted]

after successful completion of the

Erasmus Mundus Joint Master Program in Astrophysics on [redacted]  
leading to a

## Master of Science in Astrophysics

has been awarded the following Academic Degree

Master of Science (MSc)  
Notification from [redacted] in  
accordance with § 87, sect.1 of the  
Universities Act 2002

Laurea Magistrale in Astronomia Classe LM-58  
dalle Lauree Magistrali in Scienze dell'Universo,  
(D.M. 16.3.2007)

Study program: Erasmus-Mundus Joint European Masters  
Studies in Astrophysics - Astromundus, officially recognized  
on 06.04.2012 under the number 512-00-02770/2011-  
04, for obtaining the academic title Master of Astrophysics

Студијски програм: Еразмус Мундус заједнички  
европски мастер академски студије из астрономије  
– Астрономија, званично призната 06.04.2012 год.  
под бројем 613-00-02270/2011-04, за стицање звања  
мастер астрономије.

Georg-August-Universität Göttingen  
Consecutive Master Degree Programme  
Master of Science, Physics Erasmus Mundus  
Joint Degree Programme in Astrophysics  
(Astromundus)



University of Innsbruck  
Tilmann Märk  
Rektor

Innsbruck, [redacted]



Università degli Studi di Padova  
Giuseppe Zaccaria  
 Rettore



University of Belgrade  
Vladimir Bumbaširević  
Rektor



*Ulrike Beisiegel*  
University of Göttingen  
Ulrike Beisiegel  
Präsidentin



# Yearly Retreats



Central event of AstroMundus!

- “ 2011, 2012, 2016: Asiago Observatory (Padova)
- “ 2013, 2014, 2018: Conference Centre Obergurgl (Innsbruck)
- “ 2015, 2017: L’Aquila, ASI (Rome)
- “ 2019: Petnica (Belgrade)

Meeting of

- “ two editions of students
- “ members of Board, Selection, Quality Evaluation Committee, Academic Advisors
- “ lecturers and tutors

Many different activities take place

- “ meetings of the committees
- “ feedback sessions with the students
- “ presentations of the Master’s theses of the older edition
- “ informal discussions of students with potential Master’s theses supervisors
- “ lots of opportunity for exchange of experience and informal discussions

# Yearly Retreats





# Yearly Retreat in 2015

visit to Gran Sasso Lab





# Joint Supervisions of Master Theses

- “ the students can make use of the experience of two different scientists resulting in particularly good theses
- “ the two supervisors from two different universities start collaborating scientifically resulting in common publications and sometimes even in continuing collaborations
- “ the frequent visits/teleconferences/presentations involved in the joint supervision brings both partners closer together

... was particularly helpful to integrate Belgrade!

# Astromundus Committees:

- “ AstroMundus Board
- “ Quality Evaluation Committee
- “ Academic Advisors
- “ Selection Committee
- “ Scientific Advisory Board
  
- “ all boards are very active!



# Scientific Advisory Board



- “ **Prof. Andrew Bunker**  
(Department of Physics, University of Oxford, UK)
- “ **Prof. Jan Palous**  
(Astronomical Institute of the Academy of Sciences of the Czech Republic)
- “ **Prof. Bozena Czerny**  
(Center for Theoretical Physics, Warsaw, Poland)

Former members:

- “ **Prof. Dr. Joachim Wambsganß**  
(Astronomisches Rechen-Institut, Heidelberg)
- “ **Prof. Malcolm Longair**  
(Cavendish Laboratory, Department of Physics, University of Cambridge)

## ... a few problems

### 1. Cancellations before Arrival

- “ several cancellations before arrival
- “ *reasons:*  
personal situation, other scholarship offer,  
failing Bachelor’s degree, visa problems
- “ late confirmation from EC

### 2. External Funding

- “ self funding: difficult
- “ industry funding: difficult for astrophysics
- “ so far: fellowships from university/ministry

# Astromundus in Serbia



- Partnet Country– fully integrated in the programme!
- Officially led by the University of Belgrade and Faculty of Mathematics







# Organization in Belgrade



- main management body is: Programme Council (“Programski savet”), under the “Council for the Universities studies”
  - accepting list of courses
  - master thesis (subjects, titles, supervisors, etc.)
  - finances and any other admin decisions
- students enrollment and other admin business: synergy of the University and Faculty of Mathematics
- support from the Astronomical Observatory of Belgrade for lecturing and thesis supervising



# Some solved issues

- **most challenging:** official recognition of the course
  - we have done it!
- Type A student - up to 3-months in Belgrade covered by the scholarship (since Serbia = Third country partner)
  - anyhow all 30 ECTS can be obtained in Belgrade
  - Belgrade courses compressed in a way to fit within 3 months
- visa – students start with application much in advance
- *still problem:* accommodation for students in student residences

# Truly international programme...

## 41 nationalities/number of students (editions 1-8)

Armenian 1	Georgian 1	Polish 1
Austrian 1	Greek 1	Russian 1
Bangladeshi 1	Guatemalan 1	Serbian 7
Bolivian 1	Hungarian 1	Slovenian 2
British 4	Indian 8	South African 1
Bulgarian 2	Indonesian 1	Spanish 1
Chilean 3	Iranian 1	Taiwanese 1
Chinese 1	Irish 1	Turkish 5
Colombian 1	Italian 3	USA 5
Croatian 1	Macedonian 1	Ugandan 1
Egyptian 1	Mexican 6	Ukrainian 2
Ethiopian 1	Nepalese 1	Venezuelan 2
Finnish 1	Pakistani 5	Vietnamese 3
French 1	Peruvian 1	

gender balanced (in last two editions ~50% female)

AstroMundus:

## Truly international programme...

PhD positions currently held by students of editions 1 and 2

employment rate so far more than 80%

Main target for the career of our students is Academia, we prepare them well for this:

- with reference letters
- encourage attendance of summer schools
- encourage visits at institutes
- use our connections to colleagues
- ...

- 1 Max Planck Institute for Radio Astronomy, Bonn, Germany
- 2 University of Groningen, Netherlands
- 4 University of Göttingen, Germany
- 1 Cornell University, USA
- 1 ETH Zürich and Davos World Radiation Center, Switzerland
- 1 Wits University, Johannesburg, South Africa
- 1 assistant position at University of Banja Luka, Bosnia-Herzegovina & PhD at University of Belgrade, Serbia
- 1 University of Leuven, Belgium
- 1 Nicolaus Copernicus Astronomical Center, Polish Academy of Science, Warsaw, Poland
- 1 Radboud University, Nijmegen, Netherlands
- 1 University of Massachusetts, USA
- 1 Middle East Technical University, Turkey
- 1 University of Innsbruck, Austria
- 1 Max Planck Institute for Astronomy, Heidelberg, Germany
- 1 assistant position at University of Mbarara, Uganda
- 2 Joint PhD University of Rome "Tor Vergata" and Rome "La Sapienza", Italy
- 1 Observatoire de la Cote d'Azur, Nice, France
- 1 University of Nottingham, UK



## Master thesis – 1<sup>st</sup> Edition

- total of 18 theses
- 3 theses defended in Belgrade (2 jointly supervised w/Göttingen)

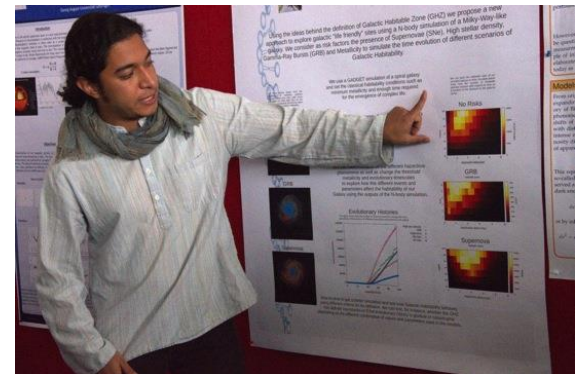
- **Payaswini Saikia** – joint master thesis on active galaxies supervised by Belgrade & Goettingen

**Best thesis awards!**

## Master thesis – 2<sup>nd</sup> Edition

“ total of 10 theses

- “ **Gerardo Martinez Aviles** – joint thesis supervised by Innsbruck & Belgrade on Astrobiology





# Mater Thesis in Belgrade Ed. 1

1. *Payaswini Saikia „The UV and optical spectral properties of a sample of broad line AGNs“*  
*JOINT THESIS: Belgrade+Goettingen*  
(advisors: Luka Popovic, Wolfram Kollatschny)
2. *Nemanja Rakic „Variability of AGN spectral properties“*  
*JOINT THESIS: Belgrade+Goettingen*  
(advisors: Luka Popovic, Wolfram Kollatschny)
3. *Luca Grassitelli „Physical Parameters of the Relativistic Shock Waves in a Sample of Gamma Ray Bursts“*  
(advisors: Luka Popovic, Sasa Simic)



# Best Thesis Award Edition 1

“ Goes to  
“ *Payaswini Saikia*

*„The UV and optical  
spectral properties of a  
sample of broad line  
AGNs“*

*Advisors:*

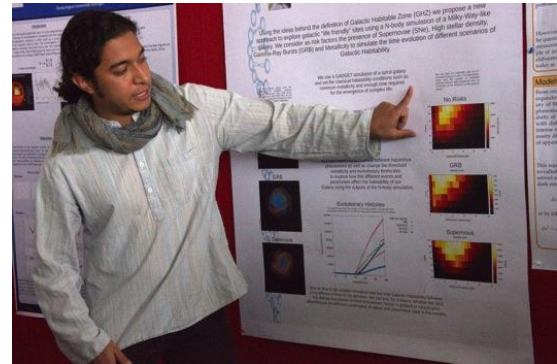
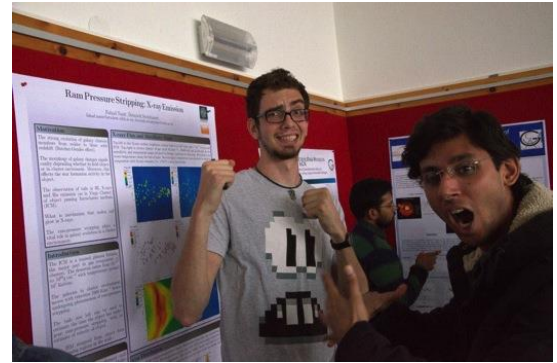
*Luka Popovic &  
Wolfram Kollatschny*

<http://astro.matf.bg.ac.rs>



# Mater Thesis in Inns. & Belgrade Ed.2

4. Levan Kakabadze „**Contribution of Structure Formation Cosmic Rays to Extragalactic Gamma-Ray Background** “  
*JOINT THESIS: Innsbruck + Belgrade* (Advisors: Tijana Prodanovic, Olaf Reiner)
5. Gerardo Martinez Aviles „**On the Evolution of Galactic Habitability Zone**“  
*JOINT THESIS: Innsbruck + Belgrade* (Advisors: Branislav Vukotic & Sabine Schindler)

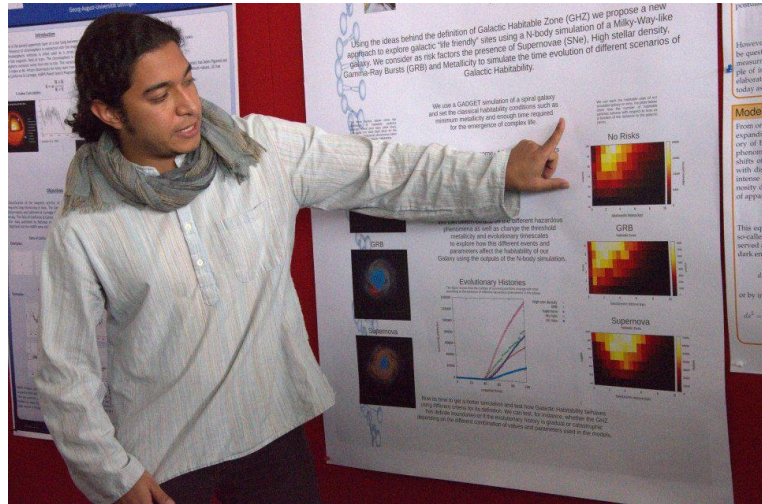


# Best Thesis Award Edition 2

“ Goes to  
“ *Gerardo Martínez  
Aviles*

*Joint thesis  
Innsbruck + Belgrade*

*Advisors:  
Branislav Vukotic &  
Sabine Schindler*



# Edition 3 & 4: Joint Master Thesis

6. KAMALI Fateme „**AGN Black Hole Masses at Different Cosmological Scales** “  
*JOINT THESIS: Goettingen + Belgrade*  
(advisors: Luka Popovic, Wolfram Kollatschny)
7. KOKOTANEKOVA Rosita Dimitrova „**X-RAY WEAK QUASARS** “  
*JOINT THESIS: Goettingen + Belgrade*  
(advisors: Luka Popovic, Wolfram Kollatschny)
8. SHORT Lawrence Anthony “**Comparison of Predicted and Observed Period Derivatives of RR Lyrae Stars**”  
*JOINT THESIS: Rome + Belgrade*  
(advisors: Giuseppe Bono, Dragana Ilic)



# Edition 5: Master Thesis

9. Miiika Pursiainen ***“The shape of the broad iron  $K\alpha$  line and the effect of the accretion disc parameters in type 1 AGN”*** – BELGRADE (advisors: Luka Popovic, Predrag Jovanovic)
10. Ernesto Perez Hernandez  
***„Variability properties of the continuum and emission lines of type 1 AGNs: Periodicity and Time delays Evolution“***  
***JOINT THESIS: Goettingen + Belgrade***  
(advisors: Andjelka Kovacevic, Wolfram Kollatschny)
11. Jana Khusanova  
***„Adaptation of LSST software stack to ESO-NNT SOFI near-infrared camera “***  
***JOINT THESIS: Innsbruck + Belgrade***  
(advisors: Darko Jevremovic, Giovanna Temporin)



# Edition 6: Master Thesis

12. Miriam Gudino ***“The Hubble constant from time-delays of gravitationally lensed quasars”*** (advisors: Predrag Jovanovic)





# Edition 7: Master Thesis

13. Agata M. Wiśłocka

***“The Radiation Impact of Active Galactic Nuclei at on the Milky Way’s Planetary Atmospheres”***

(supervisor: Andjelka B. Kovačević, Andrea Balbi)

14. Adrián Castañón Esteban ***“Blast Waves with Cosmic Rays”***

(supervisor: Bojan Arbutina)

15. Abhishek Chougule

***“Influence of improved Stark broadening data on chromium spectral lines”***

**JOINT THESIS Innsbruck + Belgrade**

(supervisors: Norbert Przybilla,  
Milan S. Dimitrijevic)



# What we are proud of

## Our students!



Edition 8, 3<sup>rd</sup> semester in Belgrade

# Truly international programme...

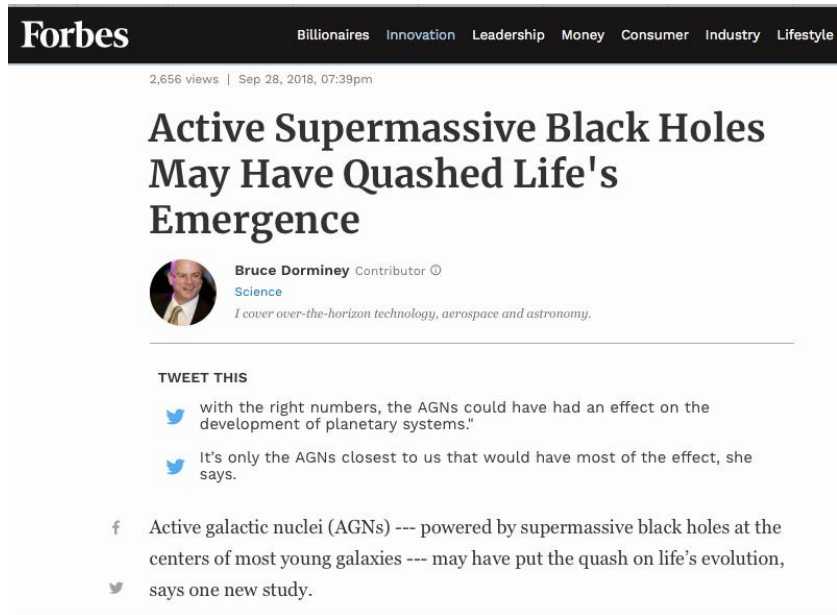
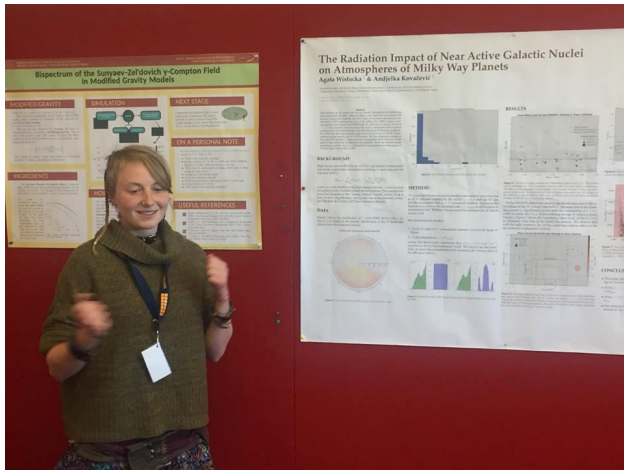
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Bulgarian 2	Indonesian 1	Spanish 1
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Colombian 1	Italian 3	USA 5
Croatian 1	Macedonian 1	Ugandan 1
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Ethiopian 1	Nepalese 1	Venezuelan 2
Finnish 1	Pakistani 5	Vietnamese 3
French 1	Peruvian 1	

gender balanced (~50% female)

# What we are proud of


” Magazine Forbes  
Interview with Agata M. Wiśłocka



**Forbes** Billionaires Innovation Leadership Money Consumer Industry Lifestyle



2,656 views | Sep 28, 2018, 07:39pm


## Active Supermassive Black Holes May Have Quashed Life's Emergence


**Bruce Dorminey** Contributor   
Science  
*I cover over-the-horizon technology, aerospace and astronomy.*

---

**TWEET THIS**

-  with the right numbers, the AGNs could have had an effect on the development of planetary systems."
-  It's only the AGNs closest to us that would have most of the effect, she says.

 Active galactic nuclei (AGNs) --- powered by supermassive black holes at the centers of most young galaxies --- may have put the quash on life's evolution, says one new study.



# What we are proud of

“ Master thesis work published in leading scientific journals

The collage displays several scientific publications:

- Astronomy Astrophysics (AM Ed. 1):** "Discovery of the correspondence between intra-cluster radio emission and a high pressure region detected through the Sunyaev-Zel'dovich effect" by Z. Praeger et al. (2014).
- EPSC Abstracts:** "Stability of Giant Planet Moons during Planet-Planet Scattering Events" by Yu-Chun Hong (2011).
- EPSC Abstracts:** "Cosmological fluid mechanics with adaptively refined large eddy simulations" by W. Schmidt et al. (2014).
- Monthly Notices of the Royal Astronomical Society (MNRAS):** "Oscillatory patterns in the light curves of five long-term monitored type 1 active galactic nuclei" by Anshu K. Basak et al. (2012).
- Astronomy Astrophysics (AM Ed. 1):** "The intrinsic Baldwin effect in broad Balmer lines of six long-term monitored AGNs" by G. La Mura et al. (2011).
- EPSC Abstracts:** "Ground in this view of life? N-body simulation models of the Galactic habitable zone" by G. La Mura et al. (2011).
- EPSC Abstracts:** "CARMENES instrument overview" by G. La Mura et al. (2011).
- EPSC Abstracts:** "CARMENES: an overview six months after first light" by G. La Mura et al. (2011).
- SPIE Proceedings:** "Ground layer correction: the heart of LINC-NIRVANA" by Kalyan Kumar Pathiramanthran et al. (2011).
- SPIE Proceedings:** "First light of the LINC-NIRVANA Pathfinder experiment" by Kalyan Kumar Pathiramanthran et al. (2011).
- SPIE Proceedings:** "Shaping the PSF to nearly top-hat profile: CHEOPS laboratory results" by Kalyan Kumar Pathiramanthran et al. (2011).
- Astronomy Astrophysics (AM Ed. 1):** "The dependence of the [FUV-MUV] colour on solar cycle" by Maja Lovric et al. (2011).





# Results of our Alumni

AstroMundus alumni who continued their career in Astrophysics are very active in publishing their new research results. Here are reported only some outstanding examples of works they authored or participated in as co-authors as PhD students mostly within large international teams.



As a PhD student at the Max Planck Institute for Gravitational Physics (Albert Einstein Institute) and Leibniz University, Hannover, the AstroMundus alumnus Avneet Singh participated in the Gravitational Waves discovery paper, which reports the first detection of gravitational waves that marked the opening of a new observational window in Astrophysics.

The detection of gravitational waves from another black hole merger with the combined use of 2 Advanced LIGO detectors and the Advanced VIRGO detector and, for the first time, the detection of gravitational waves from a binary neutron star merger were announced in two subsequent papers that saw the participation of two AstroMundus alumni as members of the research team: Avneet Singh and Odysse Malim, PhD student at the Gran Sasso Science Institute, L'Aquila. The latter detection was particularly important, because for the first time it was possible to combine the gravitational wave signal with the emission across the electromagnetic spectrum that accompanies a neutron star merger event.

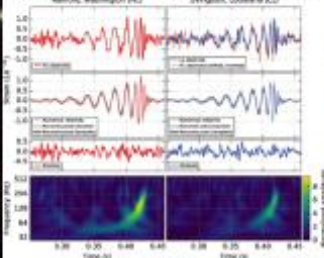
The paper reporting the observation of a kilonova as the electro-magnetic counterpart of the gravitational wave source has seen another AstroMundus alumnus in the authoring team, Aleksandar Cikota, ESO fellow at the International Max Planck Research School in Garching.



## Observation of Gravitational Waves from a Binary Black Hole Merger

R. Abbott et al. (90 Scientific Collaborations and 100 Institutions)  
 Phys. Rev. Lett. **116**, 061102 (2016). Published 12 February 2016

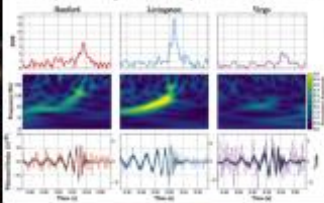
DOI: <https://doi.org/10.1103/PhysRevLett.116.061102>



## GW170817: A Three-Detector Observation of Gravitational Waves from a Binary Neutron Star Coalescence

R. Abbott et al. (2400 Scientific Collaborations and 100 Institutions)  
 Phys. Rev. Lett. **118**, 141101 (2017). Published 10 October 2017

DOI: <https://doi.org/10.1103/PhysRevLett.118.141101>



## GW170817: Observation of Gravitational Waves from a Binary Neutron Star Inspiral

R. Abbott et al. (2400 Scientific Collaborations and 100 Institutions)  
 Phys. Rev. Lett. **118**, 141101 (2017). Published 10 October 2017

DOI: <https://doi.org/10.1103/PhysRevLett.118.141101>

**nature**  
 International journal of science

Letter • Published 26 August 2016

### A terrestrial planet candidate in a temperate orbit around Proxima Centauri

Guillem Anglada-Escarot<sup>1</sup>, Peter J. F. Lucas<sup>1</sup>, L. J. Watkins<sup>1</sup>, Jakob Teske<sup>1</sup>  
 Nature **536**, 471–474 (25 August 2016) | Downloaded October 6, 2016

doi:10.1038/nature16745 — Science Release

Planet Found in Habitable Zone Around Nearest Star

Pale Red Dot campaign reveals Earth-mass world in orbit around Proxima Centauri

16 October 2016



As a PhD student at the Institute for Astrophysics at the University of Göttingen, the AstroMundus alumnus Christopher J. Marvin took part in the discovery of an Earth-mass planet orbiting the nearest star to the Sun, Proxima Centauri. Its temperature is within the favourable range for liquid water to be present on the surface.

THE ASTROPHYSICAL JOURNAL LETTERS

### THE UNIFICATION OF POWERFUL QUASARS AND RADIO GALAXIES AND THEIR RELATION TO OTHER MASSIVE GALAXIES

Peter Podigachoski<sup>1</sup>, Peter Barthel<sup>1</sup>, Martin Haas<sup>1</sup>, Christian Ledoux<sup>1</sup>, and Boris Willott<sup>1</sup>  
 Published 2015 June 4 • 2015 L. The American Astrophysical Society. All rights reserved.  
 (The Astrophysical Journal Letters, Volume 810, Number 1)



As a PhD student at the Kapteyn Astronomical Institute, University of Groningen, the AstroMundus alumnus Peter Podigachoski authored a study providing new hints to the unification model of Quasars and radio-galaxies and co-authored a paper on the discovery of prodigious starburst-driven superwinds in Quasar host galaxies.

THE ASTROPHYSICAL JOURNAL LETTERS

### Starburst-driven Superwinds in Quasar Host Galaxies

Peter Barthel<sup>1</sup>, Peter Podigachoski<sup>1</sup>, Bolinda Wilcox<sup>1</sup>, and Martin Haas<sup>1</sup>  
 Published 2017 June 30 • 2017. The American Astrophysical Society. All rights reserved.  
 (The Astrophysical Journal Letters, Volume 843, Number 1)

**nature**  
 International journal of science

Letter • Published 26 October 2017

### A kilonova as the electromagnetic counterpart to a gravitational-wave source

16 October 2017

DOI: <https://doi.org/10.1038/nature24342>

Volume 551, 75–82 (November 2017) | Downloaded October 6, 2017



# Finally... what have we learned and gained from AstroMundus

- “ A lot of experience in the coordination of international education and in the organization of such a complex programme
- “ During the numerous discussions with the students we have learned much about their home countries, about their personal situation at home and about the status of research and education in the home countries
- “ We grew together with the colleagues at our partner universities remarkably well

# Finally... what have we learned and gained from AstroMundus

- “ We did not only benefit from having excellent Master’s students at the partner institutes, but as we have taken on and continue taking on AstroMundus students as PhD students, we have now a constant influx of excellent PhD students
- “ We benefitted a lot from the invited scholars
- “ And last not least - it was a lot of fun to communicate and work with highly motivated, young people from all over the world

# Erasmus+ Quality Review Report 2014

*“A panel of external experts assisted the Quality Review Committee in the evaluation of your report against the criteria indicated below and overall **your assessment was very good**. I am pleased to inform you that your above-mentioned EMMC has been **included** to the Erasmus Mundus Joint Master Degrees (EMJMD) **Catalogue**. “*

” Based on:

- ✓ Relevance
- ✓ Attractiveness
- ✓ Level of integration
- ✓ Sustainability





Thank you for your attention!



[www.astromundus.eu](http://www.astromundus.eu)

