instituto de astrofísica
e ciências do espaço

# Institute of Astrophysics and Space Sciences

2019 Activity Report

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e ciências do espaço

U.PORTO

Ciências ULisboa

COFINANCIAMENTO

FCT Fundação para a Ciência e a Tecnologia

COMPETE 2020

PORTUGAL 2020

UNIÃO EUROPEIA
Fundo Europeu de Desenvolvimento Regional

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# Unit Overview

The **Instituto de Astrofísica e Ciências do Espaço (IA)** is the reference institution for research in Astronomy, Astrophysics and Space Sciences in Portugal, continuing to assume a bold strategy for the development of this area in the country. Being the largest national research unit in this area, and with a strong participation in major international projects, IA is responsible for the majority of the national productivity in international ISI journals in the area of Space Sciences, one of the scientific areas with the highest relative impact for Portugal.

The mission of IA is to foster research with the highest impact in the field of astrophysics and space sciences and to support teaching and training of young researchers and students in close collaboration with the Universities of Lisbon and Porto. It also aims to promote wide-ranging science communication activities that enhance public understanding of the Universe and our place in it, as well as awareness of the importance of research in this field.

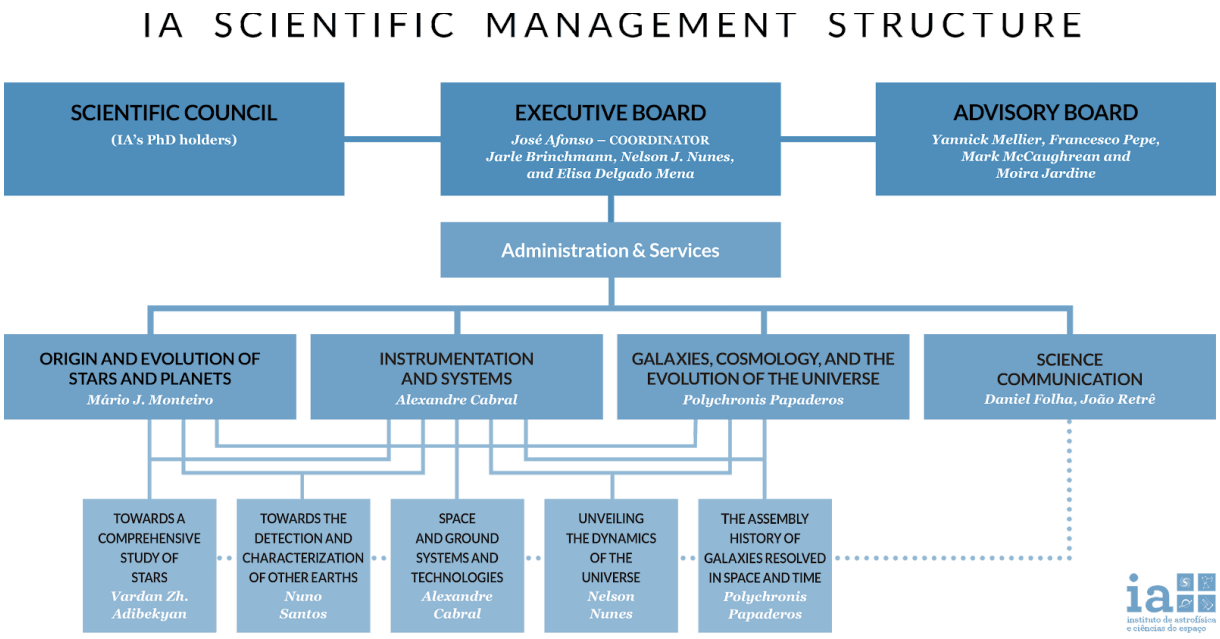
Our vision is to achieve international leadership in key areas of astrophysics and space sciences, taking full advantage and realising the potential created by the national membership of the European Space Agency (ESA), the European Southern Observatory (ESO) and the Square Kilometre Array Observatory (SKAO). This is done through state-of-the-art research, enabled by our leading participation in strategic international ground and space-based projects and missions.

The year of 2019 has been, once again, rich in activities and exciting discoveries, as summarised in the following pages. This was also the year when the second international evaluation of IA was concluded. We are excited to have achieved, once again, the highest possible evaluation marks (Excellent), and proud of the remarkable range of activities we were able to successfully convey to an international Physics panel. After this exercise we remain absolutely focused in the advance of the study of the Universe, increasingly capacitated by our intense participation in a range of instruments and missions. For 2020 we look forward to the initial results from ESPRESSO and Cheops, using, and supporting the use of, ALMA, nearing completion of MOONS and Euclid, and eagerly contributing to the ongoing development of PLATO, ARIEL and Athena. A very special effort will be dedicated to the future ELT instruments, HIRES and MOSAIC, which provide a natural continuation of our legacy from ESPRESSO and MOONS.  It is probably too much, it certainly appears too much, and yet it feels just about right to feed this endless thirst for knowledge that continues to drive our activity.

José Afonso, Jarle Brinchmann, Elisa Delgado Mena, Nelson Nunes
IA Executive Board

# IA Management

The Executive Board (EB, elected in April 2018) is composed of 2 members from the Porto node (Jarle Brinchmann and Elisa Delgado Mena) and 2 members from the Lisbon node (José Afonso and Nelson Nunes), with José Afonso as the coordinator of the research unit.




During 2019, the EB continued having regular weekly meetings to coordinate the scientific and management activities of the IA strategic plan. Every other week these meetings also include thematic line and group leaders, including the Science Communication Group. Contacts with the two management institutions (CAUP and FCiências.ID) were also done whenever needed.

# The Visitor Program at the Institute for Astrophysics and Space Sciences

The Visitor Program at the Institute for Astrophysics and Space Sciences was established at IA in 2016. Its main goal is to attract senior scientists to work at the Institute for periods from 1 week to 1 month (http://www.iastro.pt/ia/visitorProgram.html) to contribute to the IA's excellence in research by promoting the interaction of IA's researchers and PhD students with internationally recognised scientists working in areas considered strategic for IA's development. Applications for this program are permanently open, with the evaluation process taking place once every 4 months. In 2019 the program supported the visit of:

- Andrés Carmona Gonzalez (Institut de Recherche en Astrophysique et Planétologie - IRAP), between March 8 and 25.

## Incentive Program for the Training of Excellence of Young Researchers in Astrophysics and Space Sciences

The Incentive Program for the Training of Excellence of Young Researchers in Astrophysics and Space Sciences was established to attract young undergraduate students to IA by offering them the possibility to work on small research projects (http://www.iastro.pt/training/bicProgram.html) for the period of three months. In 2019, after selection from 23 applications, the following fellowships and selected projects were implemented:

- Alexandre Faria dos Santos, “Modeling galaxy cluster populations with Machine Learning methods” (supervisor: António da Silva);
- Beatriz de Sousa Ataide da Silva, “ALMA serendipitous detections” (supervisors: Israel Matute and Ciro Pappalardo).
- Beatriz Gamboa Pereira, “Testes de modelos de energia escura a baixo e alto redshift" (supervisor: Carlos Martins);
- Beatriz Maria Franco Pinto, “An online catalogue of exoplanet data" (supervisor: João Faria);
- Barbara Maria Teixeira Basto Soares, “Explorando os dados científicos provenientes do satélite TESS da NASA” (supervisor: Tiago Campante);
- Constança Freire, “Titan atmosphere′ s studies using VLT/UVES and Cassini space mission data” (supervisors: Pedro Machado and Gabriella Gilli);
- Daniel Filipe Baptista Gonçalves, “Time Domain Astronomy: Following the tessellation of the Universe” (supervisors: António da Silva and José Pedro Mimoso)
- Ines Meira Leite, “Desenvolvimento de um sistema de aquisição de dados 2D com camara CCD para aplicação em metrologia óptica” (supervisors: Alexandre Cabral);
- Maria Carolina de Barros Barbosa, “Search for transiting planets in K2 light curves” (supervisors: Susana Barros and Olivier Demangeon);
- Veridiano Moreno Marques, “SOAP united” (supervisors: Susana Barros and Sérgio Sousa).

## IA-ON 6

The IA-ON meetings continue to be a fundamental annual event enhancing scientific discussion between the whole IA team on outreach, management issues and strategic lines of the Institute. The 6$^{th}$ Internal workshop (IA-ON 6) took place in Porto on the 10$^{th}$ and 11$^{th}$ of October, at the Seminário de Vilar.

The IA-ON 6 assembled most of the team, with an attendance of 83. The highlights of the year were shared with the whole team, with the majority presented by younger researchers. In 2019 the focus was given to scientific discussions, pausing the customary SOAR and SWOT analyses. As in previous

IA-ON meetings, the various thematic lines had the opportunity to have their splinter meetings where an update on their research was made and plans for the future were set.

# The IA team (2019)

## Origin and Evolution of Stars and Planets Group

| Researchers (PhDs) |
|---|
| Alberto Negrão |
| Charlotte Gehan (joined in 14 October 2019) |
| Daniel F. M. Folha* |
| Elisa Delgado-Mena |
| Diego Bossini (joined in 23 January 2019) |
| Doris Arzoumanian (joined in 15 April 2019) |
| Gabriella Gilli |
| Hugo M. Tabernero Guzmán (joined in 1 May 2019) |
| Isa M. Brandão (left in 28 February 2019) |
| João P. S. Faria |
| João J. G. Lima |
| João Lin Yun |
| João Gomes da Silva (joined in 1 January 2019) |
| Jorge Filipe S. Gameiro |
| Jorge H. C. Martins |
| Margarida S. Cunha |
| Maria Teresa V. T. Lago |
| Maria Tsantaki (left in 30 June 2019) |
| Mário J. P. F. G. Monteiro |
| Mathieu Vrard (left in 31 August 2019) |
| Morgan Deal (joined in 28 January 2019) |
| M. S. Nanda Kumar |
| Nuno C. Santos |
| Olivier Demangeon |
| Pedro M. Palmeirim |
| Pedro Machado |
| Pedro Figueira |
| Pedro T. P. Viana |
| Rui Agostinho* |
| Sérgio A. G. Sousa* |
| Susana C. C. Barros |
| Tiago Campante |
| Vardan Zh. Adibekyan |
| Vítor M. M. Costa |

| Others |
|---|
| Akinsanmi Babatunde (PhD student) |
| Alexandros Antoniadis Karnavas (PhD student) |
| André Miguel A. C. V. Silva* (PhD student) (joined in 1 October 2019) |
| Andressa C. S. Ferreira (PhD student) (left in 31 july 2019) |
| Benard Nsamba (PhD student) |
| Eduardo Cristo (PhD student) (joined in 1 October 2019) |
| Guilherme D. C. Teixeira (PhD student) |
| Jason J. Neal (PhD student)* (left in 9 September 2019) |
| João D. R. Camacho (PhD student) |
| José Silva (PhD student) |
| Luís Filipe Pereira (PhD student) |
| Luisa M. Serrano (PhD student) |
| Miguel Clara (PhD student, joined in 27 November 2019 |
| Miguel Silva (PhD student) (left in 30 June 2019) |
| Paola A. Quitral Manosalva (PhD student) (left in 6 March 2019) |
| Paulina M. Zaworska (PhD student) |
| Pedro I. T. K. Sarmento (PhD student) |
| Raquel M. G. Albuquerque (PhD student) |
| Ruben Gonçalves (PhD student) |
| Saeed Hojjatpanah (PhD student) |
| Solène C. Ulmer-Moll (PhD student)* |
| Thibault Boulet (PhD Student) (joined in 1 October 2019) |
| Tomás Silva (PhD student) (joined in 1 October 2019) |

## Galaxies, Cosmology, and the Evolution of the Universe Group

| Researchers (PhDs) |
|---|
| Alberto Rozas-Fernández |
| Andrew J. Humphrey |
| Andrew R. Liddle |
| António C. da Silva* |
| Carlos J. A. P. Martins |
| Catarina Lobo |
| Cirino Pappalardo |
| Claudio Llinares (joined in 16 December 2019) |
| Daniele Vernieri (joined in 27 February 2019) |
| Diego Rubiera-Garcia (left in 31 May 2019) |
| Fernando Buitrago |
| Francisco S. N. Lobo |
| Giuseppe Fanizza (joined in 1 October 2019) |
| Hugo Messias (joined in 18 September 2019) |
| Iris P. Breda (finished PhD student in 3 May 2019) |
| Ismael Tereno* |
| Israel Matute |
| Ivan Rybak (joined in 1 April 2019) |
| Jarle Brinchmann |
| Jean Michel Gomes |
| José Afonso |
| José Pedro Mimoso |
| Lara G. Sousa |
| Leandro Cardoso (left in 30 June 2019) |
| Marina Cortês |
| Martina Vicinanza (left in 15 February 2019) |
| Nelson J. Nunes |
| Noemi Frusciante |
| Patricio Lagos (joined in 28 January 2019) |
| Paulo Crawford |
| Paulo Maurício de Carvalho |
| Pedro Pina Avelino |
| Polychronis Papaderos |
| Ricardo Caldeira Costa (joined in 1 Sept. 2019) |
| Rui Agostinho* |
| Silvio Lorenzoni |
| Tiago Barreiro |
| Tom C. Scott |

| Others |
|---|
| Abhishek Chougule (PhD Student) (joined in 1 October 2019) |
| Ana C. O. Leite (PhD student) |
| Ana S. Paulino Afonso (PhD student, left in 7 January 2019) |
| Bruno J. C. B. Barros (PhD student) |
| Diogo Castelão (PhD student) |
| Fábio A. R. Ferreira (PhD student, left in 31 August 2019) |
| Francisco T. O. Cabral (PhD student) |
| Iris P. Breda (finished PhD student in 3 May 2019) |
| Ismael Ayuso (PhD student) |
| José Ricardo Correia (PhD student) |
| Marckelson S. Silva (PhD student) (left in 11 September 2019) |
| Rodrigo A. Carvajal Pizarro (PhD) (joined in 1 November 2019) |
| Rui P. L. Azevedo (PhD Student) |
| Sandra N. Reis (PhD student) |
| Sandy Gonçalves Morais (PhD student) |
| Stergios Amarantidis (PhD student) |
| Vasco M. C. Ferreira (PhD student) |

## Instrumentation and Systems Group

| Researchers (PhDs) |
|---|
| Alexandre Cabral |
| António C. da Silva* |
| David C. Alves |
| Elena Duarte |
| Ismael Tereno* |
| João Coelho |
| João Dinis |
| José M. Rebordão |
| Manuel Abreu |
| Sérgio A. G. Sousa* |

| Others |
|---|
| André Miguel A. C. V. Silva* (PhD student) (joined in 1 October 2019) |
| António Joaquim Marques de Oliveira |
| Bachar Wehbe (PhD student) |
| Cédric P. Pereira (PhD student) (joined in 1 Oct.r 2019) |
| Jason J. Neal (PhD student)* (left in 9 Sept. 2019) |
| Manuel Monteiro |
| Pedro Manuel Fonseca Nunes dos Santos |
| Solène C. Ulmer-Moll (PhD student)* |
| Tiago Magalhães (PhD student) |

## Interface to Science

| Science Communication Group |
|---|
| Catarina Leote |
| Elsa M. P. S. Moreira |
| Daniel F. M. Folha* |
| Filipe A. L. Pires |
| Hilberto M. R. Silva |
| Ilídio André P. M. Costa (PhD student) |
| João Retrê |
| Lupércio B. Bezerra (PhD student) |
| Paulo J. T. Pereira |
| Ricardo S. S. C. Reis |
| Sérgio Pereira Ribeiro |
| Tânia F. S. Cunha (joined in 1 February 2019) |

| Administration and Services |
|---|
| Argentina Pereira |
| Carla Mendes (joined in 1 November 2019) |
| Carlos M. A. Santos |
| Elsa M. P. P. Silva |
| Marta Castelão (1 February to 30 September 2019) |
| Sandra M. F. Homem |
| Teresa Vareta (left in 31 October 2019) |

Researchers that work in more than one group are marked with (*).

# Research Projects/Programmes

During 2019, a number of funded projects were on-going at IA, providing most of the funds available for research, including outreach activities.

## Projects focused on scientific activities

The research projects that in 2019 were supported by national and European funds are:

(i) **Projects funded by the European Commission (EC):**

Detecting and characterization exoplanets around evolved stars with NASA's TESS mission (PULSATION) (MSCA-IF-EF-ST-792848)
PI: Tiago Campante
[start date: 1st November 2018 – end date: 31th October 2020]

Hot Terrestrial Exo-planet Atmospheres: preparing new generation instrument observations with a global climate model (Hot-TEA) (MSCA-IF-EF-ST-796923)
PI: Gabriella Gilli
[start date: 1st September 2018 – end date: 31th August 2020]

CANTATA – Cosmology and Astrophysics Network for Theoretical Advances and Training Actions (COST Association Cost Action CA-15117)
PI: Ruth Lazkoz. Management Committee: José Pedro Mimoso
[start date: 8th April 2016 – end date: 7th April 2020]

Revealing the Milk Way with Gaia (MW-GAIA) (COST ACTION CA18104)
PI: Vardan Adibekyan & Nuno Santos
[start date: 14th March 2019 – end date: 13th March 2023]

(ii) **Research projects funded by Fundação para a Ciência e a Tecnologia (FCT):**

The Gaia-ESO census of the Milky Way: unlocking the secrets of stellar populations (GES) (PTDC/FIS-AST/7073/2014 & POCI-01-0145-FEDER-016880)
PI: Vardan Adibekyan
[start date: 1st July 2016 – end date: 30th June 2019]

Characterizing the smallest planet hosts (IF/00849/2015/CP1276/CT0003)
PI: Elisa Delgado Mena
[start date: 1st January 2017 – end date: 31th December 2021]

Zoom-In ON hIgh-mass Star forMation (ZIONISM) (IF/00956/2015/CP1273/CT0002)
PI: Nanda Kumar
[start date: 15th December 2016 – end date: 14h December 2021]

Resolving galaxy evolution (IF/01654/2014/CP1215/CT003)
PI: Jarle Brinchmann
[start date: 30th June 2015 – end date: 29th June 2020]

Gravitational Lensing in the Universe with Euclid (IF/01518/2014)
PI: Ismael Tereno
[start date: 30th June 2015 – end date: 29th June 2020]

Towards characterization of Earth-like exoplanets (IF/00028/2014/CP1215/CT0002)
PI: Sérgio Sousa
[start date: 1st May 2015 – end date: 30th April 2020]

Probing the Physics of the Dark Universe with Euclid (IF/01135/2015)
PI: António da Silva
[start date: 3rd October 2016 – end date: 2nd October 2021]

Dark Couplings (IF/00852/2015)
PI: Nelson Nunes
[start date: 1st October 2016 – end date: 30th September 2021]

Probing cosmic strings and other topological defects with gravitational waves (Gwstrings)
(POCI-01-0145-FEDER-031938 & PTDC/FIS-PAR/31938/2017)
PI: Lara Sousa
[start date: 15th October 2018 - end date: 14th October 2021]

Planets - Towards Understanding their General circulation Atmospheres (P-TUGA)
(PTDC/FIS-AST/29942/2017)
PI: Pedro Machado
[start date: 3rd September 2018 - end date: 2nd September 2021]

Identify the Earliest Supermassive Black Holes with ALMA (IdEaS with ALMA)
(PTDC/FIS-AST/29245)
PI: José Afonso
[start date: 3rd September 2018 - end date: 2nd September 2021]

Spacetime ripples in the dark gravitational Universe (DarkRipple)
(PTDC/FIS-OUT/29048/2017)
PI: Francisco Lobo
[start date: 1st September 2018 - end date: 31th August 2021]

a Generation of Earth-ANalogs Exploration Spectrographs (G.EANES)
(POCI-01-0145-FEDER-032113 & PTDC/FIS-AST/32113/2017
PI: Nuno Santos
[start date: 1st August 2018 - end date: 31th July 2021]

Cosmology and Fundamental Physics with ESPRESSO (CosmoESPRESSO)
(POCI-01-0145-FEDER-028987 & PTDC/FIS-AST/28987/2017
PI: Carlos Martins
[start date: 1st June 2018 - end date: 31th May 2021]

Exploring exoPlanets wIth CHEOPS (EPIC)
(POCI-01-0145-FEDER-028953 & PTDC/FIS-AST/28953/2017)
PI: Sérgio Sousa
[start date: 1st June 2018 - end date: 31th May 2021]

Breaking through outstanding problems in stellar evolution with ultra-precise space-based photometry (BreakStarS) (POCI-01-0145-FEDER-030389 & PTDC/FIS-AST/30389/2017)
PI: Margarida Cunha
[start date: 1st May 2018 - end date: 30th April 2021]

(iii) ***Infrastructure* funded projects (FCT):**

R&D Units: Instituto de Astrofísica e Ciências do Espaço (UID/FIS/04434/2019)
PI: José Afonso
[start date: 1st January 2019 – end date: 31th December 2019]

(iv) **Doctoral programme (FCT):**

Doctoral Network in Space Sciences (PhD::SPACE) (PD/00040/2012)
PI: Mário João Monteiro
[start date: 1st October 2013 – end date: 31th December 2020]

(v) **Cooperation projects funded by Gabinete de Relações Internacionais da Ciência e do Ensino Superior (FCT) and by Conselho de Reitores das Universidades Portuguesas**

Strategic partnership in astrophysics Portugal-Brazil: the connection between black holes and galaxies using powerful new instrumentation and theoretical insights (Cooperação Cientifica e Tecnológica FCT/CAPES - 2018/2019)
PI at IA: Andrew Humphrey
[start date: 1st May 2018 – end date: 30th April 2019]

The impact of stellar activity on the detection of extrasolar planets: the road to an Earths's twin (Cooperação Científica e Tecnológica FCT/DAAAD 2019/2020)
PI: João Faria
[start date: 1st January 2019 – end date: 31st December 2019]

## Projects focused on communication and outreach

During 2019, there was several funded projects in IA:

Ciência Viva no Laboratório – Ocupação Científica de Jovens nas Férias 2018 (CV: 4-2018)
PI: João Retrê
[start date: 1st July 2018 – end date: 1st January 2019]

Ciência Viva no Verão em Rede 2019 (CV: 56-2019/446)
PI: Daniel Folha
[start date: 1st July 2019 – end date: 15th October 2019]

Astrocamp2019 (CV: 11-2019/852)
PI: Carlos Martins
[start date: 2nd May 2019 – end date: 16th September 2019]

Ciência Viva no Laboratório – Ocupação Científica de Jovens nas Férias 2019
PI: Carlos Martins
[start date: 1st June 2019 – end date: 30th September 2019]

Formação ESERO - Conhecer a Terra através do Espaço - 1ª Edição
PI: Filipe Pires
[start date: 1st February 2019 - end date: 31st July 2020]

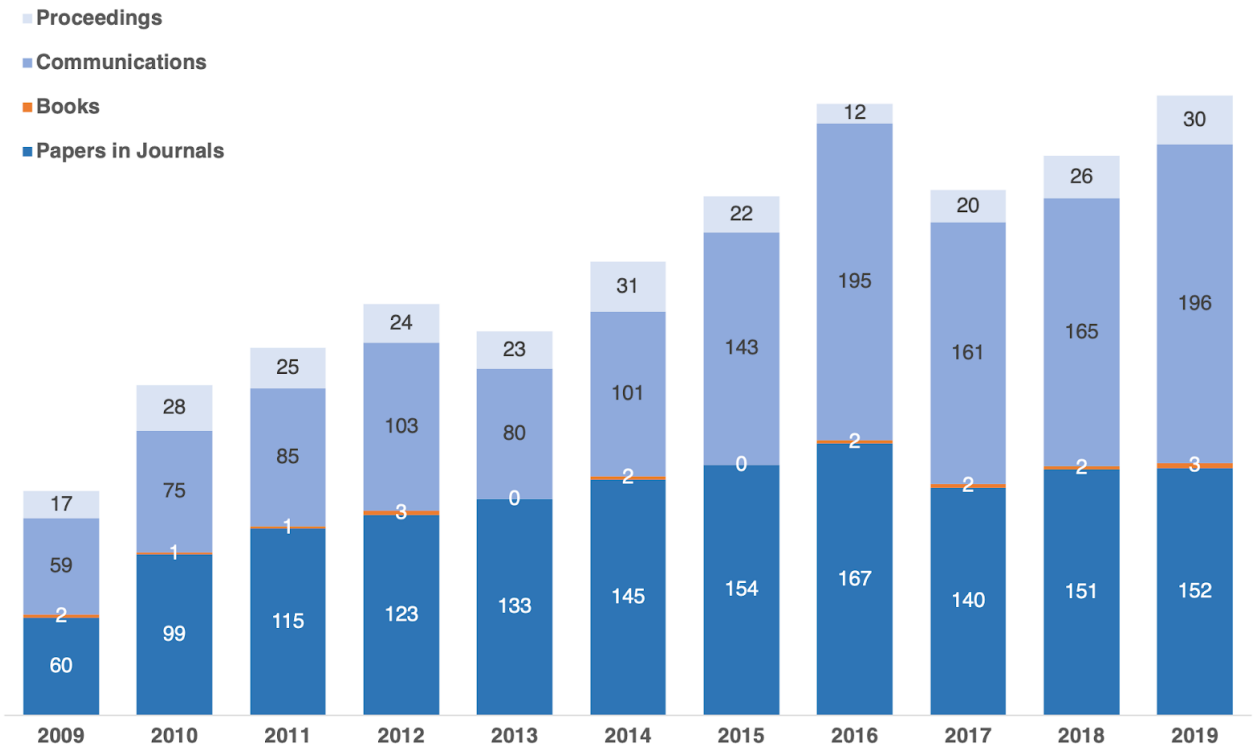
Formação ESERO - Conhecer a Terra através do Espaço - 2ª Edição
PI: Filipe Pires
[start date: 1st September 2019 - end date: 28th February 2020]

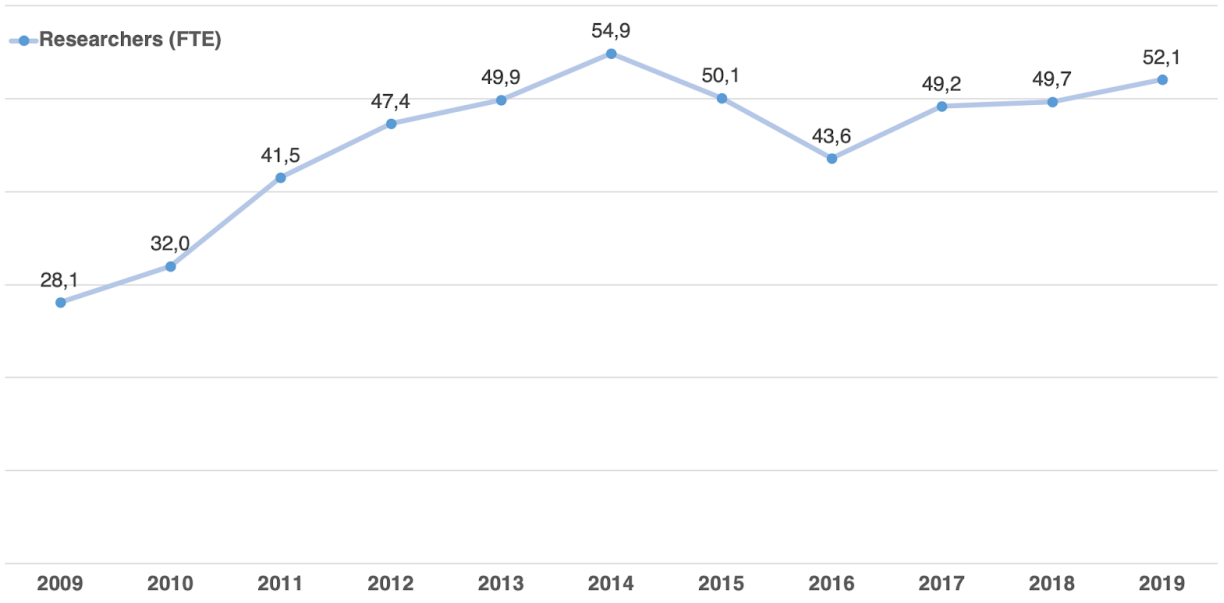
# Scientific Output and Activities

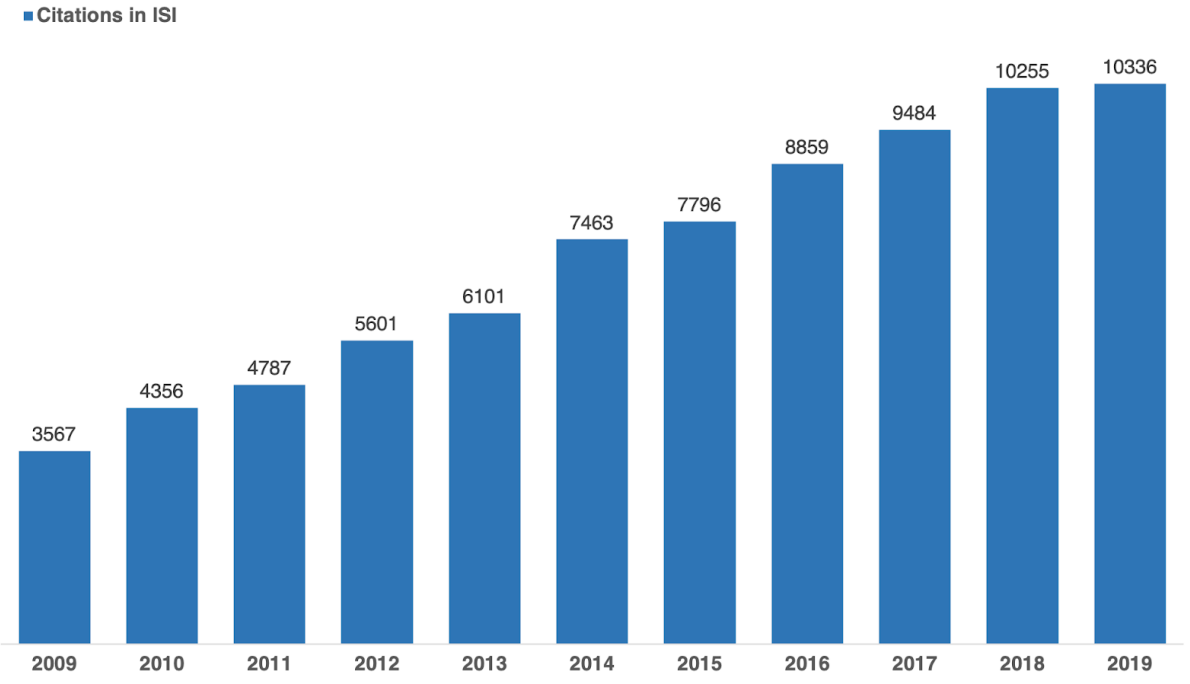
The overall scientific output of IA in **2019** was (see Appendix for details):

| | | |
|---|---|---|
| 152<br>Papers in refereed journals | 30<br>Papers in books and proceedings | 149<br>Communications in international meetings |
| 47<br>Communications in national meetings | 29<br>Seminars in other institutions | 57<br>Seminars organized at IA |
| 134<br>Public outreach talks | 12/5<br>MSc/PhD thesis completed | 36<br>Observing runs |
| 12<br>Organization of conferences | 3<br>Books | 4<br>Reports |

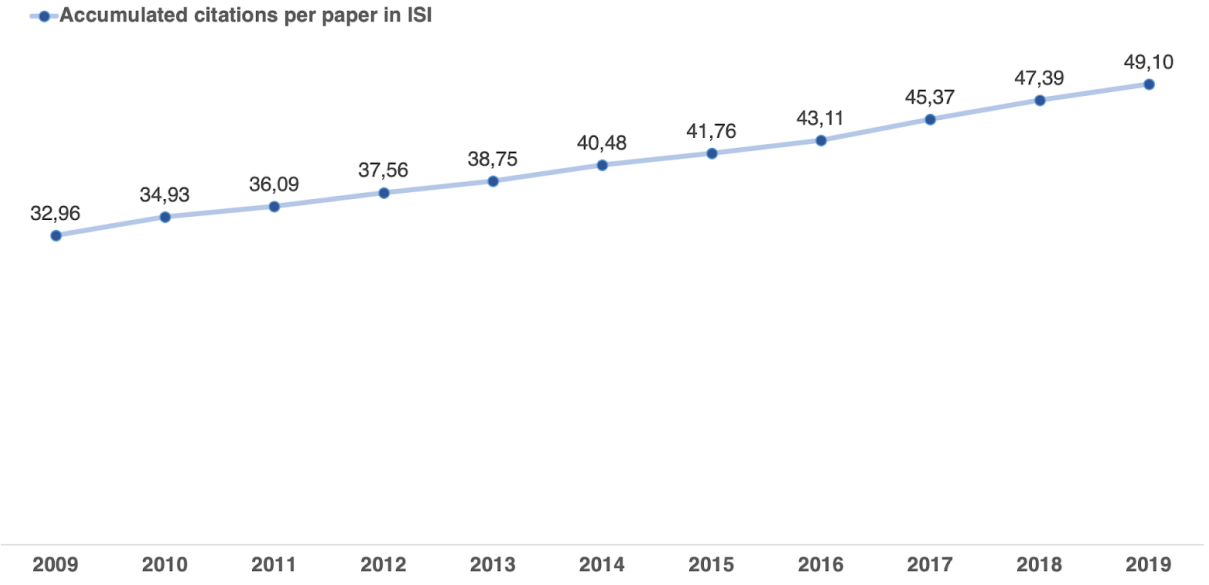
The figures below illustrate the institute's productivity during the past year. There is a clear and natural relation between the number of researchers and the number of papers in journals subject, understandably, to a small shift in time. The figures show a continuation of the increase in the number of publications and communications, which is a strong indication for the strong activity of the Institute. The number of citations also maintains an increasing trend which is not simply justified by an increase in the numbers or articles. Indeed, the figures show that the accumulated impact continues to grow.






*The number of citations obtained in a given year for all the IA articles published since 1990 up to that year.*




*The accumulated impact in a given year is measured as the ratio between the sum of the number of citations up to that year since 1990 and the number of articles in the same period.*

**Report from the Group**

# Origin and Evolution of Stars and Planets

During 2019 the group on the Origin and Evolution of Stars and Planets continued to dedicate a significant part of its scientific efforts towards fulfilling ongoing commitments that the team assumed in the context of the development of major ground-based projects and space-based missions, including HIRES@E-ELT (ESO), SPIrou (CFHT), and NIRPS (ESO) projects, and the Plato (ESA), CHEOPS (ESA), and TESS (NASA) missions. Also of relevance are the active participation in large surveys and the use of major instruments and facilities.

The commissioning and science exploitation of the ESPRESSO (ESO) instrument was a major task pursued in 2019, as well as the start of a national participation in ARIEL/ESA and the preparation for launch of the CHEOPS/ESA mission. Along with this, the team continued to dedicate a significant share of its time to the exploitation of data from state-of-the-art instruments, particularly in relation to planet search programs and to stellar characterisation and modelling through asteroseismology.

The group has also continued to work towards the consolidation of the interaction between the thematic lines "Towards the detection and characterisation of other Earths" and "Towards a comprehensive study of stars". Group meetings and joint activities have been organised, gathering together members from the two thematic lines. In addition, members of both thematic lines often participated in the weekly Journal clubs and meetings that are organised by each thematic line.

The distribution of group members amongst the two thematic lines has been kept even and a number of group researchers continue to contribute effectively to both research lines. The team ends 2019 with 31 researchers and 19 PhD students (5 new students joined the group in 2019). The team had several ongoing projects funded by national and international sources. A new COST Action was initiated in 2019 as well as a cooperation action with Gottingen/Germany.

Mário João Monteiro
Group Leader

**Report from the Thematic Line**

## Towards the detection and characterisation of other Earths

In 2019, Planetary System research at IA continued the activities around the two major branches, namely Exoplanet research and Solar System atmospheres.

Exoplanet research focused on multiple complementary aspects, mostly observationally driven: 1) the search and characterization of exoplanets using state-of-the-art radial velocity data, including the detection and mass measurement of planets previously detected by the transit method; 2) the detection or identification of planets using high-precision transit photometry from space missions (e.g. K2 and TESS); 3) the study of astrophysical sources of noise for the detection and characterization of planets as well as methods to correct/model them; 4) the study of planet-host stars as a way to characterize planets as well as their properties and formation processes; 5) the statistical study of planet characteristics as well as the relation with the properties of the host stars; 6) the study of exoplanet atmospheres using broad-band photometry and high-resolution spectroscopy.

Our team is a major participant/player (e.g. Co-PIship and Board membership) in current (e.g. ESPRESSO@VLT and SPIROU@CFHT) and future (NIRPS@ ESO's 3.6m and HIRES@ESO's ELT) state-of-the-art ground based facilities, as well as space missions (CHEOPS, ESA - launched December 2019; Plato, ESA, 2026; ARIEL, ESA, 2018). For all of those, we are responsible for scientific tasks as well as part of the data reduction/analysis pipelines (among other HW and SW participations responsibility of the Instrumentation team in IA). As such, the strategy of the team is developed taking advantage of our privileged position to make use of the data from these facilities.

In this respect, in 2019 we can highlight the strong effort done by the team in the analysis of data from the ESPRESSO spectrograph (Guaranteed Time Observations). The IA team has a strong contribution to all three working-groups of the ESPRESSO consortium: blind radial velocity search for planets in the habitable zone of solar type stars, transit follow-up to derive masses for rocky planets, and study of exoplanet atmospheres using high resolution spectroscopy. Several papers are now being prepared, including led by IA-team members.

Also of relevance was the launch of the CHEOPS mission (18$^{th}$ December 2019). The scientific acquisition and analysis of CHEOPS data will start in March/April 2020, but several team members have been very active in preparing the scientific observations (including leading roles in some working groups within the CHEOPS Science Team).

ESPRESSO and CHEOPS will be major references for the team in the next 2-4 years, since our leading participation in these projects allows us to be in a privileged position inside the respective consortia to exploit the valuable data obtained in the 273 guaranteed nights of observations (GTO) with ESPRESSO at the VLT (until 2022) and the 80% of the time of the CHEOPS ESA mission (until 2024). To this we should add the 725 nights of GTO for the NIRPS consortium (first light expected in late 2020). Our participation in these projects will reinforce the existing strategy, and allow the team to be in the forefront of exoplanet detection and characterization. Further ahead, our secured participation in the ESA-PLATO, ESA-ARIEL, and ESO-HIRES (ELT) projects guarantee our international leadership role beyond 2026.

On the Solar System side, research mainly focused on solar-system planet atmospheres, with clear synergies with the exoplanet side. The recent selection by ESA (already in 2018) of the space mission ARIEL, with a relevant IA participation, shows that the adopted strategy was correct.

Furthermore, the team continued different studies of the atmospheres of Venus, Mars, Saturn, and Jupiter. We can highlight here the use of space-based observations (from the missions Akatsuki and Venus Express for Venus, and from Cassini for Jupiter and Saturn) to perform dynamical studies based on cloud tracking techniques (UV and IR) and for the detection and characterization of atmospheric waves. To these we add the use of ground-based observations (VLT/UVES for Saturn, HARPSN/TNG and CFHT/ESPaDOnS for Venus) and their related high-resolution spectra in order to retrieve wind velocities using our Doppler velocimetry method (long-slit and fiber-fed techniques).

**Scientific Highlights for 2019**

1. **Unveiling new Earths among the "noise" of stars: the first ESPRESSO results.** Stellar "noise" is known to be a strong limitation to the detection of planets using the Doppler radial velocity method. This may be particularly problematic when dealing with the detection of low mass planets, since stellar physical processes can produce low amplitude signals that can mimic the signature of a planet, thus producing false positive detections.
   Our team has been particularly active in understanding these limitations, as well as studying methods to diagnose and correct for spurious radial velocity signals (of stellar origin). Now, in a study led by IA (Faria et al., 2020, A&A, 635, 13), our team has unambiguously shown that a previously announced radial velocity signal observed for the star HD41248 is not of planetary origin, contrarily to what had been published by other teams. This result was obtained thanks to the unprecedented precision of ESPRESSO and led to the publication of the first paper based on ESPRESSO data.
   The results help us to better understand how to tackle the problems related with the effects of stellar activity and how to diagnose spurious signals in future datasets. Furthermore, it shows that ESPRESSO is providing unique data, capable of detecting Earth-like planets orbiting other solar type stars.

2. **CHEOPS mission successfully launched.** Following a long-term effort started in 2012, in December 2019 the IA team has seen the successful launch of the CHEOPS mission, the first ESA mission fully planned for exoplanet science.
   With a strong participation from the IA team, including the development of a significant part of the Data Reduction Pipeline, CHEOPS will use extremely high-precision photometric measurements to measure the precise radii of known exoplanets using the transit technique. Furthermore, the accuracy of CHEOPS will allow a deeper study of exoplanet atmospheres using phase curves and planet occultations, and possibly to detect special features on exoplanets such as rings and moons.
   The launch of CHEOPS was done with a Russian Soyuz Fregat from the Kourou spaceport in French Guiana, and took place on the 18th of December. In January 2020, the first tests of the instrument will be performed, and first light is scheduled for the 27th. Following a 2-month commissioning phase, science observations will start at the end of March 2020.
   The team has been strongly involved in the preparation of the scientific exploitation of CHEOPS, including leading roles in different working groups within the CHEOPS Science

Team, including 1) the characterization of second order effects like those produced by rings and deformations in shape, 2) the characterization of stellar properties for the planet host stars, and 3) the study of exoplanet atmospheres using CHEOPS data. Starting in March/April 2020, the team will start analysing the incoming data, with the first results expected to be published soon after.

3. **Using artificial intelligence to derive exoplanet sizes.** A work led by IA researchers has published an article (Ulmer-Moll et al.), which shows that by knowing an exoplanet's mass and its equilibrium temperature, it is possible to constrain its radius with higher accuracy than previous methods. To achieve that, the team used machine learning methods together with the most recent databases of mass, radii, and stellar properties for existing exoplanetary systems. This novel way to forecast exoplanet radius is a perfect example of the synergy between exoplanet science and machine learning techniques.
   To characterize a planet, both its mass and radius are needed, in order to find the planet's density, and from that infer its composition. But both data are only available for a reduced number of exoplanets, since the mass is often determined by radial velocity measurements, while radius is measured with the transit method.
   To tackle that problem, the team developed an algorithm which accurately forecasts the radius for a wide range of exoplanets, if several other planetary and stellar parameters are known, mainly, the exoplanet's mass and its equilibrium temperature. For the hundreds of planets discovered with the radial velocity method, we are now able to predict their radius.
   This work beautifully puts together the expertise in our team, uniting the existing knowledge about exoplanet detection and characterization and the statistical analysis of the detected systems, using state-of-the-art mathematical tools. These are essentially the same mathematical tools that are now leading to the development of autonomous cars.

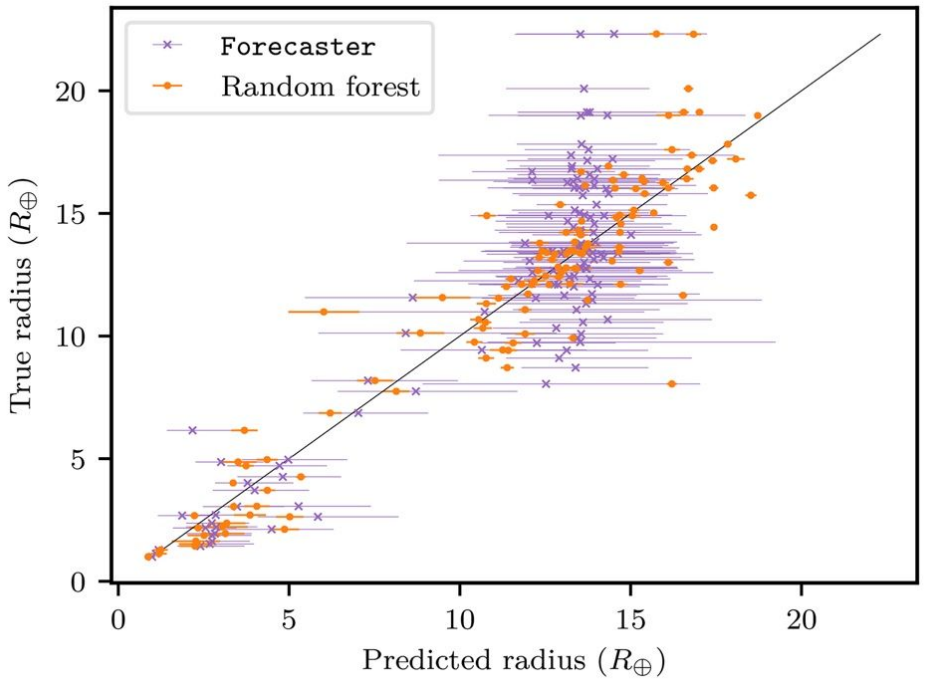



Figure: Comparison of the measured radius for exoplanets and the predicted value using the new tool developed by the team (in orange) and using previously existing tools (in magenta). The results show a clear improvement.

4. **From Venus to other worlds.** The IA team led a study to measure, with unprecedented precision, the winds in the atmosphere of Venus (Gonçalves et al.). The data allowed to better understand the way the clouds of Venus move, and obtain their average velocities both parallel and perpendicular to the equator of the planet.
   Venus is a slowly rotating planet, turning around its axis once every 243 days. However, its atmosphere makes a complete tour of the planet every 4 days, with winds that travel with speeds of around 400 km/s, the velocity of the strongest hurricanes on Earth. The reason for this difference is not yet completely understood though, and to tackle this conundrum several studies are trying to understand in detail the atmospheric motions in the atmosphere.
   Now, a team led by IA has used the HARPS-North spectrograph, an instrument built to detect and study exoplanets, to measure the speeds of Venus atmosphere at an altitude of about 70 km. The data was complemented with space based data, obtained with the Japanese Akatsuki mission. Together, the study made it possible to measure the so-called meridional wind, the component of the wind that goes from the equator to the poles of Venus, with an unprecedented precision. Curiously, the velocities derived using space data and ground based spectroscopy also show significant differences, suggesting that the two approaches are observing different cloud layers.

5. **The metallicity–period–mass diagram of low-mass exoplanets.** The correlation between the presence of giant planets and the metallicity of their host stars shows that massive planets are more common around more metal-rich stars. This was one of the first important clues for the theories of planet formation and evolution. With the increase of the number of exoplanet detection this correlation is being tested for different types of planets, including lower mass ones. Interestingly the metallicity correlation seems to be absent when looking only at stars hosting low-mass planets.
   Using SWEET-Cat data, an online compilation of stellar parameters for planet host stars maintained by the IA team, and focusing only on low-mass planets with a minimum mass below 30 Earth masses, the team has now found hints for a new possible correlation in the metallicity–period–mass diagram. The results point towards the possibility that the mass of the planet increases with both metallicity and orbital period. In the study led by IA (Sousa et al.) our analysis suggests that the general observed correlation may not be fully explained by observational biases, although additional precise data is required to confirm or deny this possible correlation.
   If confirmed, this correlation can also provide important clues and constraints for the formation and evolution of low-mass planets like our own Earth.

**Thematic line meetings, Journal Clubs and other activities**

In 2019, as in previous years, the IA-planet line maintained a regular journal club and team meeting agenda. Team meetings and journal clubs are organized now every two weeks. Meetings include a presentation of “general information”, as well as a short presentation of the work being carried out by one PhD student, followed by discussion. This format helps the whole team to be acquainted with the research that is being carried out and helps the students develop presentation skills and identify potential problems and solutions in his/her research project. Journal clubs include the presentation of

one paper, followed by discussions. A journal club more specific about solar system research is also organised.

All team meetings and Journal Clubs are done using a videoconference link (Zoom), so that all members can attend.

We also organised our annual team meeting (called "2-DEMOC"), that in 2019 took place in Porto, where the team strategy (both scientific and organisational) was discussed with the help of a SOAR analysis.

Team members actively participated in different public outreach activities, including "IAstro Junior" (co-organized with the magazine Visão), several Ignite IAstro events throughout the country, as well as with public talks and debates in schools and other outreach events.

In 2019, one PhD thesis was successfully finished: “Towards the Near-Infrared detection of exoplanets” by Jason Neal. Additionally, 7 MSc students successfully finished their thesis in the team (Tomás Silva, André Silva, Eduardo Cristo, Pedro Silva, Daniela Espadinha, Hermano Valido, and José Ribeiro). Several of these MSc students have now started PhD within the team.

The team also continued the activities within three funded FCT projects. Further to this, team members became involved in an approved COST action (MW-Gaia – Revealing the Milky-Way with Gaia), including one member of the Management Committee (V. Adibekyan) and one substitute member. The team also leads one sub-WG within this same COST action (Exoplanet environments, stellar properties from asteroseismology and local chemistry).

Team members further organized two international conferences/workshops: one related with the COST action mentioned above (“Porto MW-Gaia WG3 Workshop: Exoplanets in the era of Gaia”) and one more focused on Solar System research (“S-SAIL: Solar System Atmospheres’ Investigation and exoplanets”). To these we can add the EPEC (Europlanet Early Career community) conference. Finally, in 2019 the team started the organization of one international conference in the interface between exoplanet science and solar system research, to take place in Lamego, in June 2020 (“Towards other Earths III: from Solar System to Exoplanets”).

Nuno Santos
Thematic Line Leader

**Report from the Thematic Line**

## Towards a comprehensive study of stars

The main goal of this thematic line is to understand the details of the structure and evolution of stars of low and intermediate masses, from the early stages of star formation to late stages of evolution. It also covers the study of rotation and activity both in Young Stellar Objects (YSOs) and in main-sequence stars, as well as the modelling of star-disk interactions in the former.

Part of the work of the team continued to be centred on the exploitation of seismic data acquired with the NASA satellite Kepler (launched in 2009, and now operating as K2), as well as on the determination of the global properties of stars in the context of the team's participation in the Gaia-ESO survey.

Simultaneously, the team started an extensive exploitation of asteroseismic data from the NASA satellite TESS (launched in 2018), in relation to which the team leads one of the working groups established by the Tess Asteroseismic Science Consortium (TASC). Following the adoption by ESA (in 2017) of the mission PLATO, the team is actively participating in the implementation of the work in the stellar part of the mission. In particular the team is leading work packages on seismic diagnostics and calculation of stellar models for the pipeline, a working group on spectroscopic characterization of the PLATO targets, a working package on the scientific validation of the PLATO as well as participating in several others. The team is also involved (leading some sub-WGs) in the preparation of the ARIEL/ESA (2028) mission through stellar characterization with asteroseismology and determination of atmospheric stellar parameters.

On the star formation side, the team is involved in the ongoing JCMT projects, the ESO-VISTA VVV survey, and also intensively uses ALMA and Herschel high-quality data. The team members are also involved in the upcoming JWST (James Webb Space Telescope, scheduled March 2021) and SPICA (Space Infrared Telescope for Cosmology and Astrophysics - still to be accepted by ESA, proposed launch date 2032) projects. Additionally, the team is involved in the SPIRou consortium work packages focusing on the study of accretion and outflow processes in T Tauri stars. All these efforts are aimed at understanding the complete picture of star formation by connecting the smaller scale of individual cores/YSOs (for the whole spectrum of mass, low-and high-mass) to the larger galactic scale of the ISM.

In 2019, the team members got involved in the CA18104 COST Action “Revealing the Milky Way with Gaia”, leading a sub-WG and participating in the Management Committee decisions of the Action.

**Scientific Highlights for 2019**

1. **The first detection of oscillations in previously known exoplanet-host stars by TESS.** The excellent photometric precision of TESS allows asteroseismic accurate characterization of solar-type and red-giant stars. The team was very active in using this high-quality data. This activity led to a publication (Campante et al.) of a 'first-light' study of two red-giant stars (HD212771 and HD203949) previously known to host planets.

These first detection of oscillations in previously known exoplanet-host stars by TESS allowed to estimate the fundamental properties of the stars and determine the evolutionary stages of the stars. The case of HD203949 turned out to be particularly interesting. The star appeared to be in the red clump which required a detailed and complex study on how the planet could survive the engulfment at the tip of the red-giant branch.

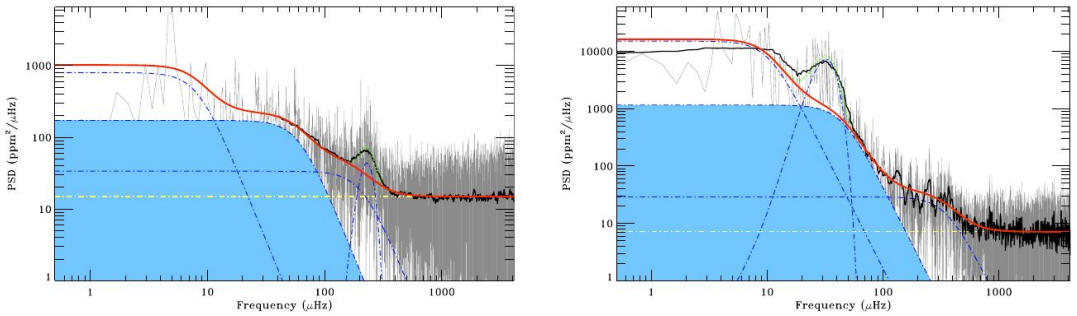



Figure: Power spectral density (PSD) of HD 212771 (left panel) and HD 203949 (right panel). The PSD is shown in gray (with a heavily smoothed version in black). The solid red curve is a fit to the background, consisting of three Harvey-like profiles (blue dot-dashed curves) plus white noise (yellow horizontal dot-dashed line). A global fit to the oscillation power excess (blue dot-dashed Gaussian curve) and the background is visible at ~ 230 μHz (HD 212771) and ~ 30 μHz (HD 203949) as a dotted green curve. Figure from **Campante** et al. 2019, ApJ, 885, 31.

2. **Rotation and pulsation in Ap stars from the first lights of TESS.** Analyzing the TESS 2-min cadence data from the first two sectors (roughly the first two months of science operations) on a sample of 83 stars the team (Cunha et al.) published the first TESS results on the rotational and pulsational variability of magnetic chemically peculiar A-type stars. Five new rapidly oscillating Ap (roAp) stars have been found; one of them being the shortest period (pulsation period of 4.7 min) roAp star known to date. Two of these five stars were found to be particularly challenging to the current understanding of the field, one because it is cooler than theoretically expected for a roAp star and the other because it exhibits pulsation frequencies that are unexpectedly high. The paper also announced 27 new rotational variable stars along with their rotation periods, and provided different rotation periods for seven other stars. The authors made an intensive discussion on how these new results challenge state-of-the-art pulsation models for roAp stars.

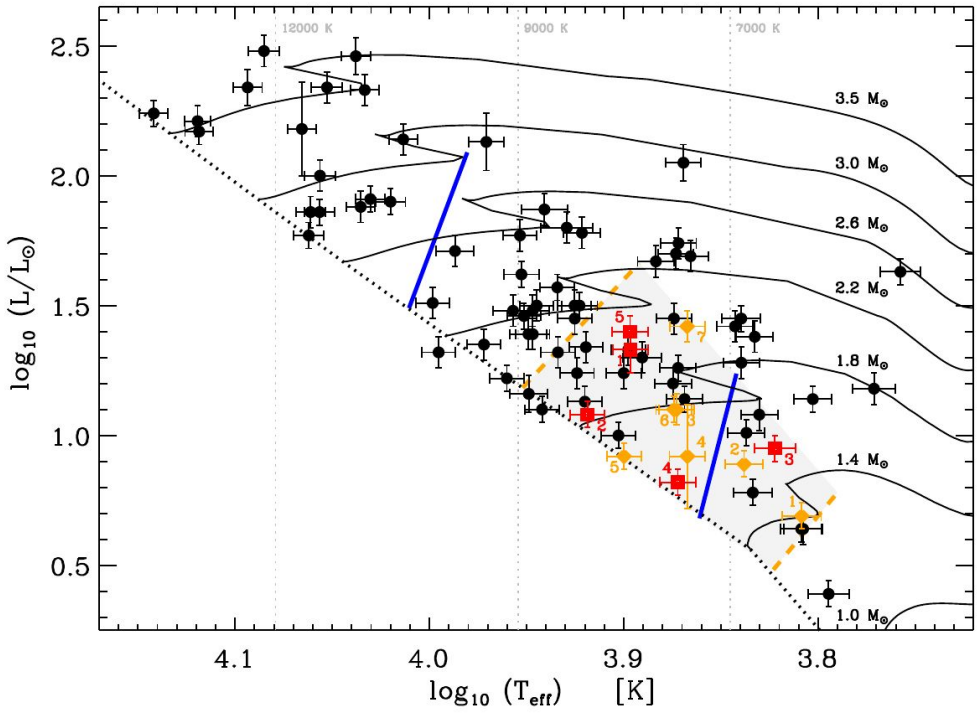



Figure: HR diagram showing the position of the 83 stars in our sample. The thick dotted line indicates the zero-age main-sequence and the continuous non-straight lines mark the evolutionary sequences for masses between 1.0 M and 3.5 M (from Marques, Monteiro & Fernandes 2008, grid B). The thick, blue, continuous straight lines indicate the theoretical instability strip from Cunha (2002) and the orange-dashed lines enclosing the shaded area indicate the region where the 61 roAp stars known prior to the TESS launch were found. This region was established by adopting the effective temperatures from Joshi et al. (2016) for all stars, except TIC 363716787, for which we adopted the value from the TIC catalogue, as the authors did not provide one, and by computing the roAp stars' luminosities from the data sources considered for the stars in the TESS sample, without considering extinction. The numbered red squares show the position of the 5 new roAp stars discovered in the TESS data: 1: TIC 12968953, 2: TIC 41259805, 3: TIC 152808505, 4: TIC 350146296, 5: TIC 431380369; the numbered orange circles show the 7 previously known roAp stars observed in sectors 1 and 2: 1: TIC 69855370, 2: TIC 139191168, 3: TIC 167695608, 4: TIC 211404370, 5: TIC 237336864, 6: TIC 348717688, 7: TIC 394124612; and the black circles show the remaining stars in the sample. Figure from Cunha et al. 2019, A&A, 629, 4

3. **Chemical clocks for sun-like stars**. Using the strong expertise on the precise spectroscopic characterization of solar-type stars the team (Delgado Mena et al.) studied the temporal evolution of different abundance ratios for about 1000 stars. High-resolution and high-quality spectra from the HARPS-GTO program were used to derive chemical abundances of several iron-peak, neutron-capture and alpha elements. Padova and Yonsei-Yale isochrones together with the Gaia parallaxes were used to determine the ages.
   The paper demonstrates that several abundance ratios present a significant correlation with age for chemically separated thin disk and thick disk population stars. The results show that the temporal evolution of some chemical species changes with metallicity, with remarkable variations at super-solar metallicities. It was shown that by using 3D relations with a chemical clock and two stellar parameters (either Teff, [Fe/H] or stellar mass) up to 89% of age variance in a star can be explained. These results will help to better constrain the yields of different nucleosynthesis processes along the history of the Galaxy.

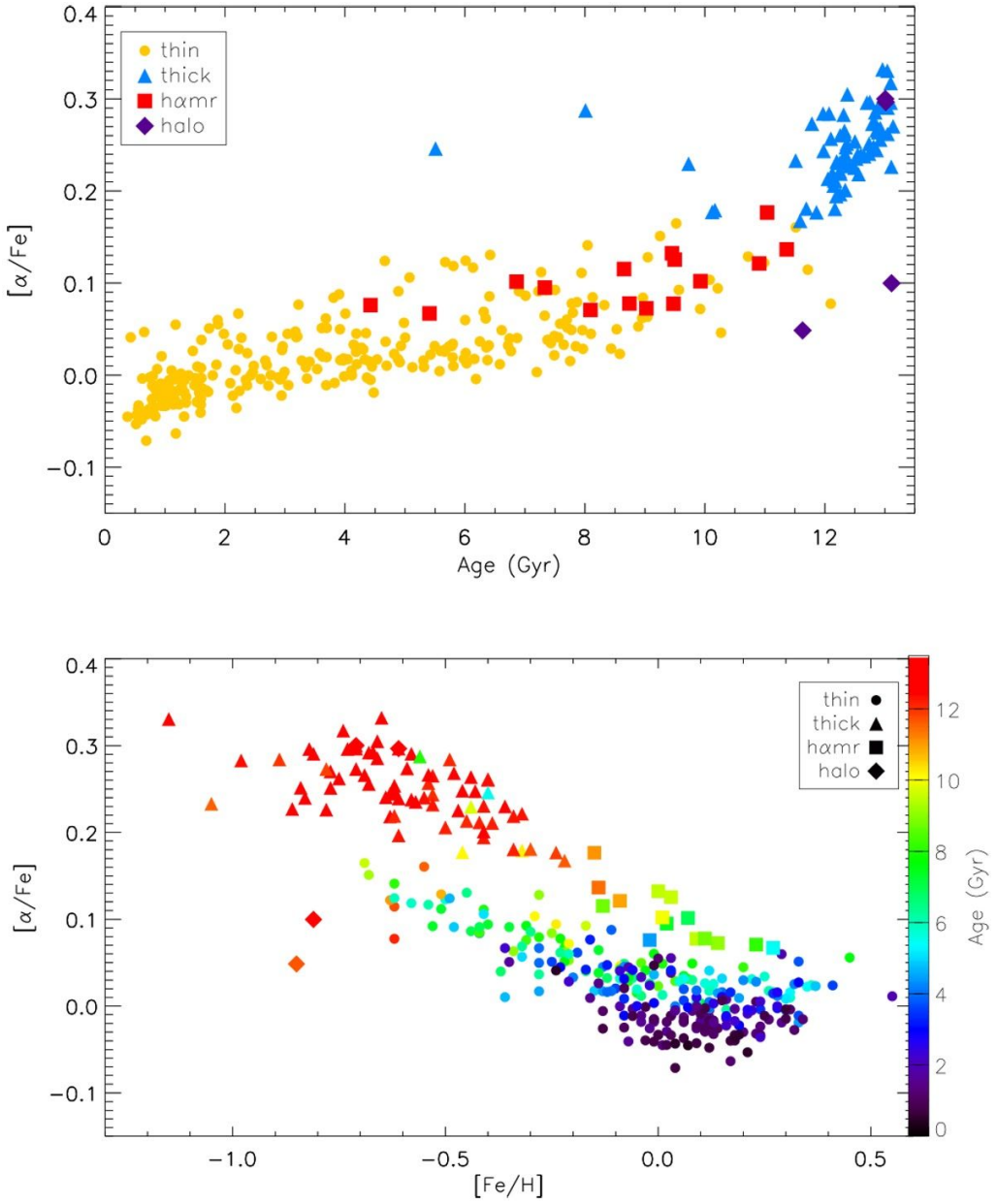



Figure: [α/Fe] as a function of [Fe/H] for the subsample of stars with errors in age from Gaia DR2 lower than 1.5 Gyr. The different stellar populations are depicted with different colors and symbols as explained in the legend. Figure from Delgado Mena et al. 2019, A&A, 624, 78.

4. **Ionization balance of cool stars**. It has been long known that the surface gravity determined spectroscopically from the ionization balance of iron lines is not well constrained. Several works also reported on ionization imbalance for cool dwarfs stars observed in the solar neighborhood.
   In order to understand the origin of the aforementioned ionization imbalance and to improve the spectroscopic surface gravities, the team (Tsantaki et al.) performed a careful spectral analysis of 450 solar-type stars observed with the HARPS spectrograph. The results of the work showed that the main reason for the observed imbalance (overabundance of FeII lines) is the unaccounted for line blending. Finally, the result of the analysis clearly shows that when forcing ionization equilibrium of Ti lines, more accurate surface gravities can be obtained that are in agreement with the trigonometric log g values.

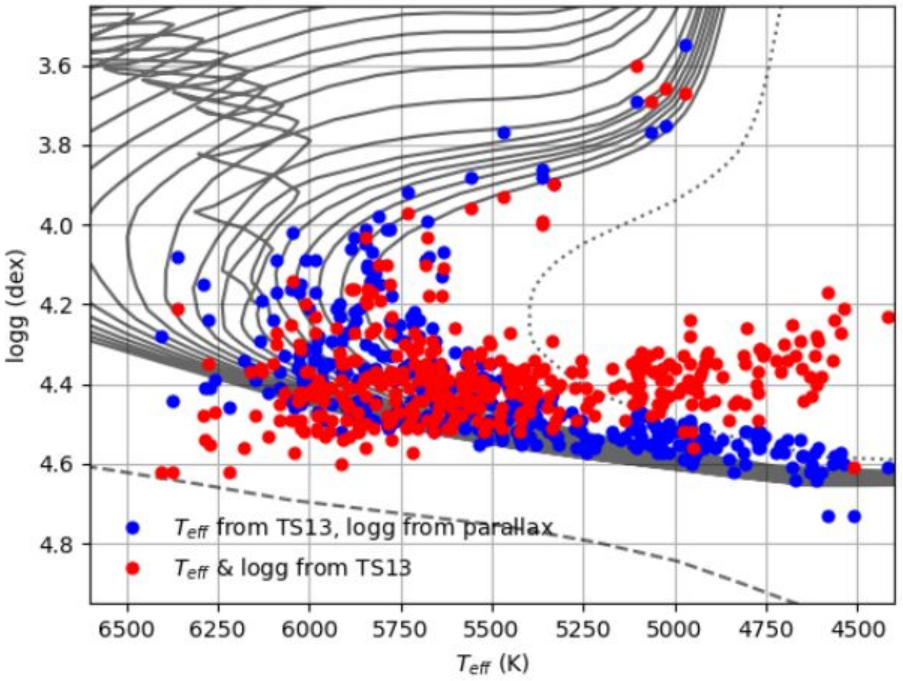
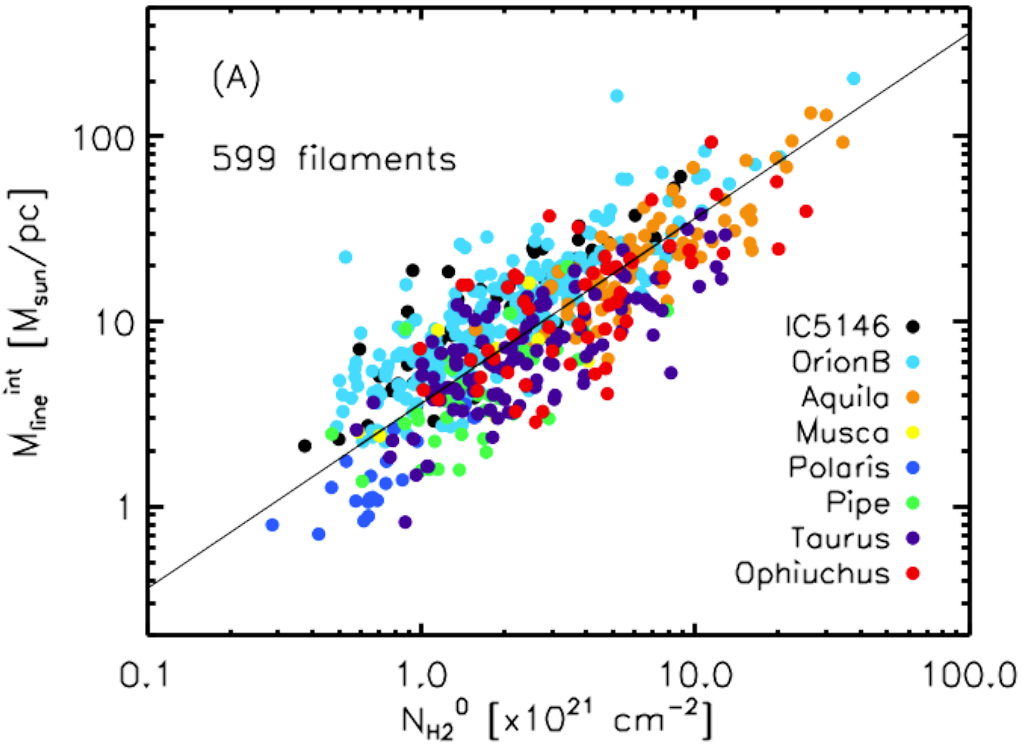
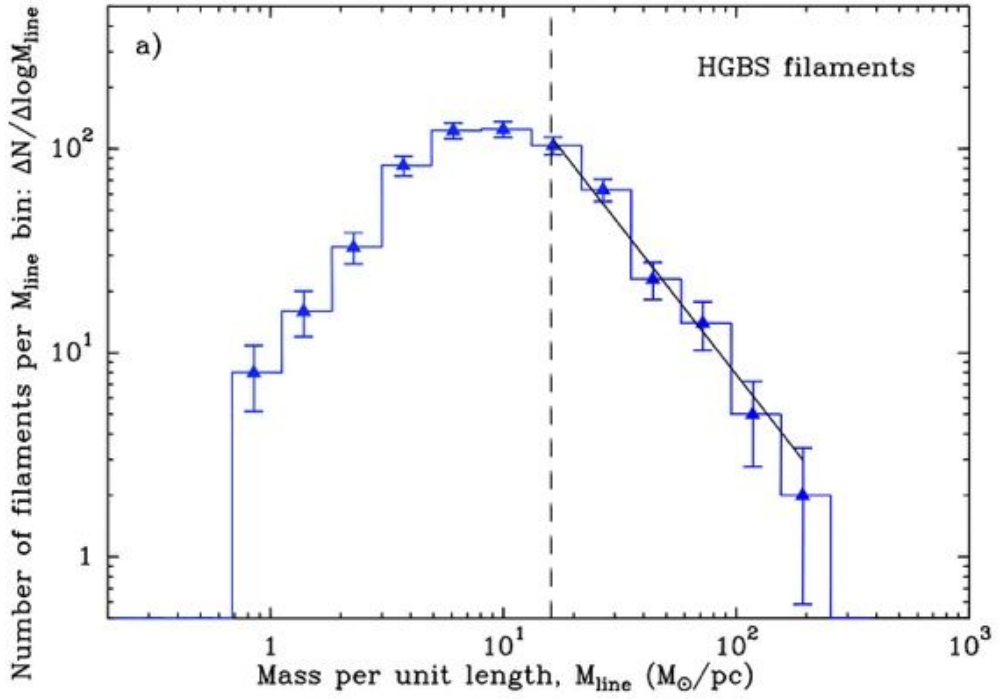



Figure:The HR diagram for the 451 stars for the two set of parameters: the spectroscopic parameters of TS13 (red points), and spectroscopic Teff and log g from Gaia parallaxes (blue points). The dotted line corresponds to 12.7 Gyr isochrone of 0.035 metallicity, and the dashed line to 1 Gyr isochrone of 0.0001 metallicity. The solid lines correspond to isochrones between 1–12.7 Gyr of solar metallicity. Figure from Tsantaki et al. 2019, MNRAS, 485, 2772.

5. **Role of molecular filaments in star formation**. It is becoming evident that molecular filaments play a crucial role in the formation of stars. Characterizing the properties of these filaments and describing their fragmentation process into stars is essential to make progress in our understanding of the star formation process. In 2019, the team continued its efforts in this direction and had a significant contribution in published articles where the role of molecular filaments in the origin of the prestellar core mass function (CMF) and stellar initial mass function (IMF) was studied. It was shown that molecular filaments with the observed distribution of masses (or line masses) would fragment into star forming cores with the observed distribution of core masses (CMF), which is shown to be similar in shape to the mass function of stars (IMF). Summarizing the observational evidence, the authors suggested that the prestellar CMF and by extension the stellar IMF are strongly related to the properties of the filaments, in particular to the filament line mass function.


(A)
599 filaments
100
10
1
0.1
1.0
10.0
100.0
$M_{line}^{int}$ [$M_{sun}$/pc]
$N_{H2}^{0}$ [x$10^{21}$ cm$^{-2}$]
IC5146
OrionB
Aquila
Musca
Polaris
Pipe
Taurus
Ophiuchus


a)
HGBS filaments
Number of filaments per $M_{line}$ bin: $\Delta N/\Delta \log M_{line}$
$10^2$
$10^1$
1
1
$10^1$
$10^2$
$10^3$
Mass per unit length, $M_{line}$ ($M_\odot$/pc)

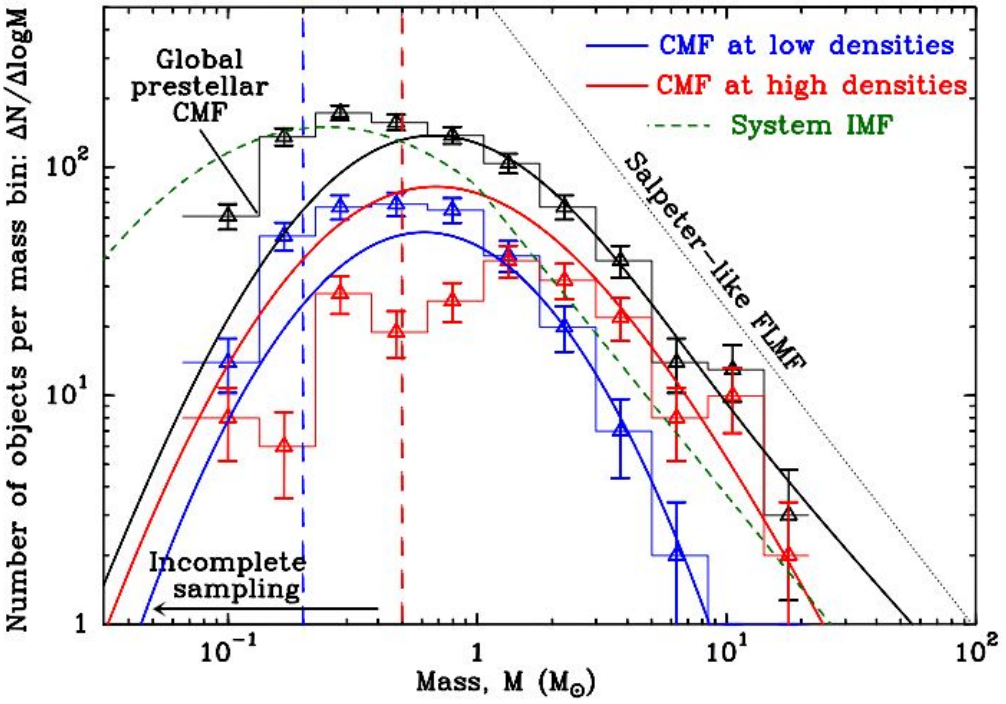



Figure: **Top:** Mass per unit length against central column density for a sample of 599 filaments observed with Herschel in 8 molecular clouds. The solid line shows the best-fit relation where the slope (0.16+-0.05) pc corresponds to the mean inner width of the filaments (from **D. Arzoumanian** et al. 2019). **Middle:** Filament line mass ($M_{line}$ ) function corresponding to the filaments sample and $M_{line}$ values shown in the top plot. Above the critical mass per unit length $M_{line,crit}$ ~ 16 $M_\odot$ pc$^{-1}$ (vertical dashed line), the distribution is well fitted by a Salpeter-like power law $\Delta N/\Delta \log M_{line} \propto M^{-1.6\pm0.1}$ (solid line). Figure from Ph. André, **D. Arzoumanian**, V. Könyves, Y. Shimajiri, and **P. Palmeirim** 2019, A&A, 629, L4. **Bottom:** Comparison of the model prestellar CMFs (solid curves) with the prestellar CMFs observed in the Orion B cloud complex (Könyves, Ph. André, **D. Arzoumanian** et al. 2019) at low column densities ($4 < A_V^{back} < 7.5$, blue curve, data points, and histogram), higher column densities ($7.5 < A_V^{back} < 21$, red curve, points, and histogram), and overall (all $A_V^{back}$, black curve, points, and histogram). The black dotted line displays the Salpeter-like power law FLMF, $dN/d\log M_{line} \propto M_{line}^{-1.4}$, assumed in the toy model and consistent with the observed FLMF in the supercritical regime (see middle panel). The green dashed curve shows the system IMF from Chabrier (2005). Figure from Ph. André, **D. Arzoumanian**, V. Könyves, Y. Shimajiri, and **P. Palmeirim** 2019, A&A, 629, L4.

**Thematic line meetings, Journal Clubs and other activities:**

Complementary to the many publications produced, the team also participated in several international conferences where the results of the project have been presented and discussed. We maintained an active participation in the large projects of ESA and ESO (also NASA's TESS mission) related to the Thematic Line selected as the backbone of IA under its strategic plan.

The team includes several PhD and MSc students working on topics related to the main goals of the thematic line. During 2019 two MSc students, Nuno Moedas and Miguel Clara, successfully finished their thesis.

In 2019, the team organized regular journal clubs on topics related to stars, having specific journal clubs and group meetings both on 'stellar physics' and also on 'star formation and early evolution'.

Participation in outreach activities covering topics on stars is also frequent, including several talks that cover topics related to this thematic line.

In 2019 the team was also very active in attracting highly recognized researchers to visit the institute and give seminars. In particular the institute hosted 14 research seminars (more than in the previous years by a factor of three) on the main scientific topics of the TL.

Vardan Adibekyan
Thematic Line Leader

**Report from the Group**

# Galaxies, Cosmology, and the Evolution of the Universe

The Group aims to provide fundamental contributions in: 1) advancing our understanding of the assembly and evolution of galaxies across cosmic time; 2) modeling cosmological scenarios and devising sensitive observational discriminators between them.

The Group currently comprises 34 researchers, 13 PhD students and 10 collaborators, and its activities are supported by 6 research projects with national funding. The strategy of the Group toward sustainable scientific excellence and international visibility also involves leadership roles in key international collaborations and consortia: In the period of this report, the Group has taken further steps toward this goal in the framework of its co-leadership roles in MOONS@VLT and Euclid, increasing involvement in ALMA, and major participations in MOSAIC@ELT (ESO, 2026), Athena (ESA, 2028) and LISA (ESA, 2032). Furthermore, the Group has organized two internal workshops and a Summer School.

In the field of extragalactic research, the Group is developing and intensively applying innovative tools (e.g., FADO) for the exploration of the star formation and chemical enrichment history of galaxies both with single-aperture data and spatially resolved integral field spectroscopy (IFS).

Taking advantage of modern IFS units (in particular, MUSE@VLT) and advanced data analysis and modelling techniques, it investigates several fundamental astrophysical subjects, such as the nature of extended Lyα halos at a redshift $> 3$, the co-evolution of super-massive black holes (SMBHs) with their galaxy hosts, the role of starburst-driven feedback on the galaxy assembly history, the influence of the environment on galaxy evolution, the build-up of galaxy structural components (e.g., bulge, disk), and gas excitation mechanisms and the size evolution of massive elliptical galaxies.

The Group places special emphasis on the exploration of the earliest stages of galaxy evolution, co-leading the development of several SKA-precursor surveys (e.g., EMU) that are expected to reveal powerful AGN activity within the Epoch of Reionization of the Universe and by making quantitative predictions on the multi-wavelength characteristics of these first AGN. Well aligned with these goals is the central role of the Group in the Portuguese ALMA Centre of Expertise (PACE), its leadership role in Euclid Legacy Science and its co-leadership of the MOONS AGN Science Working Group (WG) and the Technical WG being responsible for the definition of source catalogues for guaranteed time observations with MOONS.

In the field of cosmology, the Group members continued their collaboration within ESPRESSO, Euclid and LISA cosmology WGs. The team hosted a researcher within the CANTATA cost action activities and participated in a number of its meetings. Some team members are involved in a program leading to the most accurate cosmic string simulations with Europe's fastest supercomputer. Within LISA's cosmology WG, a team member collaborated in a thorough study of the amplitude and spectrum of stochastic gravitational wave background within the window available to LISA. One team member has joined the ELT WG on Line Calibrations. We continue being strongly involved in the Survey Group and

joined the Inter-Science Working Groups Team. Participation in the latter resulted in an article on the Cosmological Forecast Methods of Euclid.

The Group continued carrying out investigations on Modified Gravity and Dark Energy models with the aim of explaining the accelerated expansion of the Universe and devising signatures that may discriminate between them against the standard ΛCDM cosmology.

Polychronis Papaderos
Group Leader

**Report from the Thematic Line**

## The assembly history of galaxies resolved in space and time

During 2019 the Thematic Line (TL) has continued the implementation of its strategic plan, intensifying its efforts toward the exploration of the formation history of galaxies and their structural components, of the genesis and growth of super-massive black holes (SMBHs) in galactic nuclei and their influence on the assembly history of galaxies, the mechanisms triggering and regulating starburst activity and its role on the galaxy stellar mass growth, and the influence of the environment on galaxy evolution.

These science goals, pursued by a team of 15 researchers and several students (three of those having successfully concluded their PhD in 2019) are being served by the participation of IA with leadership roles in the instrument consortia of MOONS@VLT and MOSAIC@ELT of ESO, and ESA missions with key relevance to the strategy of the TL (Euclid, Athena), as well as by the parallel development of highly optimized computational tools for the scientific exploitation of multi-wavelength data for galaxies near and far.

The growth of SMBHs, and their observational manifestations as Active Galactic Nuclei (AGN), is being investigated by the TL both at the highest redshifts and in the nearby universe. The emergence of the very first powerful AGN in the Universe, and how they shaped the earliest galaxy evolution is being studied through sub-mm observations with IRAM and the revolutionary ALMA, and by post-processing cosmological simulations that recently permitted team members to obtain quantitative predictions on the number and detectability of early SMBHs at X-rays and radio wavelengths. Building upon its expertise on the analysis and interpretation of multi-wavelength data, and as part of a coherent strategic roadmap, the TL is developing new observational discriminators for the detection of proto-AGN at the Epoch of Reionization (EoR). It also acts as a strong driver in the development of the future ASKAP's Evolutionary Map of the Universe survey, through the IA-lead Key Science Project "Radio AGN in the EoR" and is represented at the Board and Science team level in ESA's future X-ray mission, Athena.

At low and intermediate redshift (z), the AGN phenomenon is being studied using the currently most powerful telescopes and instruments, most notably the Multi Unit Spectroscopic Explorer (MUSE) at ESO-VLT. Special emphasis is being laid on the study of quasars surrounded by gigantic Lyman-α halos and the definition of new diagnostics for constraining the physical conditions and excitation mechanisms in the nebular component of these extreme environments. This line of research is further supported by a comparative analysis of gas kinematics and excitation properties obtained from integral field spectroscopy (IFS) with predictions from cosmological simulations incorporating AGN feedback, and through the ongoing further development of IA's spectral synthesis code FADO with the capability of self-consistently modelling stellar and nebular emission jointly with an AGN power-law component. FADO, together with other tools being developed at IA, are being used to prepare the scientific exploitation of MOONS (the Multi Object Optical and Near-infrared Spectrograph for the VLT), an instrument the IA co-leads and which is expected to start observations in 2021.

During 2019, the team continued having a key involvement in the preparation of guaranteed time observations with MOONS and in the definition of strategies for the reduction and analysis of data from it. IA researchers assume major roles in several MOONS Science and Technical Working Groups (WGs), including the co-leadership of the AGN WG and the technical WG-1, and having an active role

in the scientific WGs on Physics of the ISM, Passive galaxies and stellar continuum, Galaxy environment, Large Scale Structures, High-z Universe and the EoR, Clusters/Protoclusters, and in the technical WGs on Mock Catalogues from Simulations, Determination of Redshift and Physical Parameters from Spectra, and on the Determination of Environmental Parameters.

Another field of the activities of the TL centres on spatially resolved investigations of galaxies with IFS and deep multi-band photometry. Using MUSE and the CALIFA IFS galaxy survey, team members are investigating a wide range of fundamental issues in extragalactic research, including the build-up history of galaxy bulges and the physical drivers of their inside-out star formation quenching, age and metallicity patterns in spiral and elliptical galaxies, cooling flows and ram pressure stripping effects in galaxy clusters, gas kinematics and excitation mechanisms in elliptical galaxies, the ionizing photon efficiency and its evolution across cosmic time, massive Wolf-Rayet stars and the diffuse ionized gas in star-forming galaxies, and the nature of ultra-faint galaxies. Furthermore, using ALMA, MUSE and FADO the team is also studying the action of starbursts on the molecular gas phase in extremely metal-poor dwarf galaxies, which may be considered the best local analogs of the first proto-galactic units that emerged at EoR. The activities of the team also encompass detailed photometric decomposition studies and the recent development of a conceptually novel tool for the robust structural characterization of galaxies via the Sérsic law. The latter publicly available tool has significant potential for an automated application to the Euclid Galaxy Legacy Survey, which is co-led by IA.

The team's expertise in current state-of-the-art telescopes and instruments is well worth stressing. Not only the team is nuclear to the activities of the Portuguese ALMA Centre of Expertise (PACE), providing manpower and expertise to support the national use of the facility and helping ESO validating its data, but during 2019 the team has shown a remarkable level of proficiency in the use of one of the most revolutionary and complex optical spectrographs currently in operation — MUSE — as detailed below.

**Scientific Highlights for 2019**

1. **Super-Massive Black Holes and Active Galactic Nuclei**. The team has continued its studies on the physical properties of large Lyα halos surrounding quasars that host SMBHs of several hundred million solar masses. It participated in a study of the exotic quasar J0952+0114 for which MUSE has revealed CIV λ1550 and HeII λ1640 emission within a 100-kpc Lyα halo. Spatially resolved HeII/Lyα and CIV/Lyα maps for this system showed a positive gradient with the distance to the quasar, hinting at a non-homogeneous distribution of the ionization parameter. The team also used advanced photoionization models to devise new diagnostics for the physical conditions in Lyα halos, addressing the origin of their extremely high Lyα/HeII ratios and prospects for using the semi-forbidden line doublet OV] λλ1213.8,1218.3 as a diagnostic for the presence of AGN. Furthermore, we continued exploring selection criteria for very high-z AGN at EoR, following our pilot study in Amarantidis et al. (2019) that demonstrated the need for improved physical prescriptions in order for existing simulations to be able to account for the observationally determined SMBH masses in high-z AGN, and that far-infrared and radio criteria can be used to select some of the most massive, dusty galaxies at z>4. These criteria were used to identify a sample of highest-z AGN candidates which we recently observed with ALMA and IRAM.

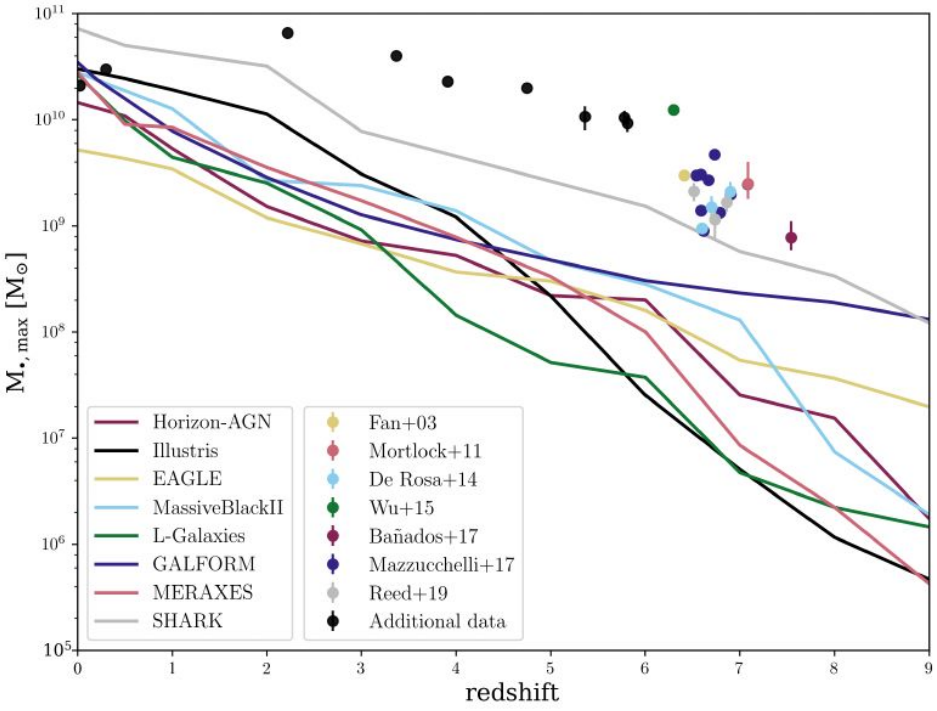
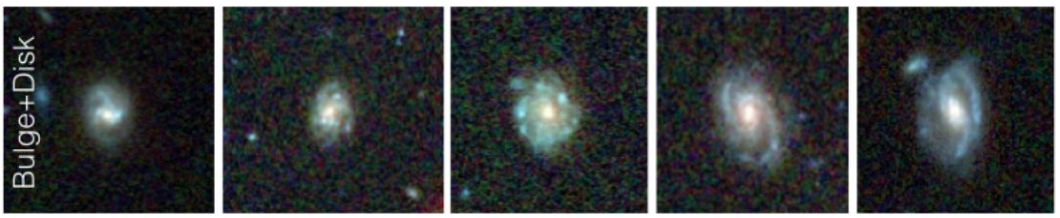



Figure: Comparison between the mass of the most massive SMBHs predicted by various state-of-the-art models of galaxy formation and evolution (solid lines) and estimated masses of some of the most massive quasars already discovered (from Amarantidis et al. 2019, MNRAS 485, 2694).

It is worth mentioning that a member of our team (Hugo Messias) has participated in the international collaboration Event Horizon Telescope (EHT), which announced in April 2019 an extraordinary result and another success of Einstein's theory – the first direct image of a black hole in the galaxy M87. The Breakthrough Prize in Fundamental Physics 2020, one of the most prestigious in Physics, was awarded to the EHT project and, with it, to each of its 347 members.

2. **Structural properties of galaxies**: The team led a bulge-disk decomposition study of approximately 500 quiescent and star-forming galaxies from the VIMOS Spectroscopic Survey of a Superstructure in COSMOS (VIS3COS) and participated in a polychromatic bulge-disk decomposition analysis of ~17600 galaxies from the CANDELS survey.
Additionally, team members have developed a conceptually novel concept for the robust determination of Sérsic model parameters to galaxy profiles. This publicly available tool has significant potential for the automatic structural characterization of galaxies from the Euclid Galaxy Legacy Survey, which is co-led by IA.

(a)



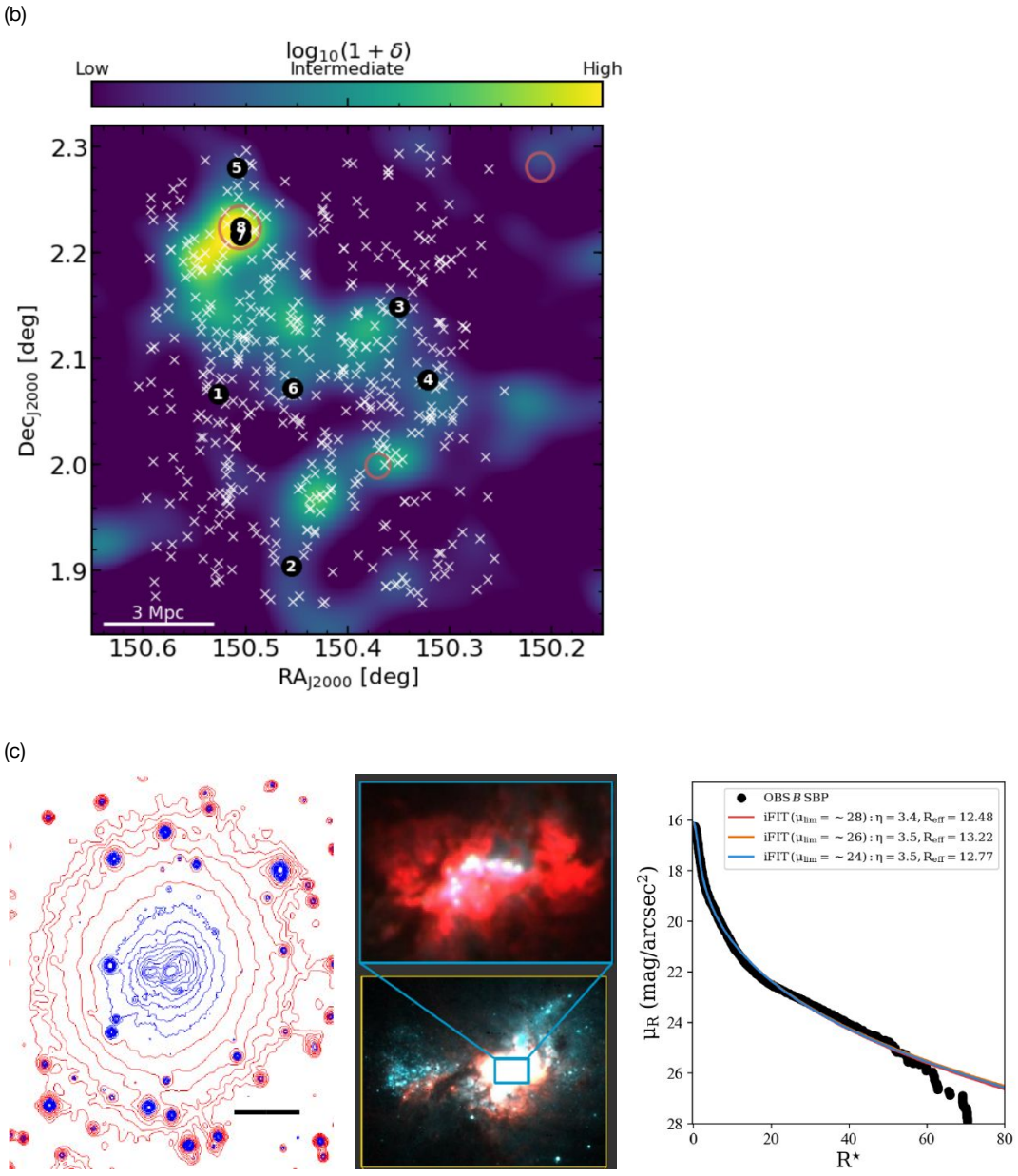



Figure: a) Examples of galaxies presenting a visually discernible bulge and disk component from the sample of 17600 galaxies analyzed in Dimauro et al. (2019, MNRAS 489, 4135); b) An overview of the VIS3COS survey showing the galaxy overdensity and analyzed galaxies at 0.8<z<0.9 with known redshifts (white crosses) along with the location of known X-ray clusters (from Paulino-Afonso et al. 2019, A&A 630, 57), c) Optical morphology (left) and zoom-in into the central starburst component (middle; stellar emission shown in blue and green, and Hα emission shown in red) of the blue compact galaxy Henize 2-10, whose surface brightness profile (right) was modeled with IA's novel surface photometry code iFIT (adapted from Breda et al. 2019, A&A 632, 128).

3. **Influence of the environment on galaxy evolution**. Our team has participated in a detailed multi-wavelength investigation of the "jellyfish" galaxy ESO 137-001 that was based on data with HST, Chandra, MUSE and ALMA. This galaxy undergoes a strong interaction with the hot intracluster medium that led to the removal of its gas and a long (~60 kpc) multi-phase tail. Superb-quality observations with ALMA permitted detection of a substantial molecular gas component in the tail in compact entities being associated with regions of strong star

formation. This detection yields important new insights into the fate of ram-pressure stripped gas in galaxies infalling onto clusters.

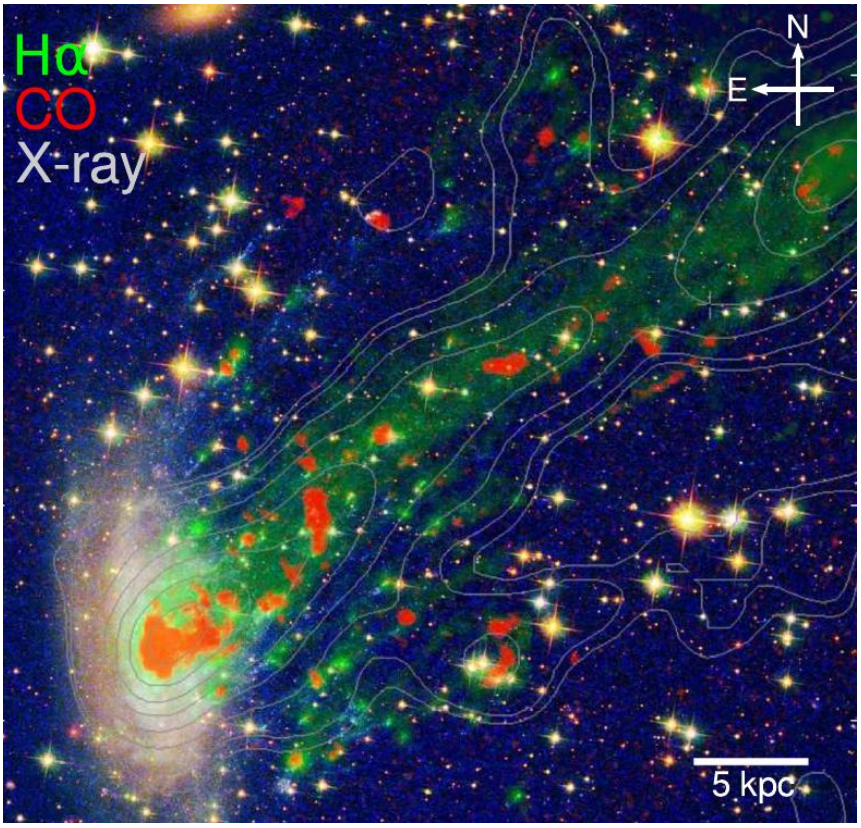



Figure: Overlay of ALMA-CO(2-1) emission (red) on MUSE Hα emission (green) and the HST image of ESO 137-001 with Chandra X-ray contours on top
(Credits: Jáchym et al. 2019, ApJ 883, 145).

During 2019, our team also used MUSE to study ram pressure stripping effects in a galaxy cluster at z=0.7 (Boselli et al. 2019, A&A 631, 114) and carried out observations with the PMAS/PPAK IFS unit at Calar Alto 3.5m telescope to study the influence of the environment on the star formation history and metallicity patterns of 11 galaxies in the galaxy cluster Abell 1367.

4. **Development and application of spectral synthesis tools**. In preparation of studies of galaxy evolution at z~1 with MOONS, our team has applied IA's spectral synthesis code FADO to synthetic spectra that cover a wide range of star formation- and chemical enrichment histories, and simulating different signal-to-noise ratios, in order to quantitatively assess the capability of the code to retrieve key evolutionary and physical properties of galaxies.
A first article from this series (Cardoso et al. 2019) demonstrated, among others, that FADO can infer galaxy stellar masses to an accuracy better than ~0.1 dex, even for starburst galaxies presenting extremely strong nebular emission with an Hα equivalent width exceeding $10^3$ Å. To the contrary, conventional spectral modeling tools, such as STARLIGHT, may severely overestimate the stellar mass of such galaxies, as a result of their neglect of the luminosity contribution by the nebular continuum. This study also revealed that STARLIGHT (and presumably other purely stellar fitting tools) suffer from a tendency to produce a bimodal age

distribution, which could significantly bias studies devoted to the regulatory role of AGN on galaxy evolution.

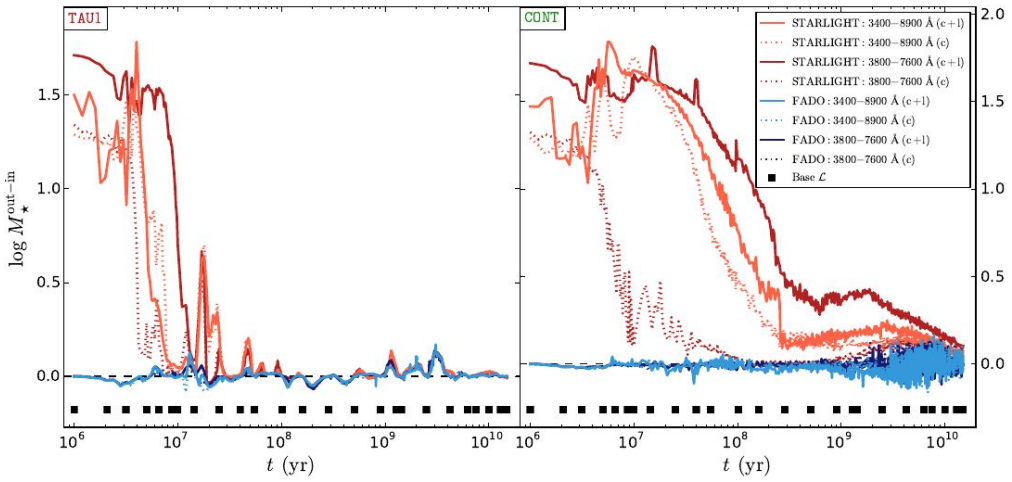



Figure: Difference in the total stellar mass $M_*$ inferred from fits with STARLIGHT and FADO and the actual value for synthetic input spectra as a function of galaxy age. Results referring to an instantaneous and continuous star formation process are shown in the l.h.s. and r.h.s. panel, respectively. It can be seen that FADO (blue) provides accurate estimates of $M_*$ over the entire age interval considered (~13 Gyr) whereas fits with STARLIGHT (orange/red) overestimate $M_*$ by more than one order of magnitude during young evolutionary stages being associated with strong nebular emission (from Cardoso et al. 2019, A&A 622, 56).

In parallel to these tests on synthetic spectra, our team has extensively applied FADO on SDSS data toward the exploration of several galaxy relations (e.g., mass-metallicity relation, star formation main sequence, stellar vs. nebular extinction). Additionally, FADO, jointly with a recently upgraded version of IA's spectral synthesis pipeline Porto3D, is being applied to IFS data from CALIFA and MUSE with the goal of gaining further insights into the formation history of massive early-type galaxies and galaxy bulges.
Finally, our team continued the development of an upgraded version of FADO with the capability of a) providing a spectroscopic classification of intermediate-to-high-z galaxies according to the criteria by Lamareille (2010) and b) including an AGN component in spectral fits. The release of the new version of FADO is planned for mid-2020.

5. **Spatially resolved studies of stellar populations and ionized gas with MUSE**. The team has participated in the analysis of IFS data from the MUSE Atlas of Disks (MAD) survey with main focus on 2D patterns in metallicity and star formation rates (SFRs), finding that the metallicity of HII regions is by 0.1 dex higher than in the diffuse ionized gas (DIG) while radial Z gradients in both components are similar. Additionally, this study finds strong evidence for a spatially resolved mass-metallicity relation and a spatially resolved star formation main sequence relation. The combined evidence suggests that both these spatially resolved relations have a local origin, as they do not depend on the total $M_*$. The observational lines of evidence from this study are consistent with the inside-out scenario for the growth of galactic disks.

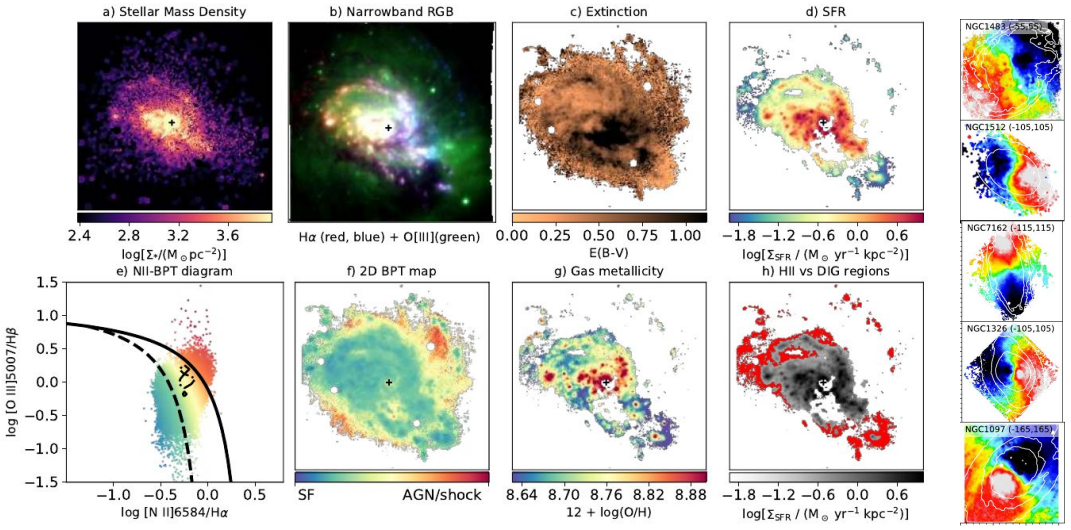



Figure: a) Illustration of various quantities determined by Erroz-Ferrer … Brinchmann et al. (2019, MNRAS 484, 5009) from a detailed spatially resolved study of IFS data from the MAD survey, such as stellar mass surface density, SFR, diagnostic BPT line ratios and nebular metallicity; b) Examples of ionized gas kinematics maps obtained by den Brok et al. (2019, MNRAS 491, 4089) for galaxies from the MAD survey.

In a follow-up study of 41 nearby galaxies from MAD a new methodology was employed for the extraction of the DIG component and its separation from HII regions. An important new insight was that the DIG rotates on average slower than gas associated with HII regions, with lags of up to ~10 km $s^{-1}$, while also having higher velocity dispersion. This suggests that the DIG originates from a thicker layer than the star forming gas.

## Thematic line meetings, Journal Clubs and other activities:

Throughout 2019, the team maintained a busy schedule of weekly Briefings in which the team's scientific work is discussed. Additionally, the team organized a two-day face-to-face meeting to discuss its research activities.

Regular weekly journal clubs were also continued, for the discussion of recent, mostly non-IA, scientific results. All meetings use a videoconference tool, zoom, which allows easy and practical access to all team members.

Team members are core participants in the Portuguese ALMA Centre of Expertise, providing support to ALMA users in Portugal, and also providing, in the context of the European ALMA Regional Centre, scientific and technical assistance to ESO on the validation of ALMA data before being delivered to the respective PIs. It is also worth noticing that team members actively participate in IA public outreach activities, not only providing frequent public talks on galaxies and the Universe, but also in major institutional initiatives such as IAstro Junior or Ignite IAstro.

Finally, during 2019, the team organized the IXth SKA Pathfinder Radio Continuum Survey Group (SPARCS) meeting (Lisbon) and the MUSE Busy Week (Braga), and co-organized the Special Session Stellar populations in the era of ELTs: advances over the next decade and beyond in the European

Week of Astronomy & Space Science (Lyon) and the Multi-messenger astronomy with SKA precursors and pathfinders, a capacity building workshop (Aveiro).

Polychronis Papaderos
Thematic Line Leader

**Report from the Thematic Line**

## Unveiling the dynamics of the Universe

In 2019 the team members continued their collaboration with ESPRESSO, Euclid and LISA. They have been active members of the CANTATA COST action by welcoming researchers from other institutions and by participating at its meetings.

The first GPU-accelerated field theory evolution code for Abelian-Higgs string networks has been successfully implemented and validated following work by a team member. The gains in speed afforded by this code (about 2 orders of magnitude faster than previous CPU-based codes) enabled us to develop second-generation Velocity-dependent One-Scale (VOS) analytic model, calibrated by more than one thousand simulations, which significantly improves the first-generation canonical VOS model by Martins & Shellard. A PRACE proposal was submitted to Piz Daint (the world's 6th fastest supercomputer, and the fastest in Europe) and awarded 68 million core-hours. An extensive 12-month program of simulations started in October 2019, and will lead to the world's most accurate cosmic string simulations.

We participated in the construction of the ELT and the development of its science cases and instruments. In September 2019 one team member became the coordinator of the ELT Working Group on Line Calibrations.

The coordinators of the national participation in the Euclid mission (who are team members) were among the authors of a review paper on the Cosmological Forecasts Methods of Euclid (submitted to A&A). This review was the outcome of the work done by the purposely created Inter-Science Working Groups Team. The participation in the various Euclid groups where team members have responsibilities continued as planned. In particular, in the Survey group we were involved in the LOC and SOC of 3 workshops (two hosted by IA/FCUL and one in Sesto, Italy), and co-authored the key project paper on Euclid's Science Performance Verification (submitted to A&A).

Since 2018, IA/FCUL is a node of the H2020 project "Enabling Weak Lensing Cosmology" (EWC). In 2019 we have started an active participation in EWC and hired a student with project funds.

Thematic line members had a major role in the selection of three extremely dark patches of the sky that will be the subject of the Euclid mission's deepest observations, aiming at exploring faint and rare objects in the Universe. The position of the Euclid Deep Fields – one in the northern sky and two in the southern sky – was announced during the annual consortium meeting in Helsinki, Finland.

2019 celebrated the 100 years of the measurements of gravitational deflection of light (a major experimental support of general relativity) with a multitude of international and national outreach and research events. One member of the team was invited to the exclusive Euclid@Sundy science conference and various team members wrote articles to a special issue of the Gazeta da Fisica journal.

Team members contributed to a detailed study of the amplitude and spectrum of stochastic gravitational waves generated by cosmic strings in the window available by LISA and estimated the constraints of the cosmic string tension obtained by LISA. These investigations were performed within

LISA's Cosmology Working Group. An article detailing this study and a thorough literature review on cosmic strings with LISA has been submitted.

One team member co-authored a review for Physics Reports on Field Theory of Dark Energy. Another team member co-authored the biannual review `The Cosmological Parameters' for the Particle Data Group's prestigious overview of particle physics, the Review of Particle Physics.

**Scientific Highlights for 2019**

1. **Minimal varying Lambda cosmology**. Two team members wrote two papers on a very novel modified gravity concept that permits the cosmological constant to become dynamical through the introduction of a new duality to general relativity. Inserting a varying Lambda in Einstein's field equations can be made consistent with the Bianchi identities by allowing for torsion, without the need to add scalar field degrees of freedom. In the minimal such theory, Lambda is totally free and undetermined by the field equations in the absence of matter. Inclusion of matter ties Lambda algebraically to it, at least when homogeneity and isotropy are assumed, i.e. when there is no Weyl curvature. They showed that Lambda is proportional to the matter density, with a proportionality constant depending on the equation of state. Unfortunately, the proportionality constant becomes infinite for pure radiation, ruling out the minimal theory prima facie despite its novel internal consistency. It is possible to generalize the theory still without the addition of kinetic terms, leading to a new algebraically-enforced proportionality between Lambda and the matter density. Lambda and radiation may now coexist in a form consistent with Big Bang Nucleosynthesis, though this places strict constraints on the single free parameter of the theory. In the matter epoch Lambda behaves just like a dark matter component. Its density is proportional to the baryonic and/or dark matter, and its presence and gravitational effects would need to be included in accounting for the necessary dark matter in our Universe.

2. **Einstein-Cartan-Dirac gravity with U(1) symmetry breaking**. Einstein-Cartan theory is an extension of the standard formulation of General Relativity where torsion (the antisymmetric part of the affine connection) is non-vanishing. Just as the space-time metric is sourced by the stress-energy tensor of the matter fields, torsion is sourced via the spin density tensor, whose physical effects become relevant at very high spin densities. Team members introduced an extension of the Einstein-Cartan-Dirac theory with an electromagnetic (Maxwell) contribution minimally coupled to torsion. This contribution breaks the U(1) gauge symmetry, which is suggested by the possibility of a torsion-induced phase transition in the early Universe, yielding new physics in extreme (spin) density regimes. They obtained the generalized gravitational, electromagnetic and fermionic field equations for this theory, estimated the strength of the corrections. They also addressed some astrophysical considerations regarding the relevance of the effects which might take place inside ultra-dense neutron stars with strong magnetic fields (magnetars).

3. **Tracking and scaling solutions in DHOST theories**. In quadratic-order degenerate higher-order scalar-tensor (DHOST) theories compatible with gravitational-wave constraints, team members derived the most general Lagrangian allowing for tracker solutions characterized by a proportionality between the velocity of the scalar field and the Hubble rate.

The analysis was extended to the coupled DHOST theories with a field-dependent coupling between the scalar field and matter, and the general form of this coupling that allows scaling solutions was identified.

4. **Redshift drift constraints**. Cosmological observations usually map our present-day past light cone. However, it is also possible to compare different past light cones. This is the concept behind the redshift drift, a model-independent probe of fundamental cosmology. In simple physical terms, this effectively allows us to watch the Universe expand in real time. While current facilities only allow sensitivities several orders of magnitude worse than the expected signal, it should be possible to detect it with forthcoming ones. Team members evaluated the potential impact of measurements by three such facilities: the Extremely Large Telescope (the subject of most existing redshift drift forecasts), but also the Square Kilometre Array and intensity mapping experiments. They focused on the role of these measurements in constraining dark energy scenarios, highlighting the fact that although on their own they yield comparatively weak constraints, they do probe regions of parameter space that are typically different from those probed by other experiments, as well as being redshift-dependent. Specifically, they quantified how combinations of several redshift drift measurements at different redshifts, or combinations of redshift drift measurements with those from other canonical cosmological probes, can constrain some representative dark energy models. The main conclusion is that a model-independent mapping of the expansion of the universe from redshift z=0 to z=4 – a challenging but feasible goal for the next generation of astrophysical facilities – can have a significant impact on fundamental cosmology.

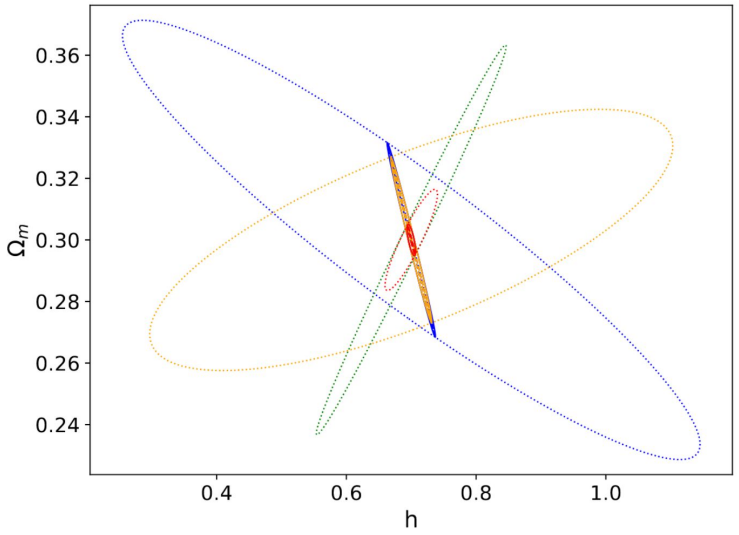



Figure: One-sigma constraints on the $\Omega_m$–h plane, for the ΛCDM model. The blue lines represent the ELT, the green ones the SKA, the yellow ones the CHIME and the red ones the combination of all three. The dotted lines are the constraints without priors, the solid lines the constraints with current priors and the dashed lines the constraints with future priors.

5. **Coupled quintessence with a LambdaCDM background**. A well-known problem of the ΛCDM model is the tension between the relatively high level of clustering, as quantified by the parameter $\sigma_8$, found in cosmic microwave background experiments and the smaller one

obtained from large-scale observations in the late Universe. Team members showed that coupled quintessence, i.e. a single dark energy scalar field conformally coupled to dark matter through a constant coupling, can solve this problem if the background is taken to be identical to the ΛCDM one. It was shown that two competing effects arise. On one hand, the additional scalar force is attractive, and is therefore expected to increase the clustering. On the other, in order to obtain the same background as ΛCDM, coupled quintessence must have a smaller amount of dark matter near the present epoch. The second effect is dominating today and leads to an overall slower growth. When comparing to redshift distortion data, it was found that coupled quintessence with ΛCDM background solves the tension between early and late clustering. Forecasts for future missions such as SKA and Euclid were also performed.

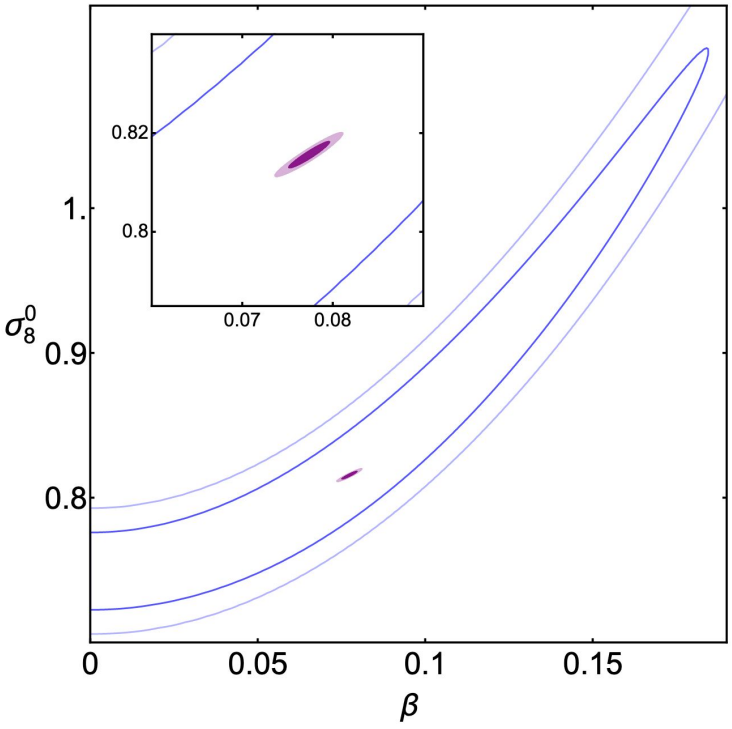



Figure: Current and forecast on the future constraints for $\beta$ and $\sigma_8$ from the SKA and Euclid missions. The two lines represent the $1\sigma$ and $2\sigma$ regions (darker to lighter), present in and the two small ellipses show the $1\sigma$ and $2\sigma$ regions expected from future data.

**Thematic line meetings, Journal Clubs and other activities:**

Two master students completed their thesis this year: Inês Albuquerque on “Cubic Galileon theory in the effective Field Theory formalism: a cosmological study” and Ana Carvalho on “Exploration of unsupervised machine learning methods to study galaxy clustering“.

In 2019 the thematic line continued organizing journal club meetings and seminars on a regular basis, typically, once a week. Approximately 38 articles were discussed during the 29 journal club sessions (http://ia-cosmoclub.wikidot.com/previous-meetings-2019). These are done via videoconference so that both nodes can participate. A monthly TL meeting was called for a research update and exchange of information on conferences and funding opportunities. The TL organized its second internal

workshop that took place in Porto on the 9th of October. We organized an internal Summer School on Cosmology with a hands on codes philosophy where CLASS, EFTCAMB and Gadget were covered and one theory set of lectures on AdS/CFT correspondence was given. The school turned out very helpful in the formation of students and promoted collaborations within the thematic line.

The TL members continued their involvement in outreach activities such as Ignite Astro, IAstro Junior and visits to schools. In addition, we offered a 9 session course on cosmology to the Grupo Desportivo e Cultural do Banco de Portugal.

Nelson Nunes
Thematic Line Leader

**Report from the Group**

# Instrumentation and Systems

During 2019, the following instruments had engineering and implementation activities at IA:

MOONS (ESO), NIRPS (ESO), HIRES (ESO), EUCLID (ESA), e-LISA (ESA), PLATO (ESA), CHEOPS (ESA) and ARIEL (ESA).

Currently the Group participates in a considerable number of projects, involving all its human resources. This includes not only the technical design of the instruments themselves but also the respective science exploration of the collected data through big collaboration projects such as consortiums and surveys. Its importance stems from the need to secure privileged access to existing and future facilities of the European Organization for Astronomical Research in the Southern Hemisphere (ESO) and of the European Space Agency (ESA) and to contribute to the long term development of Astronomy in Portugal.

The group is composed of 17 people. 9 researchers (with PhD) 4 engineers and 4 PhD students. Some researchers are also part of the other two scientific groups and PhD students are mainly focused on their thesis work, leading to a manpower availability to the running project of about 10 FTE.

In the beginning of 2019, the Group and the labs and integration facilities in Lisbon moved to the Campus of the Faculty of Sciences of the University of Lisbon. This will also help to reinforce the connection with the students, increasing their presence in our labs and the visibility of our activities among the university.

During 2019, the following researchers (R), engineers (E) and PhD Students (S) terminated the participation in the instrumentation group:

Pedro Figueira (R), Catarina Mendes (E), Jason Neal (S) and Solène Ulmer-Moll.

The following researchers (R), engineers (E) and PhD Students (S) started to participate in the instrumentation group: Inês Leite (E), Cédric Pereira (S).

In the following is listed the activity detail of the running projects.

### MOONS (ESO)

The Multi-Object Optical and Near-infrared Spectrograph (MOONS) is a future third-generation instrument for the Very Large Telescope (VLT) to have first light by 2021. It matches an enormous multiplexing capability, reaching up to 1000 positions being spectroscopically observed at the same time over a single telescope pointing, to the grasp of the 8.2m VLT, making it a unique instrument for deep galaxy surveys. The subsystems under IA responsibility are the MOONS Rotating Front End (RFE) and the Field Corrector (1 m diameter set of two lenses). In 2019 the activities focused on the follow up of the manufacturing of several mechanical parts and in the testing of all the mechanisms that the RFE will comprise. The first mechanical parts arrived in the end of 2019 and in the following year the integration of the RFE will start in Lisbon, to be

transferred in the end of the year to UKATC in Edinburgh for Preliminary tests in Europe before its integration in Chile.

### NIRPS (ESO)

NIRPS is a new (fast-track instrument) high resolution spectrograph working in the near-infrared bands, that is being designed for the ESO 3.6-m telescope (La Silla-Paranal Observatory). NIRPS will work together with the existing HARPS spectrograph, allowing us to obtain simultaneous optical and near-IR spectra of stars. The major goal of NIRPS is to detect and characterize planets orbiting late type stars. The NIRPS consortium includes a strong participation from IA, including in the development of hardware and software (the Atmospheric Dispersion Correctors - ADC), and in the definition of the scientific activities. In 2019 the ADC (optics, mechanics and control) were fully integrated in the NIRPS front end and, at the end of the year, integrated in the ESO 3.6 m telescope in La Silla. A preliminary commissioning of the ADC was done in November, to be followed by the full ADC commissioning in April 2020.

### Hires (ESO)

HIRES is the project for a high resolution spectrograph to be installed at the ESO ELT telescope. The concept of HIRES is being developed by a consortium that comprises several institutes in different European countries, as well as Brazil and Chile. The Portuguese participation in this consortium is done through IA that is leading the “front end” work package component of the instrument, the data reduction and analysis software, the software system architecture, and the science drivers for the project. The group also participates in the management of the consortium, having several key persons. After the finishing of the Phase A studies in 2017, during 2019 the work was focused on the phase B consortium definition (phase planned to start in 2020).

### Euclid (ESA)

Euclid (ESA): Euclid is ESA's mission dedicated to the exploration of the dark universe through the measurement of the properties of the cosmological large-scale structure. IA is strongly involved in this mission, participating in the consortium board, in various science working groups, and in the Survey Design, which is an activity of support to the Euclid Consortium Lead. In 2019, IA's Instrumentation and Systems Group continued its long standing participation in the preparation of the Survey Design, focusing on the development of the ECTile software. This software computes the mission's Reference Survey, i.e., it produces schedules of the Euclid Deep and Wide surveys, including implementation of all calibrations, compliant with all constraints and requirements. This year, the group contributed strongly in three activities. Firstly, on the analysis and implementation of the Euclid Deep Field South, finding its optimal location (suitable for scientific purposes and feasible for spacecraft constraints) and geometry (to accommodate a synergy with the LSST telescope). Secondly, we generated a new reference survey, which was an improvement from the previous 2018 survey that had been delivered to the Critical Design Review milestone, by including the polar-caps. The new survey was presented at the Euclid annual conference, this year in Helsinki, Finland. Thirdly, the ECTile saw a new major cycle of development. This time, to address new requirements on thermal stability that impact the quality of the VIS detector data, and impose stronger limitations on the rotations of the telescope. This triggered the development of a revised algorithm for scheduling patches, dubbed the diffusion algorithm, which took a great part of this year's effort. As the launch date approaches (scheduled to 2022), ESA has shown interest in the extension of our participation in Survey design activities for beyond launch, and

wishes to define a new Survey Operations Support Team that would give support to all Survey Design needs during operations. We are now working with PT-Space in a funding proposal to Prodex, seeking financial support for the extension of the activities. In 2019, the group was present in 6 meetings, having hosted 2 of them:
Euclid Sky Survey Working Group meeting (ESSWG#11), 4-5 February 2019, ESAC, Madrid, Spain. Euclid Survey Group Meeting (ECSURV), 6-7 May, 2019, FCUL, Lisbon, Portugal. Euclid Survey(s): Scientific Optimisation (workshop), 24-28 June, 2019, Sexten Centre for Astrophysics, Sesto, Italy. Euclid Consortium Meeting 2019, 4-7, June, 2019, Helsinki, Finland. Euclid Survey Group meeting (ECSURV), 4-6 November 2019, Frascati, Italy. Euclid Sky Survey Working Group meeting (ESSWG#12), 25-26 November, 2019 FCUL, Lisbon, Portugal.

### PLATO (ESA)

The PLATO mission, whose main scientific focus is the detection and characterization of extra-solar planets orbiting nearby, bright stars, using the transit method, as well as the detailed characterization of their host stars through asteroseismology, has been adopted by ESA in June 2017. The IA team is deeply involved in this project. On top of the scientific activities, the team has leadership of several work packages for the development of software for the Plato Data Center (PDC) as well as in the development of the Optical Ground Segment (OGSE) component to test the PLATO cameras on the ground. In 2019 the work of the Instrumentation group was focused on the finalization and testing of the Room Temperature Collimator. According to the tests performed in our labs, the collimator could comply with all the requirements set by the Plato client. At this stage we are preparing the final steps to ship and install the collimator at CSL-Belgium. During this year a full set of documentation was produced in the scope of the MAIV review milestone. All documentation was accepted after correction of a small number of RID set by ESA and the rest of the consortium. The Instrumentation team participated in a Progress Meeting at Graz and in 2 technical meetings of the MAIV and Camera teams. The activities regarding other workpackages associated with instrumentation, namely with SW work, in Star Centroids and Target Position, our team continued to produce documentation and supporting algorithms, in the scope of the activities led by LESIA group.

### CHEOPS (ESA)

The Characterising Exoplanet Satellite (CHEOPS) is the first mission dedicated to search for transits of exoplanets by means of ultrahigh precision photometry on bright stars already known to host planets. It will provide the unique capability of determining accurate radii for a subset of those planets for which the mass has already been estimated from ground-based spectroscopic surveys. CHEOPS will also provide prime targets for future instruments suited to the spectroscopic characterization of exoplanetary atmospheres. IA is strongly contributing for this mission participating both in the board and the core science team of the mission. This work is also closely related with the science data archive which is being developed by our industry partners (DEIMOS), contributing to the development of stronger relation with the Portuguese industry in the area of scientific related software. Moreover there is a contribution for the mission science operation center, more specifically for the CHEOPS data reduction pipeline where we are responsible for the calibration of the pipeline. In 2019, we have finalized the implementation of the code and respective documentation for the pipeline software to be ready for launch at the end of the year. The code has passed a series of rehearsal tests before launch. CHEOPS was

successfully launched on December 18th 2019. In the first months of 2020 there in orbit commissioning to check the status of the instrument will take place.

## ARIEL (ESA)

ARIEL (Atmospheric Remote-sensing Exoplanet Large-survey) was one of the three candidate missions selected by the European Space Agency (ESA) for its next medium-class science mission due for launch in 2028. The goal of the ARIEL mission is to investigate the atmospheres of several hundred planets orbiting distant stars in order to address the fundamental questions on how planetary systems form and evolve. The main activities in ARIEL and with the OGSE team regarded the elaboration of a draft OGSE design report, integrating the Portuguese - IA contribution associated to the VIS-NIR optical source and modulator. To this date and with a continuous activity throughout the whole year of 2019, there have been a series of activities and contributions regarding the definition of the System Requirements, in preparation of the SRR milestone in beginning 2020. Regarding institutional matters, there was finally a clear step towards the funding of the activity, with the signature of the Letter of Endorsement by Portuguese Space and kick off of the Prodex process.

Alexandre Cabral
Group Leader

**Report from the Thematic Line**

## Space and Ground Systems and Technologies

The Instrumentation thematic line shares basically the same manpower of the Instrumentation group. Its activity is dedicated to the exploration of new avenues in the expertise of the group or to the development of capabilities and competences in the scope of running projects or new funding proposals.

The activities of this thematic line are focused in two main objectives

1. **Exploitation of in-house expertise in new missions and instruments**
   As referred in the report from the Instrumentation group, several initiatives are on course for the participation in international consortiums, also seeking diverse sources of activity financing. In this scope, in 2019, besides all the projects that started in 2019, the group leads a proposal for an ESA call in view of the development of the On Board Metrology for the Athena Mission. This is a major project that will join together IA (the leading institution), two Portuguese companies and a major partner in Europe Space business.

2. **New themes of research**
   In terms of new themes of research, somehow supported by background expertise in Astronomy Instruments / Space missions, are consolidated by the work of two PhD students supervised by Instrumentation Group researchers:
   a) Investigation on the Wolf Effect and its implications on astronomical observations. Development of a dedicated simulator and baseline design of an instrument for the verification of this effect in solar telescopes. This work will be concluded at the end of next year.
   b) Development of tools/ models for Atmospheric Dispersion Compensators, resulting from the work done / projected work on different instruments such as Espresso, NIRPS and HIRES.
   c) Stabilization of calibration light sources for High Accuracy Photometry Instruments resulting from research and develop a device that senses the light source fluctuations and modulates the beam, both in flux and in spectra, to produce a sufficiently stable source, a truly impressive challenge when stabilization levels of few ppm are required over long periods of observation.

Manuel Abreu
Thematic Line Leader

**Report from the Group**

# Science Communication

During 2019, the Science Communication Group at IA (SCG) organized and participated in several public outreach initiatives which reached in total more than 72,759 people.

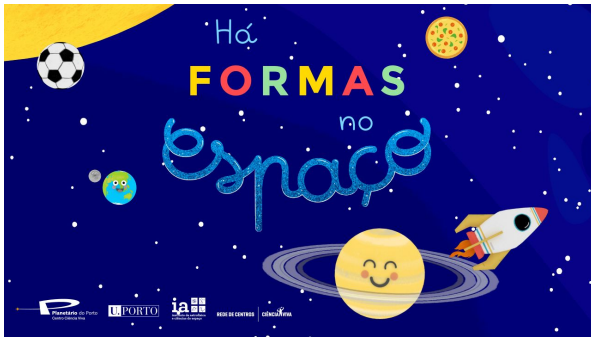
The public activities directly organized by IA reached about 51,498 people including, among others, planetarium presentations, monthly periodic outreach sessions, exhibitions, showcases, hands-on laboratories and special public events and talks. The SCG team has also participated in several initiatives promoted by other institutions, such as Ciência Viva, the Museums of the University of Lisbon and many schools, contributing also with talks, observations of the night sky, planetarium sessions, exhibitions, showcases, workshops and short courses, having reached about 21,261 people.

Throughout 2019, IA has framed its several activities and projects in the celebrations of the International Astronomical Union (IAU) centenary celebrations. One of the international activities promoted by IAU was the celebration of the 50th anniversary of the Moon landing, for which IA organized a series of events in Porto and Lisbon. In Lisbon, IA and the Museu da Presidência da República, organized a special public event at the gardens of the Belém Palace, the official home of the President of the Portuguese Republic. This event, highlighted by IAU was attended by the President himself, and also by more than 1550 people.




Another project highlighted by IAU was the international website “Do the Stars Gaze Back? Art inspired by the Universe”, a December calendar that links artworks to milestones in astronomy and space exploration.

The SCG created and produced two fulldome movies: “Há Formas no Universo” and “Vítor e Sofia vão à Lua”; for exhibition at the Planetário do Porto CCV and possibly elsewhere. In addition, several showcase and exhibition products were produced, such as flyers, roll-ups, exhibition boards and pop-ups, 19 short flat screen videos were produced, as well as contents for its official webpage.





The book “Big Ideas in Astronomy: A Proposed Definition of Astronomy Literacy” was announced by IAU on the 3rd of May 2019. This is the first outcome of the Astronomy Literacy project, led by IA and the University of Leiden. It was produced within the framework of the IAU Commission C1 for Astronomy Education and Development, in particular within the Working Group on Literacy and Curriculum Development, in alignment with the IAU’s strategy to foster the use of astronomy in teaching and education at school level.



The first national meeting of planetariums was organized, attended by 15 people of various fixed dome and portable planetariums, an important landmark to build a sense of community in this type of science communication instrument, so important within IA.

The team produced and made available to the media 32 press releases (18 national, 6 international and 8 regional) related to the science produced by the Institute or to its outreach activities. This number of press releases resulted in about 754 references in national news media with a total Automatic Advertisement Value (AAV) of about € 5.522.970,80, which is more than double of the corresponding 2018 value, and a total airtime (radio and TV) of 8:18:47. We also made available through our webpage and partners, 11 news releases.

IA has been mentioned by international news media, for example, Forbes, Fox News, Le Monde and Space.com. IA was also mentioned by Media INAF- Istituto Nazionale di Astrofísica in Italy. Eleven SC newsletters were prepared and distributed to more than 2,700 people.

The science communication and education work at IA has been presented in national and international conferences with invited and contributed talks, workshops and posters - 4 invited talks, 3 invited workshops, 9 contributed talks, 3 contributed workshops and 4 contributed posters. The conferences include, among others, the IAU C1 astro.EDU Conference, Ciência 2019, the 7º Congresso SciComPt and the VI Encontro Internacional da Casa das Ciências. The team published one book, one article for a book, seven papers in conference proceedings and is responsible for several articles for monthly columns.

The SCG has co-supervised the dissertation project of two students from Mestrado em Comunicação de Ciência from the Faculdade de Ciências Sociais e Humanas da Universidade Nova de Lisboa, 9 students' short projects and internships from the Licenciatura in Animação Digital of the the Universidade Lusófona, the Science Communication MSc degree from the Faculdade de Ciências Sociais e Humanas da Universidade Nova de Lisboa and from the Licenciatura in Design de Comunicação from Faculdade de Belas Artes da Universidade do Porto.

During 2019, the SCG has conducted several training sessions for teachers, science communication officers, students and the general public.

The SCG is responsible for the creation and development of several national projects, including the Tour Ignite IAstro or the IAstro Júnior. During 2019, 16 IA researchers toured Portugal bringing IA's science to towns and cities with less access to science communication in Astronomy and Astrophysics. The Ignite IAstro Tour reached more than 200 people in 2 events, held in 2 districts, mainly in the interior of the country. In each event there were 8-9 researchers present, performing in total 16 presentations of 5 minutes each.


IA developed another national project (Ler+Espaço), together with the Plano Nacional de Leitura 2017-2027 (PNL2027), and the Faculdade de Ciências da Universidade de Lisboa (FCUL), aiming at encouraging schools to develop reading strategies of scientific nature. IA also participates in the Cientificamente Provável programme, a partnership by the Portuguese Government, implemented through the network of school libraries, partnering with 7 schools, and in the Clubes Ciência Viva na Escola, a Ciência Viva project, partnering with 13 schools.

The IAstro Junior initiative consists of a series of sessions conceived by IA in partnership with Visão Júnior magazine, targeted to 7 to 12 years old children, held at the Planetário Calouste Gulbenkian - Centro Ciência Viva and Planetário do Porto – Centro Ciência Viva. Four sessions took place in 2019,

and gathered more than 650 people. Each session consisted of 3 mini-talks (10 min. each) about an Astronomy and Astrophysics theme, followed by a Q&A session.



IA provides the scientific management of the Planetário do Porto CCV activities, all of which are developed, organized and implemented by members of the IA SCG, having reached in 2019 to very nearly 36000 people through fixed domed and portable planetarium sessions and hands-on laboratories.

IA has an ongoing partnership with the Leiden Observatory/ University of Leiden for the development of an Astronomy Literacy Project. This international joint-project aims to define global astronomy education goals to be applied in worldwide school curricula. Another goal of this project is the production of localized astronomy educational contents in several languages, together with educational guidelines for educators.

IA continues with a strong involvement with the “Portuguese Language Expertise Centre for the Office of Astronomy for Development (of the International Astronomical Union)” - PLOAD. It is hosted by Núcleo Interativo de Astronomia (NUCLIO), in collaboration with IA. The PLOAD’s main objectives are to establish a strong collaborative network between portuguese speaking countries and communities and empower these countries and communities with the necessary tools to build their own local support structures and strategy development in Astronomy and Space Sciences.

The strategy of the SCG for the 2020-2021 period envisions the continuation of the implementation of proximity activities with the public, students of the various school cycles in particular and the production of Astronomy related educational and science communication contents for several specific target audiences, with a special focus on students and teachers. This production will be strengthened by the involvement in the “Astronomy Literacy” international project. These contents can exist by themselves or be produced with specific uses such as planetarium sessions, hands-on activities or exhibitions. The production of these materials will place IA as the main institution in Portugal in terms of the production of Astronomy related contents. IA’s strong involvement in the PLOAD will allow the dissemination of its contents throughout the portuguese language countries which engulfs 240 million people, giving to the IA’s Science Communication a real international dimension.

João Retrê and Daniel Folha
Group Leaders

**Other reports**

# The Portuguese ALMA Centre of Expertise

Since 2014 the Portuguese ALMA Center of Expertise (PACE) supports the Atacama Large Millimetre Array (ALMA) facility as a Center of Expertise (CoE), recognizing to the Institute of Astrophysics (IA) the capability to support the astronomical community in its use of ALMA and contribute to the development of the Observatory. More specifically, at a national level, the main tasks of PACE are the support to the proposal preparation and the training of a radio astronomical community. At international level, within the ALMA Regional Centre network, the CoE participates and/or coordinates observatory development projects and offers technical support for the quality assessment, a procedure that validates ALMA data before the delivery to a Principal Investigator.

In 2019, the main PACE activities can be summarized as follows:

- The emphasis on continuing to build up a national expertise in radio astronomy has been driving the involvement of a larger number of students, already from the BSc level. In particular, through IA's Incentive Program for the Training of Excellence of Young Researchers in Astrophysics and Space Sciences, one student was involved in the exploitation of ALMA data. At the MSc level, as a part of the course 'Observations and Data reduction in Astronomy', PACE members provided a introduction on interferometry at the Faculty of Science of the University of Lisbon (FCUL) and, building up from that effort, planned, proposed and got approval for a completely new course in "Radio Astronomy", that should start on the second semester of 2019/2020. This course will include a practical component where students will use the radio telescope in Santa Maria Island (Azores), as part of a collaboration signed between IA and the Association RAEGE-Azores (Rede Atlântica de Estações Geodinâmicas e Espaciais) in 2019.
- In preparation to the 2019 ALMA call for proposals, PACE members visited various research centres in Portugal (Lisbon, Porto), introducing interferometry, ALMA status, and PACE activities in support to the submission of proposal for that Call;
- ALMA and PACE activities were presented in several events and meetings throughout the year, such as: at the 'open day' of the Faculty of Sciences of the University of Lisbon; at the National Astronomy Meeting (ENAA); in various IA outreach events such as the Ignite IASTRO tour; at the National Science Exhibition event, organised by the Ministry of Science, Technology and Higher Education and attended by the national scientific community;
- PACE is involved in the SKA Pathfinder Radio Continuum Survey (SPARCS), and hosted in Lisbon in 2019 the yearly meeting of the consortium (6—10 May 2019), gathering 61 participants. In the context of SKA-precursors PACE is contributing to the Evolutionary Map of the Universe (EMU), leading the Technical Working Group "High-z radio galaxies in the epoch of reionization". PACE members also contributed to the Portuguese SKA White Book, which would be published in 2020;
- PACE members helped in the organization and presented PACE activities and future plans for radioastronomy in Portugal in the "Multi-messenger astronomy with SKA" meeting, hosted in Aveiro (12 – 15 May 2019);
- PACE hosted the ALMA general director Sean Dougherty, which presented ALMA to the Faculty of Sciences of the University of Lisbon (21 October 2019);

In particular, in what concerns the PACE direct contribution to the European ALMA Region Centre Activities, one should highlight the following:

- Participation in the ALMA Data Mining Working Group (ADaM), a project aiming at maximizing the exploitation of the ALMA archive;
- PACE researchers are supervising the MSc Thesis of António Antunes entitled "Better Science through an enhanced user interface with the ALMA Archive". The thesis aims at creating a platform were any ALMA user will be able to get a more comprehensive view of the data currently available in the ALMA Science Archive (ASA) and provide the tools to perform more complex queries than those currently implemented;
- Leadership of a Technical Working Group on Hardware, aimed at solving the hardware technical issues encountered within the European ALMA network during data reduction processes;
- Since May 2019 PACE is performing weblog review, after a successful visit of the ALMA data reduction manager Dirk Petry for training;
- Participation to the usability-testing of the New Query Interface of the ALMA archive;
- PACE participated successfully in the Polarization workshop and started the data analysis of the first full polarization ALMA data sets;
- PACE researchers actively participated during the Software Tools workshop organized by the Nordic node in Goteborg. During the meeting, PACE research on automated algorithms to search for serendipitous lines in data cubes and its application to archival ALMA data was presented. The meeting finished setting up a specific working group (the EU Software Tools team) with PACE participation, aiming at giving recommendations to the Science Portal team on the software tools section that will be elevated to the integrated Science Operational Team.

For 2020, PACE continues to develop a range of activities which include: hosting a RadioNet-supported workshop on the use of data archives in radio Astronomy, co-organized with the University of Manchester; supporting the national funding agency in the development of the national participation in SKA, something which will increase during 2020; PACE researchers continue to support on-going SKA-pathfinders surveys, in particular, the Evolutionary Map of the Universe (ASKAP) and MIGHTEE (MeerKAT), which are already collecting or about to collect data; PACE researchers are continuing to explore the possibility of serendipitous line searches within the ALMA archive (with the collaboration of two students, one at the MSc level developing an interface to facilitate the exploration of the ALMA Science Archive); starting to use of the Azores geodetic radio telescope, which is part of an Atlantic network of geodynamic and space stations (RAEGE), for astrophysical purposes, realizing an agreement signed between the Institute of Astrophysics and the regional government of the Azores in 2019). Finally, a new course in Radio Astronomy has been set up for the MSc in Physics at the Faculty of Sciences of the University of Lisbon. The first edition will start in February 2020 and is being led by PACE researchers. This will also help in attracting new students for PACE activities.

Ciro Pappalardo
PACE Lead Scientist

# Scientific Output

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4. **V. Zh. Adibekyan**; 2019; *Heavy Metal Rules: How do the super-massive planets form?*; Ringberg Conference on Star-Planet connection, Tegernsee, Alemanha
5. **V. Zh. Adibekyan**; 2019; *HD186302: A nearby solar sibling candidate*; The Gaia Treasure Hunt Workshop, Cambridge, Reino Unido
6. **V. Zh. Adibekyan**; 2019; *HD186302: the best target to search for life?*; ESPRESSO Science Team Meeting 8, Tenerife, Espanha
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14. **S. Amarantidis**; 2019; *The first SMBHs: indications from models*; Supermassive Black Holes: Environment and Evolution, Corfu, Grécia
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18. **D. Arzoumanian**; 2019; *Filament and sheet like cloud interaction: Hint to understand the history of star formation*; Zooming in on Star Formation, Nafplio, Grécia
19. **I. Ayuso**, **J. P. Mimoso**, **N. J. Nunes**; 2019; *About the sign of the effective gravitational coupling constant*; IberiCOS 2019, Bilbao, Espanha
20. **I. Ayuso**; 2019; *About the sign of the effective gravitational coupling constant*; XIV Iberian Cosmology Meeting (IberiCOS 2019), Bilbao, Espanha
21. **I. Ayuso**; 2019; *About the sign of the effective gravitational coupling constant*; Congress on Numerical Methods in Engineering, Braga, Portugal
22. **R. P. L. Azevedo**, **P. P. Avelino**; 2019; *Particle creation and decay in nonminimally coupled models*; IberiCOS 2019, Bilbao, Espanha
23. **T. Barreiro**; 2019; *Coupled quintessence with a ΛCDM background: removing the σ8 tension*; Euclid Theory Group Meeting, Oxford, Reino Unido
24. **J. Brinchmann**; 2019; *Galaxy evolution with Euclid (and a bit of other legacy science)*; The Universe in 56 colours: science with the first J-PAS data, Teruel, Espanha
25. **J. Brinchmann**; 2019; *The temperature sensitive method for metallicity estimation versus photo-ionisation models - an easy win?*; Metals in Galaxies, Near and Far: Looking Ahead, Leiden, Holanda
26. **J. Brinchmann**; 2019; *Ultra-faint dwarfs - an update. MUSE-Faint*; MUSE Busy Week, Braga, Portugal
27. **F. Buitrago**; 2019; *Las galaxias más masivas del Universo*; Charlas de Física en dos jornadas intensivas, Valladolid, Espanha
28. **F. Buitrago**; 2019; *Extremely large and small galaxies unveiled by Euclid*; EC Meeting 2019, Helsínquia, Finlândia
29. **F. Buitrago**; 2019; *Why finding an extended galaxy in a high redshift survey is not an annoyance but a potential treasure trove*; IAU Symposium 355 - The realm of Low Surface Brightness, Tenerife, Espanha
30. **F. Buitrago**; 2019; *Extended galaxies in deep extragalactic fields are not an annoyance but a potential treasure trove*; Extremely Big Eyes on the Early Universe meeting, Roma, Itália
31. **A. Cabral**; 2019; *ESPRESSO Coudé-Train: ESO's VLT working as 16-metre telescope*; Fourth International Conference on Applications of Optics and Photonics, Lisboa, Portugal
32. **F. T. O. Cabral**; 2019; *An eagle view into Gauge theories of gravity and post-Riemann geometry. Gws probes of propagating torsion*; 22nd international conference on General Relativity and Gravitation, 13th Edoardo Amaldi conference on gravitational waves;, Valência, Espanha
33. **T. L. Campante**; 2019; *TESS's first asteroseismic known hosts*; TASC5/KASC12, Cambridge, Estados Unidos da América
34. **T. L. Campante**; 2019; *Synergy between asteroseismology and exoplanet science: an outlook*; MW-Gaia WG3 Workshop: Exoplanets in the era of Gaia, Porto, Portugal
35. J. M. Cannon, E. C. Herenz, G. Ostlin, A. Bik, J. Melinder, **P. Papaderos**, J. Puschnig, C. Koen; 2019; *Deep HI Imaging of the Metal-Poor Starburst Galaxy SBS 0335-052*; 233rd Meeting of the American Astronomical Society, Seattle, Estados Unidos da América
36. **L. S. M. Cardoso**, **J. M. Gomes**, **P. Papaderos**; 2019; *Self-consistent population spectral synthesis with FADO - The importance of nebular emission in modelling star-forming galaxies*; IAU Symposium 352, Viana do Castelo, Portugal
37. O. Carrión González, A. Garcia Muñoz, J. Cabrera, Sz. Csizmadia, **N. C. Santos**; 2019; *Direct imaging of cold exoplanets. A theory framework for atmospheric characterization*; EPSC-DPS Joint Meeting 2019, Genebra, Suíça
38. **D. M. L. Castelão**, **A. Rozas-Fernández**, **I. Tereno**; 2019; *Observational constraints on a Unified Dark Matter model with fast transition*; VII Meeting on Fundamental Cosmology, Madrid, Espanha
39. **J. R. C. C. C. Correia**, **C. J. A. P. Martins**; 2019; *On cosmic string evolution and graphical supercomputing*; IberiCOS 2019, Bilbao, Espanha
40. **J. R. C. C. C. Correia**, **C. J. A. P. Martins**; 2019; *Calibrating String Evolution Models with 1032 simulations*; 30th Texas Symposium on Relativistic Astrophysics, Portsmouth, Reino Unido
41. **M. Cortês**, R. Østensen; 2019; *Our time-symmetric life style*; Cosmology Seminar, Perimeter Institute, Canadá
42. **M. Cortês**; 2019; *Towards the Inclusion of Biology in Cosmology*; Emmy Noether Research Conference, Perimeter Institute, Canadá
43. **I. A. Costa**; 2019; *Divulgação da Astronomia, através do seu ensino não formal, no Planetário do Porto – Centro Ciência Viva*; XVIII Encontro Nacional de Educação em Ciências | III International Seminar of Science Education, Porto, Portugal
44. **I. A. Costa**; 2019; *CoAstro: um Condomínio de Astronomi@ – Práticas de Divulgação Científica pelos Astrónomos*; XVIII Encontro Nacional de Educação em Ciências | III International Seminar of Science Education, Porto, Portugal
45. **I. A. Costa**; 2019; *Divulgação da Astronomia, através do seu ensino não formal, no Planetário do Porto –*

*Centro Ciência Viva: limites e potencialidades*; VI Encontro Internacional da Casa das Ciências: Ensino das Ciências e a Sociedade Moderna, Lisboa, Portugal

46. **I. A. Costa**; 2019; *O Planetário do Porto - Centro Ciência Viva como recurso para a educação não formal*; Porto International Conference on Research in Education 2019, Porto, Portugal
47. **I. A. Costa**; 2019; *Porto Planetarium - Ciência Viva Center from a dissemination program to an educational program*; END – Education and New Developments, Porto, Portugal
48. **I. A. Costa**; 2019; *Porto Planetarium - Ciência Viva Center on education and science dissemination*; International Conference on Childhood and Adolescence (ICCA 2019), Porto, Portugal
49. **I. A. Costa**; 2019; *Porto Planetarium - Ciência Viva Center (PP-CCV) as a resource for non-formal education*; Congress Science, Technology and Society 2019, Lisboa, Portugal
50. **E. Delgado Mena**; 2019; *RV search for planets around evolded stars in open clusters*; Giant stars and their planetary systems, Genebra, Suíça
51. **E. Delgado Mena**; 2019; *RV variations in evolved stars in open clusters: planets, oscillations or stellar activity?*; MW-Gaia WG3 Workshop: Exoplanets in the era of Gaia, Porto, Portugal
52. **O. Demangeon**; 2019; *Measuring reflected light from exoplanet atmospheres with ESPRESSO*; ESPRESSO Science Team Meeting 8, Tenerife, Espanha
53. **O. Demangeon**; 2019; *Exoplanet Atmospheres with CHEOPS and ESPRESSO*; S-SAIL Workshop, Lisboa, Portugal
54. **D. Espadinha**, **P. Machado**, J. Peralta, **G. Gilli**, **J. Silva**, **R. Gonçalves**, **M. Silva**, K. Brasch; 2019; *Atmospheric Dynamics of Venus Using Akatsuki's Space-Based Observations and Cloud Tracking Techniques*; VI Reunión de Ciencias Planetarias y Exploración de Sistema Solar, Torrejón de Ardoz, Espanha
55. **G. Fanizza**, R. Abraham; 2019; *H0 measurement from higher redshift surveys*; Practitioners' workshop on relativistic effects in large scale structure, Zurique, Suíça
56. **G. Fanizza**; 2019; *The dynamics of General Relativity in the Geodesic Light-Cone coordinates*; Inhomogeneous Cosmologies IV, Torun, Polónia
57. **G. Fanizza**; 2019; *Averaging observables in the LSS surveys: a new rigorous approach*; 30th Texas Symposium on Relativistic Astrophysics, Portsmouth, Reino Unido
58. **J. P. Faria**; 2019; *Statistical Methods for Estimating Radial Velocities in the Presence of Stellar Activity*; Extreme Precision in Radial Velocity IV, Grindelwald, Suíça
59. **J. P. Faria**; 2019; *Searching for low-mass planets around metal-poor stars*; Extreme Precision in Radial Velocity IV, Grindelwald, Suíça
60. J. Ferreira, P. Tanga, **P. Machado**; 2019; *A Bayesian approach to the processing of stellar occultations*; EPSC-DPS Joint Meeting 2019, Genebra, Suíça
61. **N. Frusciante**; 2019; *Healthy conditions and observational constraints of modified gravity theories*; UniVersum III, Milão, Itália
62. **J. F. Gameiro**; 2019; *Observations and simulations of the star-disk interaction process in YSOs*; EWASS 2019, Lyon, França
63. **G. Gilli**, M. Turbet, J. Leconte, **N. C. Santos**, S. Lebonnois, F. Lefèvre, **P. Machado**; 2019; *Studying Venus-like atmospheres with a GCM to address observational prospects of close-in orbit hot rocky exoplanets*; EPSC-DPS Joint Meeting 2019, Genebra, Suíça
64. **G. Gilli**, M. Turbet, J. Leconte, **N. C. Santos**, S. Lebonnois, F. Lefèvre, **P. Machado**; 2019; *Studying Venus-like atmospheres with a GCM to address observational prospects of close-in orbit hot rocky exoplanets*; EPSC-DPS Joint Meeting 2019, Genebra, Suíça
65. **G. Gilli**; 2019; *Gender Balance and Diversity in Science*; NYRIA Workshop 2019, Lisboa, Portugal
66. **G. Gilli**, S. Lebonnois, F. Forget, A. Spiga, T. Navarro, E. Millour, L. Montabone, **P. Machado**, V. Silva, P.-O. Quirion; 2019; *Impact of non-orographic Gravity waves on Mars and Venus atmosphere*; S-SAIL Workshop, Lisboa, Portugal
67. **J. M. Gomes**; 2019; *FADO: a novel self-consistency spectral population synthesis tool for starburst galaxies*; XII Workshop Estallidos: Starbursts in Galaxies, Almería, Espanha
68. **J. M. Gomes**; 2019; *Self-consistent population spectral synthesis with FADO: an exploration of galaxy evolution in the ELTs era*; Extremely Big Eyes on the Early Universe, Roma, Itália
69. **J. M. Gomes**; 2019; *FADO: a novel self-consistency spectral population synthesis tool*; IAU Symposium 355 – The Realm of the Low Surface Brightness Universe, Tenerife, Espanha
70. **J. M. Gomes**, **P. Papaderos**; 2019; *FADO: a novel self-consistency spectral population synthesis tool*; The Art of Measuring Galaxy Physical Properties, Milão, Itália
71. **J. M. Gomes**; 2019; *FADO: a novel self-consistency spectral population synthesis tool for the exploration of galaxy evolution at high redshift*; IAUS 352: Uncovering early galaxy evolution in the ALMA and JWST era, Viana do Castelo, Portugal
72. **R. Gonçalves**; 2019; *Akatsuki (cloud-tracking) and TNG/HARPS-N (Doppler Velocimetry) coordinated wind measurements of cloud top Venus atmosphere*; International Venus Conference, Hokkaido, Japão
73. **R. Gonçalves**; 2019; *Venus' cloud-top wind measurements with TNG/HARPS-N and coordinated Akatsuki observations*; EPSC-DPS Joint Meeting 2019, Genebra, Suíça
74. **R. Gonçalves**; 2019; *Akatsuki (cloud tracking) and TNG/HARPS-N (Doppler velocimetry) coordinated wind*

*measurements of cloud top Venus' atmosphere*; S-SAIL Workshop, Lisboa, Portugal

75. **S. Hojjatpanah**; 2019; *Target selection report for the blind Radial Velocity search using ESPRESSO (WG1)*; ESPRESSO Science Team Meeting 8, Tenerife, Espanha
76. **S. Hojjatpanah**, **P. Figueira**, **N. C. Santos**; 2019; *Selected stars for the blind radial velocity ESPRESSO survey*; Extreme Precision in Radial Velocity IV, Grindelwald, Suíça
77. **A. Humphrey**; 2019; *Photoionization Models for Extreme Ly-alpha and HeII ratios in quasar halos*; II Workshop: Chemical Abundances in Gaseous Nebulae, São José dos Campos, Brasil
78. **A. Humphrey**; 2019; *Photoionization Models for Extreme Ly-alpha and HeII ratios in quasar halos*; CAPES-FCT Workshop on Galaxies, Porto Alegre, Brasil
79. **M. S. N. Kumar**, **P. M. Palmeirim**, **D. Arzoumanian**; 2019; *Hub-filament systems and massive star formation*; Zooming in on Star Formation, Nafplio, Grécia
80. **M. S. N. Kumar**, **P. M. Palmeirim**, **D. Arzoumanian**; 2019; *The hub-filament paradigm for star formation*; Crete III through dark lanes to new stars, Crete, Grécia
81. Y. J. Lee, **P. Machado**; 2019; *2020 Coordinated Venus Observations of BepiColombo (ESA and JAXA), Akatsuki (JAXA), and Ground-based Telescopes*; EPSC-DPS Joint Meeting 2019, Genebra, Suíça
82. I. M. Leite, **A. Cabral**; 2019; *Measurement of the refractive index of glass by optical metrology*; Fourth International Conference on Applications of Optics and Photonics, Lisboa, Portugal
83. **F. S. N. Lobo**; 2019; *Wormholes, Warp Drives and Interstellar Travel*; Foundations of Interstellar Studies Workshop 2019, Charfield, Reino Unido
84. **F. S. N. Lobo**; 2019; *Generalized curvature-matter couplings in modified gravity*; 10th Australasian Conference on General Relativity and Gravitation (ACGRG10), Wellington, Nova Zelândia
85. **J. Silva**, **P. Machado**, J. Peralta, R. Hueso, **G. Gilli**, **M. Silva**, **R. Gonçalves**; 2019; *Characterising Atmospheric Gravity Waves on the lower and upper cloud bank of Venus using Venus Express VMC and VIRTIS images*; CPESS-VI, Torrejón de Ardoz, Espanha
86. **P. Machado**; 2019; *Meridional and Zonal winds at Venus atmosphere from Cloud tracking, Doppler techniques and comparison with modelling*; International Venus Conference, Hokkaido, Japão
87. **P. Machado**; 2019; *Venus' atmosphere cloud tracked winds (283 and 385 nm): comparison with Doppler winds and GCM simulations*; EPSC-DPS Joint Meeting 2019, Genebra, Suíça
88. **P. Machado**; 2019; *Meridional and Zonal winds at Venus' atmosphere from Cloud tracking, Doppler techniques and comparison with modelling*; S-SAIL Workshop, Lisboa, Portugal
89. **P. Machado**; 2019; *Bepi Colombo Science at Venus' flyby, Akatsuki and coordination with Ground-based observation support campaign*; BepiColombo Young Scientists Working Group, Coimbra, Portugal
90. **P. Machado**; 2019; *Planetary Systems' research in Portugal*; EPEC Annual Week 2019, Lisboa, Portugal
91. **T. E. C. Magalhães**, **J. M. Rebordão**; 2019; *Digital micromirror devices for selective imaging and coherence metrology in space payloads*; Workshop on Innovative Technologies for Space Optics, Noordwijk, Holanda
92. **T. E. C. Magalhães**, **J. M. Rebordão**; 2019; *Solar coherence instrument based on digital micromirror devices, to measure spatial coherence of solar granules*; Fourth International Conference on Applications of Optics and Photonics, Lisboa, Portugal
93. **C. J. A. P. Martins**; 2019; *The Status of Varying Constants*; III Cosmological Olentzero Workshop, Bilbao, Espanha
94. **C. J. A. P. Martins**; 2019; *Fundamental Physics and Cosmology in the ESPRESSO Era*; IberiCOS 2019, Bilbao, Espanha
95. **J. H. C. Martins**; 2019; *Studying exoplanet atmospheres with reflected light: The CCF approach*; S-SAIL Workshop, Lisboa, Portugal
96. **I. Matute**, **C. Pappalardo**, **J. Afonso**, **S. Amarantidis**; 2019; *Growing radio-interferometry expertise in Portugal: the PACE*; Multi-messenger astronomy with SKA precursors and pathfinders, a capacity building workshop, Aveiro, Portugal
97. **I. Matute**, **J. Afonso**, **C. Pappalardo**, **L. Bizzocchi**, **S. Amarantidis**, **H. Messias**; 2019; *Searching for the first Radio Galaxies*; Multi-messenger astronomy with SKA precursors and pathfinders, a capacity building workshop, Aveiro, Portugal
98. **I. Matute**, **J. Afonso**, **C. Pappalardo**, **S. Amarantidis**, **L. Bizzocchi**, **H. Messias**; 2019; *Towards the First Radio Galaxies*; IAUS 352: Uncovering early galaxy evolution in the ALMA and JWST era, Viana do Castelo, Portugal
99. **S. G. Morais**; 2019; *Electron Energy Distributions in the Extended Halos associated with High Redshift AGN: Maxwell-Boltzmann vs. non-Maxwellian (k)*; CAPES-FCT Workshop on Galaxies, Porto Alegre, Brasil
100. **S. G. Morais**, **A. Humphrey**; 2019; *Electron Energy Distributions in the Extended Halos associated with High Redshift AGN: Maxwell-Boltzmann vs. non-Maxwellian (k)*; II Workshop: Chemical Abundances in Gaseous Nebulae, São José dos Campos, Brasil
101. **S. G. Morais**, **A. Humphrey**; 2019; *Feedback in Lyman-alpha halos around two radio galaxies at z~2.5*; Feedback and its Role in Galaxy Formation, Spetses, Grécia
102. **E. M. P. S. Moreira**, **I. A. Costa**, **D. F. M. Folha**; 2019; *Porto Planetarium - Ciência Viva Center: from immersive fulldome to hands-on laboratories*; Astronomy Education Conference: Bridging Research and Practice, Garching, Alemanha

103. **B. Nsamba**, **M. S. Cunha**, **T. L. Campante**, T. L. Astraatmadja; 2019; *Asteroseismology with ESA's PLATO Mission: Testing Modelling Requirements for Subgiant Stars*; PLATO Stellar Science Workshop #3, Barcelona, Espanha
104. **P. Papaderos**; 2019; *Spectral synthesis studies of galaxies with FADO*; CAPES-FCT Workshop on Galaxies, Porto Alegre, Brasil
105. **C. Pappalardo**; 2019; *Galaxy Evolution through spectral fitting tools: a comparative study between STECKMAP and FADO*; EWASS 2019, Lyon, França
106. **C. Pappalardo**; 2019; *Galaxy Evolution through spectral fitting tools: a comparative study between STECKMAP and FADO*; Multi-messenger astronomy with SKA precursors and pathfinders, a capacity building workshop, Aveiro, Portugal
107. **C. Pappalardo**; 2019; *Growing radio-interferometry expertise in Portugal: the PACE*; IAU Symposium 352, Viana do Castelo, Portugal
108. J. Peralta, T. Satoh, K. McGouldrick, E. F. Young, T. Horinouchi, A. Sánchez-Lavega, R. Hueso, K. Muto, Y. J. Lee, T. M. Sato, T. Kouyama, H. Sagawa, S. Murakami, T. Imamura, S. S. Limaye, **P. Machado**, I. Garate-Lopez, M. Nakamura; 2019; *The complex features and dynamics of the nightside clouds of Venus as revealed by Akatsuki and Venus Express*; International Venus Conference, Hokkaido, Japão
109. **C. P. Pereira**; 2019; *Photometric Light Curves of Exoplanets*; NYRIA Workshop 2019, Lisboa, Portugal
110. **L. F. Pereira**, **T. L. Campante**, **M. S. Cunha**, **J. P. Faria**, **N. C. Santos**, **S. C. C. Barros**, **O. Demangeon**; 2019; *Gaussian process modelling of TESS light curves in the presence of stellar variability and transits*; TASC5/KASC12, Cambridge, Estados Unidos da América
111. **S. N. Reis**, **F. Buitrago**, **P. Papaderos**, **A. Paulino-Afonso**, **T. C. Scott**; 2019; *Structural analysis of massive galaxies using Hubble Space Telescope deep imaging at $z < 0.5$*; IAU Symposium 352, Viana do Castelo, Portugal
112. **J. Retrê**; 2019; *Workshop - Big Ideas in Astronomy: A Proposed Definition of Astronomy Literacy*; IAU Commission C1 and AstroEdu Conference on Astronomy Education: Bridging Research & Practice 2019, Garching, Alemanha
113. **J. Retrê**; 2019; *Workshop - Escalas no Sistema Solar*; VI Encontro Internacional da Casa das Ciências: Ensino das Ciências e a Sociedade Moderna, Lisboa, Portugal
114. **J. Retrê**; 2019; *Why Communicate Science*; NYRIA Workshop 2019, Lisboa, Portugal
115. **J. Retrê**; 2019; *Workshop: How to give a talk*; EPEC Annual Week 2019, Lisboa, Portugal
116. **J. Retrê**; 2019; *Workshop - Estimativa da massa de Júpiter por observação das suas luas Galileanas*; VI Encontro Internacional da Casa das Ciências: Ensino das Ciências e a Sociedade Moderna, Lisboa, Portugal
117. H. Sagawa, M. Takagi, **G. Gilli**; 2019; *Doppler-wind observations of Venus mesosphere: Comparison with new GCM experiments*; International Venus Conference, Hokkaido, Japão
118. H. Sagawa, **G. Gilli**, M. Takagi, Ph. André; 2019; *Doppler wind measurements of Venus upper atmosphere: Comparisons with updated GCM experiments*; EPSC-DPS Joint Meeting 2019, Genebra, Suíça
119. **N. C. Santos**, A. Aparicio; 2019; *Designing instrumentation: the astronomer's perspective*; Fourth International Conference on Applications of Optics and Photonics, Lisboa, Portugal
120. **N. C. Santos**; 2019; *Designing instrumentation for exoplanet science*; NYRIA Workshop 2019, Lisboa, Portugal
121. **N. C. Santos**; 2019; *ESPRESSO: first results from the new planet hunter*; Big Data, Small Planets, Jerusalém, Israel
122. **N. C. Santos**; 2019; *ESPRESSO: first results from the new planet hunter*; Ringberg Conference on Star-Planet connection, Schloss Ringberg, Alemanha
123. **N. C. Santos**, Z. Çelik Orhan; 2019; *ESPRESSO and its first science*; MW-Gaia WG3 Workshop: Exoplanets in the era of Gaia, Porto, Portugal
124. **T. C. Scott**; 2019; *HI in late-type galaxies in Galaxy clusters*; Multi-messenger astronomy with SKA precursors and pathfinders, a capacity building workshop, Aveiro, Portugal
125. **L. M. Serrano**; 2019; *Coupling planetary transit and RM observations to measure the stellar differential rotation*; PLATOEsp2019: Single, shallow and strange Transits, Warwick, Reino Unido
126. **J. Silva**, J. Peralta, **G. Gilli**, R. Hueso, D. Espadinha, **R. Gonçalves**, **M. Silva**; 2019; *Characterising Atmospheric Gravity Waves on Venus' lower and upper cloud banks using Venus Express VIRTIS and VMC data*; EPSC-DPS Joint Meeting 2019, Genebra, Suíça
127. **J. Silva**, **P. Machado**, J. Peralta, **G. Gilli**, R. Hueso, **R. Gonçalves**, **M. Silva**; 2019; *Characterising Atmospheric Gravity Waves on the lower and upper cloud bank of Venus using Venus Express VMC and VIRTIS images*; EGU General Assembly 2019, Viena, Áustria
128. **J. Silva**, **P. Machado**, J. Peralta, **G. Gilli**, R. Hueso, D. Espadinha, **R. Gonçalves**, M. Silva; 2019; *Characterising Atmospheric Gravity Waves on the lower and upper cloud bank using Venus Express VMC and VIRTIS images*; S-SAIL Workshop, Lisboa, Portugal
129. **M. Silva**; 2019; *Adaptation to infrared of Doppler Velocimetry applied to Saturn with CARMENES*; EPSC-DPS Joint Meeting 2019, Genebra, Suíça
130. **L. Sousa**; 2019; *Probing cosmic strings with LISA*; IberiCOS 2019, Bilbao, Espanha
131. **L. Sousa**; 2019; *Probing cosmic strings with LISA*; COSMO 19, Aachen, Alemanha
132. **L. Sousa**; 2019; *Probing cosmic (super)strings with gravitational waves*; Multi-messenger astronomy with SKA precursors and pathfinders, a capacity building workshop, Aveiro, Portugal

133. **H. M. Tabernero**; 2019; *SteParSyn a method to derive parameters with spectral synthesis: application to M stars*; Abundances in M dwarf stars: its implications for planet formation, evolution and structure (interiors and atmospheres), Granada, Espanha
134. **H. M. Tabernero**; 2019; *CARMENES in the era of GAIA*; MW-Gaia WG3 Workshop: Exoplanets in the era of Gaia, Porto, Portugal
135. **I. Tereno**; 2019; *100 years of Gravitational Lensing: from Eddington to Euclid*; Eddington at Sundy: 100 years later, Roça Sundy, São Tomé e Príncipe
136. **I. Tereno**, **J. Dinis**; 2019; *Scheduling the Euclid Surveys*; OU-MER splinter meeting within the Euclid Consortium Meeting, Helsínquia, Finlândia
137. **I. Tereno**, **J. Dinis**, R. Scaramella; 2019; *Survey Implementation Status*; Euclid Calibration Working Group Meeting, Heidelberg, Alemanha
138. **I. Tereno**; 2019; *Implementation of Calibrations*; Euclid Surveys Workshop, Sesto, Itália
139. **I. Tereno**; 2019; *Plan of RSD Deliveries*; Euclid Sky Survey Working Group Meeting, Lisboa, Portugal
140. **M. Tsantaki**; 2019; *Improvements on spectroscopic surface gravities of cool stars with Gaia*; EWASS 2019, Lyon, França
141. **M. Tsantaki**; 2019; *On the iron ionization balance of cool stars: the role of accurate surface gravities from Gaia*; ESLAB 53: The Gaia Universe, Noordwijk, Holanda
142. **S. C. Ulmer-Moll**; 2019; *Is telluric correction required for precise radial velocities?*; Extreme Precision in Radial Velocity IV, Grindelwald, Suíça
143. **S. C. Ulmer-Moll**; 2019; *To which precision can we correct telluric lines in the near-infrared?*; Extreme Precision in Radial Velocity IV, Grindelwald, Suíça
144. **S. C. Ulmer-Moll**; 2019; *Forecasting exoplanet radii using random forests*; MW-Gaia WG3 Workshop: Exoplanets in the era of Gaia, Porto, Portugal
145. **D. Vernieri**; 2019; *Covariant action for bouncing cosmologies in modified Gauss-Bonnet gravity*; UniVersum III, Milão, Itália
146. **P. T. P. Viana**, L. Cabona, M. Landoni, **J. P. Faria**; 2019; *Optimal scheduling of radial velocity follow-up of transiting exoplanets*; Extreme Precision in Radial Velocity IV, Grindelwald, Suíça
147. **B. Wehbe**; 2019; *The development of an optical design tool for atmospheric dispersion correction*; Fourth International Conference on Applications of Optics and Photonics, Lisboa, Portugal
148. **B. Wehbe**; 2019; *Atmospheric dispersion correction: Model requirements and impact on radial velocity*; Fourth International Conference on Applications of Optics and Photonics, Lisboa, Portugal
149. **B. Wehbe**; 2019; *Atmospheric dispersion correction: Residuals requirements*; NYRIA Workshop 2019, Lisboa, Portugal

## National Scientific Communications [47]

1. **M. Abreu**, D. C. Alves, **A. Cabral**, R. Østensen; 2019; *Ground calibration of transit and photometry instrumentation*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
2. **V. Zh. Adibekyan**; 2019; *ESPRESSO: the first science results*; Ciência 2019, Lisboa, Portugal
3. **R. M. G. Albuquerque**; 2019; *Accreting low-mass stars in the Orion Nebula Cluster*; IA-ON6, Porto, Portugal
4. **R. M. G. Albuquerque**, **J. F. Gameiro**, S. Alencar, **J. J. G. Lima**, C. Sauty, C. Melo; 2019; *Accretion in low-mass stars with young transition disks*; Ciência 2019, Lisboa, Portugal
5. **A. Antoniadis-Karnavas**; 2019; *ODUSSEAS: A machine learning tool to derive Teff and [Fe/H] for M Dwarfs*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
6. **T. Barreiro**; 2019; *Coupled quintessence with a ΛCDM background: removing the σ8 tension*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
7. **J. Brinchmann**; 2019; *First results from MUSE-Faint-MACHO constraints from a faint cluster in an ultra-faint dwarf galaxy*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
8. **J. Brinchmann**; 2019; *Two accreting protoplanets around the young star PDS 70*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
9. **J. Brinchmann**; 2019; *The Trifid nebula - the largest IFU mosaic*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
10. **A. Cabral**, **M. Abreu**, **J. Coelho**, P. Santos, A. Oliveira, **M. A. Monteiro**, D. C. Alves, **N. C. Santos**, **S. G. Sousa**, **P. Figueira**, G. Avila, M. Riva, D. Megevand, F. Pepe; 2019; *ESPRESSO: a high-resolution spectrograph at the 4 ESO's VLT telescopes*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
11. **A. Cabral**, **M. Abreu**, **J. Coelho**, P. Santos, A. Oliveira, **J. Afonso**, P. Rees, W. Taylor, S. Watson, D. Lee, A. Fairley, M. Cirasuolo; 2019; *MOONS: the next ESO VLT's multi-object spectrograph*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
12. **D. M. L. Castelão**; 2019; *Testing Unified Dark matter-energy models against structure formation*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
13. **J. R. C. C. C. Correia**, **C. J. A. P. Martins**; 2019; *On modelling string network evolution*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
14. **J. R. C. C. C. Correia**, **C. J. A. P. Martins**; 2019; *Domain wall evolution in contracting universes*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal

15. **J. R. C. C. C. Correia**, **C. J. A. P. Martins**; 2019; *On modeling string network evolution*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
16. M. S. Encarnação, M. Pereira, **J. R. C. C. C. Correia**, **C. J. A. P. Martins**; 2019; *Visualizing energy losses in domain wall networks*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
17. **D. Espadinha**, **P. Machado**; 2019; *Cloud tracking technique and Akatsuki's spacebased observations in ultraviolet*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
18. **G. Fanizza**; 2019; *Averaging observables in the LSS surveys: a new rigorous approach*; IA-ON6, Porto, Portugal
19. **J. Ferreira**, **P. Machado**; 2019; *A Bayesian approach to the processing of stellar occultations*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
20. **J. Gomes da Silva**; 2019; *Stellar activity of the AMBRE-HARPS sample: preliminary results*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
21. **A. C. O. Leite**; 2019; *First results from ESPRESSO – WG4*; IA-ON6, Porto, Portugal
22. **P. Machado**, R. Østensen; 2019; *Comparative study of circulation regimes of terrestrial planets' atmospheres*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
23. **P. Machado**, A. Ribeiro; 2019; *Detection of chemical species in Titan's atmosphere using high-resolution spectroscopy*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
24. **P. Machado**, G. Östlin; 2019; *Studying global dust storms on Mars using high resolution spectroscopy*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
25. **P. Machado**; 2019; *Atmospheric gravity waves: with Venus GCM simulations and Venus express VMC data*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
26. **T. E. C. Magalhães**; 2019; *Conceptual design of an instrument for spatial coherence measurements of solar granular cells*; IA-ON6, Porto, Portugal
27. **T. E. C. Magalhães**, **J. M. Rebordão**; 2019; *Solar Coherence Instrument: A conceptual optical system for solar studies*; CIÊNCIAS Research Day 2019, Lisboa, Portugal
28. C. Marques, **C. J. A. P. Martins**; 2019; *Low-redshift constraints on homogeneous and isotropic universes with torsion*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
29. **C. J. A. P. Martins**, D. Colombo; 2019; *Fine-structure constant constraints on latetime dark energy transitions*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
30. **C. J. A. P. Martins**, A. N. Taylor; 2019; *Updated constraints on rolling tachyon models*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
31. **C. J. A. P. Martins**; 2019; *Low redshift constraints on dark energy*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
32. **J. P. Mimoso**, **I. Ayuso**, **N. J. Nunes**; 2019; *A cosmological stabilization mechanism of the sign of the gravitational constant*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
33. **C. Pappalardo**; 2019; *Understanding the galaxy evolution through spectral fitting tools: a comparative study of the star formation history*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
34. **C. Pappalardo**; 2019; *Growing radio-interferometry expertise in Portugal: the PACE*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
35. B. Pereira, C. S. Alves, **C. J. A. P. Martins**, R. Østensen; 2019; *Watching the Universe Expand in Real Time*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
36. **S. Pereira**, **P. J. T. Pereira**, **J. Retrê**, **F. A. L. Pires**; 2019; *Astronomia na Cultura: Parcerias com escolas de artes e agentes culturais*; 7º Congresso de Comunicação de Ciência SciComPT, Aveiro, Portugal
37. **S. Pereira**, **P. J. T. Pereira**, **J. Retrê**, **F. A. L. Pires**; 2019; *Astronomy in culture: partnerships with art schools and cultural agents*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
38. **R. S. S. C. Reis**; 2019; *Eventos de entrada livre ou por marcação: O caso do "Mais Perto das Estrelas"*; 7º Congresso SciCom PT, Aveiro, Portugal
39. **S. N. Reis**; 2019; *Structure of massive galaxies at $z < 0.5$*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
40. **S. N. Reis**, **F. Buitrago**, **P. Papaderos**, **I. Matute**, **J. Afonso**, **S. Amarantidis**, **I. P. Breda**, **J. M. Gomes**, **A. Humphrey**, **C. Lobo**, **S. Lorenzoni**, **C. Pappalardo**, **A. Paulino-Afonso**, **T. C. Scott**, R. Østensen; 2019; *Structural analysis of massive galaxies using Hubble Space Telescope deep imaging at $z < 0.5$*; CIÊNCIAS Research Day 2019, Lisboa, Portugal
41. **J. Retrê**; 2019; *Public Speaking*; Física Fora da Academia, Lisboa, Portugal
42. **J. Retrê**; 2019; *Future Scientists Communicating Science*; Ciência 2019, Lisboa, Portugal
43. A. Rozas-Fernández, **D. M. L. Castelão**, **I. Tereno**; 2019; *Testing Unified Dark matter-energy models against structure formation*; Ciência 2019, Lisboa, Portugal
44. **J. Silva**, **P. Machado**, J. Peralta, **G. Gilli**, R. Hueso, D. Espadinha, **M. Silva**, **R. Gonçalves**; 2019; *Characterising Atmospheric Gravity Waves on Venus*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
45. **H. M. Tabernero**; 2019; *Exoplanet atmospheres with ESPRESSO*; IA-ON6, Porto, Portugal

46. **I. Tereno**; 2019; *The light deflection measurements of 1919*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal
47. **S. C. Ulmer-Moll**; 2019; *Beyond the exoplanet mass-radius relation*; XXIX Encontro Nacional de Estudantes de Astronomia, Lisboa, Portugal

## Seminars at IA [57]

1. Bitsch, B.; 2019; *Planet formation in the pebble accretion scenario*
2. Bossini, D.; 2019; *Asteroseismology of Red Giant Stars: a Tool for Determining Stellar Properties*
3. Cabral, A. D.; 2019; *Travelling through the galactic potential*
4. Cardone, V. F.; 2019; *Forecasts for the Euclid: from validation to updated Figure of Merit and beyond*
5. Carmona, A.; 2019; *SPIRou @CFHT: Searching for earth-like planets & unveiling the magnetic topology of young stars: in-lab and on-sky performances*
6. Carmona, A.; 2019; *Gas in the inner cavities of transition disks & recent news of the near-IR planet-hunter SPIRou at the Canada France Hawaii-Telescope*
7. Correia, A. C. M.; 2019; *The importance of astrometric measurements for the characterisation of multi-planet systems*
8. Corsaro, E.; 2019; *Spin alignment of stars in old open clusters*
9. da Silva Santos, J. M.; 2019; *The Solar chromosphere: old challenges, new diagnostics*
10. Deal, M.; 2019; *Transport of chemical elements in stars*
11. Donevski, D.; 2019; *Knocking on Giant's Door: Modelling the dust-to-stellar properties of distant, massive galaxies*
12. Dougherty, S.; 2019; *ALMA – current status and looking to the future*
13. Encrenaz, T.; 2019; *Infrared Spectroscopy of the Giant Planets*
14. Fanizza, G.; 2019; *Non-linear CMB lensing and next generation experiments*
15. Favole, J.; 2019; *Modelling the clustering properties of emission line galaxies in new-generation cosmological surveys*
16. Feng, J. C.; 2019; *New class of generalized coupling theories*
17. Fonseca, J. C.; 2019; *Multi-wavelength Cosmology and Intensity Mapping as gravity and inflation probes*
18. Fonseca, J. C.; 2019; *Power of multi-tracing to access the largest cosmic scales*
19. Furuya, R. S.; 2019; *The JCMT BISTRO Survey: A First Look at 850 and 450 micron dust polarization images toward high-density star-forming gas*
20. Génova-Santos, R. T.; 2019; *Measuring the CMB temperature at high redshift to test the standard Lambda-CDM prediction Tcmb=T0(1+z)*
21. Girardi, L.; 2019; *Towards more reliable stellar evolutionary models for population synthesis of galaxies*
22. Gunawardhana, M.; 2019; *Evidence for a non-universal stellar initial mass function*
23. Inutsuka, S.-I.; 2019; *Filament Paradigm and Galactic Star Formation*
24. Koivisto, T. S.; 2019; *Gravitational energy and entropy*
25. Kubiak, K.; 2019; *On the nature of the Orion Belt Population sources*
26. Lehnert, M. D.; 2019; *The impact of radio jets on massive galaxies: Feedback on galaxy to halo scales*
27. Leite, A. C. O.; 2019; *ESPRESSO's Tests of the stability of fundamental constants*
28. Llinares, C.; 2019; *Two talks: Testing fundamental physics with astronomical observations; Bullying in academia*
29. Lombriser, L.; 2019; *Towards Understanding the Cosmic Expansion at Late Times*
30. Manara, C. F.; 2019; *Constraining planet formation by understanding protoplanetary disk evolution*
31. Martinelli, M.; 2019; *Tensions in cosmological data: impact of non standard models and systematic effects*
32. Martins, C. J. A. P.; 2019; *CosmoESPRESSO: First results*
33. Martins, J. H. C.; 2019; *Studying exoplanet atmospheres with reflected light: The CCF approach*
34. Mendonça, J.; 2019; *Exploring the Climate of Exoplanets with OASIS*
35. Messias, H.; 2019; *Bridging ALMA and SKA – the scientific potential of the largest interferometers working together*
36. Minamitsuji, M.; 2019; *Spontaneous scalarization of black holes in higher-derivative scalar-tensor theories*
37. Morais, M. H. M.; 2019; *Periodic orbits in the three-dimensional 3-body problem: How can they provide information about the primordial solar system?*
38. Pace, F.; 2019; *Dark sector evolution in Horndeski models*
39. Pappalardo, C.; 2019; *Cycle 7, ALMA, PACE, and other stories*
40. Pedroso. J. P.; 2019; *A Model for Scheduling Telescope Observations*
41. Pompea, S. M.; 2019; *Einstein Schools: Design of an Educational Program to Celebrate 100 Years of General Relativity*
42. Ribó, M.; 2019; *Studying the Universe in Very-High-Energy gamma rays*
43. Rosa, J. L.; 2019; *Hybrid metric-Palatini gravity: applications to cosmology and astrophysics*
44. Santos, A. C.; 2019; *The rich population of jellyfish galaxies in Abell 901/2 at z ~ 0.165*

45. Santos, A. R. G.; 2019; *Surface rotation and photometric activity of Kepler solar-type stars*
46. Shapiro, A. I.; 2019; *Activity of Sun-like stars*
47. Tabernero, H. M.; 2019; *High resolution transmission spectroscopy*
48. Tahani, M.; 2019; *The Large-Scale Structure of Magnetic Fields Associated with Filamentary Molecular Clouds*
49. Tokuda, K.; 2019; *Quest for the moment of star formation with ALMA*
50. Turbet, M.; 2019; *Characterizing the habitability and climate of temperate, Earth-sized exoplanets using a hierarchy of numerical climate models*
51. Valls-Gabaud, D.; 2019; *The messier surveyor: lifting the veil on the ultra low surface brightness universe*
52. Vaz, D. A.; 2019; *The morphology and dynamic of large aeolian ripples in Gale Crater (Mars)*
53. Verhamme, A.; 2019; *Indirect probes of the escape of ionizing radiation from galaxies to unveil the nature of the sources of Cosmic Reionization*
54. Verma, K.; 2019; *Learning stellar physics and unravelling history of the Milky Way using asteroseismology*
55. Vernieri, D.; 2019; *Covariant action for bouncing cosmologies in modified Gauss-Bonnet gravity*
56. Widemann, T.; 2019; *EnVision: Understanding Why our most Earth-like Neighbour is so Different*
57. Yun, J. L.; 2019; *Galactic Star Formation sites: from a few young stars to rich young stellar clusters*

## Organization of Conferences [12]

1. *SPARCS IX - Pathfinders get to work*; 6 to 10 May 2019; Lisboa, Portugal
2. *EPEC anual week 2019*; 20 to 24 May 2019; Lisboa, Portugal
3. *S-SAIL: Solar System Atmospheres' Investigation and exopLanets*; 27 to 28 June 2019; Lisboa, Portugal
4. *IA School on Cosmology*; 15 to 19 July 2019; Lisboa, Portugal
5. *Unveiling the dynamics of the universe; Thematic Line Meeting*; 9 October 2019; Porto, Portugal
6. *2-DEMOC 2019; "Towards the detection and characterization of other Earths" Thematic Line Internal Meeting*; 9 October 2019; Porto, Portugal
7. *IA-ON6; Instituto de Astrofísica e Ciências do Espaço 6$^{th}$ internal workshop*; 10 to 11 October 2019; Porto, Portugal
8. *MUSE Busy Week 2019*; 4 to 8 November 2019; Braga, Portugal
9. *2019 NYRIA Workshop*; 4 to 8 November 2019; Lisboa, Portugal
10. *Porto MW-Gaia WG3 Workshop: Exoplanets in the era of Gaia*; 18 to 20 November 2019; Porto, Portugal
11. *The assembly history of galaxies resolved in space and time; Brainstorming Meeting of the IA Thematic Line*; 16 to 17 December 2019; Porto, Portugal
12. *COSMONATA 2019*; 23 December 2019; Lisboa, Portugal

## Observing runs [36]

1. **Bachar Wehbe**; **Alexandre Cabral**; **Pedro Figueira** et al.; Direct measurement of atmospheric dispersion: the long-awaited model validation, 4103.L-0942(A), UVES/UT2, Period 103, April-May 2019
2. **Jason J. Neal**; ESPRESSO, VLT, Chile, 4 - 10 Jan [6n] 3n
3. D. Huber, **T. Campante**, W. Chaplin, **M. S. Cunha**, E. Gaidos, S. Grunblatt et al., TESS satellite, from July 2019 - June 2020
4. D. L. Holdsworth, D. W. Kurtz, **M. S.Cunha**, J. L. Provencal, K. R. Pollard, R. R. Sefako; Asteroseismology of HD218495: probing the temperature dependence on roAp pulsation amplitudes with the WET, South African Astronomical Observatory, 1.0m, SHOC, Sep 2019 (3 weeks)
5. Jose M. Vílchez, J. Iglesias, S. Sánchez, J. Aceituno, C. Kehrig, B. Rodríguez del Pino, **J. M. Gomes**, **C. Lobo**, **P. Papaderos**, **T. Scott**; Infalling late-type galaxies meet the A1367 merging cluster environment: assessing the damage with PPAK, FADO and cold gas; CAHA F19-3.5-013, PMAS PPAK (IFU) at the 3.5m telescope of the Calar Alto Observatory; 4-9 march 2019 (6 nights)
6. Sheng-Yuan Liu, **M. S. Nanda Kumar, P. Palmeirim**, Hseih; Ionised accretion flows and bloated photospheres in young high-mass stars: observational tests with SPIRou; SPIRou, CFHT; 2019B
7. **P. Papaderos**; Observations (6 nights; 4-9 March 2019) of galaxies in the A1367 cluster with the PMAS/PPAK IFS spectrograph at the 3.5m Calar Alto telescope
8. **S. A. G. Sousa**, **N. C. Santos**, **E. Delgado Mena**, **V. Adibekyan**, **M. Tsantaki**, Ferreira, Rojas-Ayala, **P. Figueira**, **O. Demangeon**, A. Mortier, G. Israelian, **S. Barros**, **I. Brandão**, **A. Antoniadis**, **J. P. Faria**; Know the star to know the planet: improving the catalog of exoplanet host stars with homogeneous parameters and chemical abundances, 5.7 hours with UVES at the ESO VLT UT2, Paranal, ESO, Chile. (0103.C-0027)
9. **J. Brinchmann**; MUSE GTO team; GTO31; MUSE on VLT; 2019-01-02-2019-01-09
10. **J. Brinchmann**; MUSE GTO team; GTO32; MUSE on VLT; 2019-03-04-2019-03-07
11. **J. Brinchmann**; MUSE GTO team; GTO33; MUSE on VLT; 2019-04-05-2019-04-11
12. **J. Brinchmann**; MUSE GTO team; GTO34; MUSE on VLT; 2019-05-03-2019-05-05
13. **J. Brinchmann**; MUSE GTO team; GTO35; MUSE on VLT; 2019-09-26-2019-10-01

14. **J. Brinchmann**; MUSE GTO team; GTO36; MUSE on VLT; 2019-10-21-2019-11-03
15. **J. Brinchmann**; MUSE GTO team; GTO37; MUSE on VLT; 2019-11-23-2019-12-01
16. **J. Brinchmann**; MUSE GTO team; GTO38; MUSE on VLT; 2019-12-24-2019-12-28
17. **D. Arzoumanian**; Investigating the multi-mode hierarchical fragmentation of a star forming filament in the Orion B molecular cloud, 2018.1.01336.S, ALMA cycle 6
18. **O. Demangeon**, F. Pepe and ESPRESSO GTO; "Detection and characterisation of Earth-like planets with ESPRESSO"; ESPRESSO at VLT; 17 Feb. 2019, 1 Mar. 2019
19. **R. Gonçalves**, **P. Machado**, **N. C. Santos**, **M. J. P. G. Monteiro**, **T. Campante** et al. Jupiter seismology with ESPRESSO 0103.C-0203(A) ESPRESSO VLT, 21-22 jul 2019
20. **J. P. Faria**, ESPRESSO dVM; ESPRESSO, VLT; 30 July 2019
21. **C. J. A. P. Martins**, **J. R. C. C. C. Correia**; Cracks in the Sky: Cosmic strings with CUDA-MPI; 2010PA4610; Piz Daint CSCS - PRACE Type B proposal; 3rd September 2018 - 17th of April of 2019
22. **C. J. A. P. Martins**, **J. R. C. C. C. Correia**; Abelian Higgs Cosmic strings: network evolution; 2019204986; Piz Daint CSCS - PRACE Call 19; 1st of October 2019 - 30th September of 2020
23. **S. Amarantidis**, L. Bizzocchi, **J. Afonso, I. Matute**, C. Pappalardo; Towards the first Radio Galaxies in the Universe; P368203, 227-19; EMIR, 30 meter antenna at Pico Veleta; 19-24 December 2019
24. S.-Y. Liu, **M. S. N. Kumar**, **P. Palmeirim**, T.-H. Hsieh; Ionised accretion flows and bloated photospheres in young high-mass stars: observational tests with SPIRou; SPIROu in polarimetric mode; 2019B
25. **D. Arzoumanian**, **P. Palmeirim**, **M. S. N. Kumar**, S.-I. Inutsuka, Y. Shimakiri, K. Tokuda, M. Tafalla; Probing the magnetic field towards a massive dense core in the potential well of a hub-filament system; ALMA; Cycle 7
26. **H. Messias, J. Afonso, I. Matute**, E. Hatziminaoglou, M.-L. Gendron-Marsolais, M. Lacy, C. Pappalardo, V. Impellizzeri; R. Kneissl; T. Mroczkowski; C. Yang; The host properties and environment of high-redshift radio galaxies with ACA; 2018.A.00046.S; ALMA Compact Array; Accepted/executed during 2019
27. **P. Machado**; IRTF Venus' atmosphere dynamics coordinated with Akatsuki space probe. MaunaKea Observatory, Hawaii, USA, January 2019
28. **P. Machado**; Jupiter dynamics investigation with CAHA/Carmenes, Spain, June 2019
29. **P. Machado**; Jupiter VLT/ESPRESSO seismology studies, Paranal, Atacama Desert, Chili, July 2019
30. **P. Machado**, J. Ferreira, J. Oliveira, H. Martins, D. Pereira, Asteroide Germania Stellar occultation, CCV Constância, 9 Mars 2019
31. **A. Humphrey**, R. Magalhaes, T. Storchi-Bergmann, R. Nemmen da Silva, **S. Morais**, R. Riffel, **M. S. Silva**, L. D. Hahn; 3D spectroscopy of giant gas halos at z=2.3-2.6: cold gas inflows vs. AGN feedback; SO2019B-002; SIFS at SOAR; Observações na segunda metade da noite 2019-11-26; Observações noite completa 2019-11-27 e 2019-11-28
32. Molaro, Martins, Cristiani, Pepe, D'Odorico, Nunes**, V. Adibekyan**, Alibert, Allende, Bouchy, Ehrenreich, **P. Figueira**, **N. C. Santos**, Gonzalez Hernandez, Lovis, Micela, Sozzetti, Poretti, Rebolo Lopez, Santos, **S. A. G. Sousa**, Udry, Zapatero Osorio, ESPRESSO Science Team, ESPRESSO tests of the invariance of fundamental physical constants, 1102.A-0852(B), ESPRESSO, VLT, Service Mode 8.0 hours , between 9 August to 21 September, 2019.
33. Molaro, Martins, Cristiani, Pepe, D'Odorico, Nunes**, V. Adibekyan**, Alibert, Allende, Bouchy, Ehrenreich, **P. Figueira**, **N. C. Santos**, Gonzalez Hernandez, Lovis, Micela, Sozzetti, Poretti, Rebolo Lopez, Santos, **S. A. G. Sousa**, Udry, Zapatero Osorio, ESPRESSO Science Team, ESPRESSO tests of the invariance of fundamental physical constants, 1102.A-0852(D), ESPRESSO, VLT, Service Mode 16.0 hours , between 22 October 2019 to 21 March 2020.
34. **E. Delgado Mena** et al.; "Follow-up of planetary candidates in stellar open clusters"; 0102.C-0812,0104.C-0358 (other observers)
35. **V. Adibekyan** et al; "ESPRESSO ultra-high-resolution spectra for Gaia benchmark stars II: creating a public library of unique reference spectra"; 0103.D-0118 ESPRESSO/VLT; P103 service mode
36. **V. Adibekyan** et al; "ESPRESSO ultra-high-resolution spectra for Gaia benchmark stars: completing the sample"; 0104.D-0362 ESPRESSO/VLT; P103 service mode

## Outreach talks [134]

1. Alberto Negrão; "Latitudes, literatura e viajantes"; Óbidos; May 2019)
2. Alberto Rozas-Fernandez, "La materia oscura en nuestro Universo", VIII Jornadas de Teatro Científico Divulgativo, Medellín, Badajoz, Spain, 14-17 November
3. Alexandre Cabral; Palestra pública: "Lua Século XXI: O Futuro de uma pegada com 50 anos", Centro Cultural de Belém – 16-11-2019
4. Alexandre Cabral; Palestra: "À Descoberta do UNIVERSO em busca de planetas extra solares", Centro Ciência Viva do Algarve 30-11-2019.
5. Alexandre Cabral; Palestra: "ESPRESSO, um caçador de exoplanetas no deserto de Atacama", Olimpíadas de Física (fase regional), Lisboa, 04/05/2019
6. Alexandre Cabral; Palestra: "ESPRESSO, um caçador de exoplanetas no deserto de Atacama", Escola Secundária de Abrantes, 16/05/2019

7. Alexandre Cabral; Palestra: “Grandes Telescópios, Espectrógrafos e a luz na busca de Planetas extra solares”, GDC Banco Portugal, 21-11-2019
8. Alexandre Cabral; Palestra: “Ser ou não ser Holograma” – Escola Secundária José Gomes Ferreira (Benfica), 08-03-19
9. Ana C. O. Leite; “Espectroscopia - Descodificando a luz dos astros”, Colégio Júlio Dinis, Porto, 8 October 2019
10. Ana C. O. Leite; “Telescópios - Do Galileu aos ELTs”, Escola Básica Frei João de Vila do conde, Vila do Conde, 7 October 2019
11. Ana C. O. Leite; “Telescópios - Do Galileu aos ELTs”, Escola Básica do Susão, Valongo, 8 October 2019
12. Ana C. O. Leite; “Telescópios - Do Galileu aos ELTs”, Escola Básica do Valado, Valongo, 8 October 2019
13. Ana C. O. Leite; “Telescópios - Do Galileu aos ELTs”, Escola Secundária do Castêlo da Maia, 14 October 2019
14. Ana C. O. Leite; “Telescópios- de Galileu aos ELTs”, Escola EB3/S José Fragateiro, Ovar, 16 October 2019
15. António Silva; “Radiação Cósmica de Fundo: No princípio era a Luz...”, palestra pública de divulgação do Banco de Portugal, Lisboa, 18/09/2019
16. Carlos J. A. P. Martins; “A Física da Atmosfera e do Aquecimento Global”, ES Camilo Castelo Branco, Famalicão, 4 October
17. Carlos J. A. P. Martins; “A Física da Gravidade e dos Satélites”, E.S. de Monserrate, Viana do Castelo, 7 January
18. Carlos J. A. P. Martins; “A Física da Gravidade e dos Satélites”, E.S. de Santa Maria Maior, Viana do Castelo, 10 January
19. Carlos J. A. P. Martins; “A Física da Gravidade e dos Satélites”, ES Laura Ayres, Quarteira, 15 October
20. Carlos J. A. P. Martins; “A Física da Gravidade e dos Satélites”, ES de Camões, Lisboa, 17 October
21. Carlos J. A. P. Martins; “A Física da Gravidade e dos Satélites”, ES Maria Amália Vaz de Carvalho, Lisboa, 18 October
22. Carlos J. A. P. Martins; “A Física da Gravidade e dos Satélites”, ES Pinhal do Rei, Marinha Grande, 22 October
23. Carlos J. A. P. Martins; “A Física da Gravidade e dos Satélites”, ES Marques Castilho, Águeda, 29 October
24. Carlos J. A. P. Martins; “A Física da Relatividade”, ES Poeta Al Berto, Sines, 16 October
25. Carlos J. A. P. Martins; “A Física da Vida e dos Extraterrestres”, E.S. de Ponte de Lima, 10 January
26. Carlos J. A. P. Martins; “A Física da Vida e dos Extraterrestres”, E.S. de Vilela, Paredes, 21 February
27. Carlos J. A. P. Martins; “A Física da Vida e dos Extraterrestres”, E.S. José Macedo Fragateiro, Ovar, 5 April
28. Carlos J. A. P. Martins; “A Física da Vida e dos Extraterrestres”, E.S. Laura Ayres, Quarteira, 21 May
29. Carlos J. A. P. Martins; “A Física da Vida e dos Extraterrestres”, ES de Rio Tinto, 11 October
30. Carlos J. A. P. Martins; “A Física da Vida e dos Extraterrestres”, ES da Amadora, 18 October
31. Carlos J. A. P. Martins; “A Física da Vida e dos Extraterrestres”, ES da Maia, 28 October
32. Carlos J. A. P. Martins; “A Física do Big Bang”, ES Afonso Lopes Vieira, Leiria, 22 October
33. Carlos J. A. P. Martins; “A Física do Big Bang”, ES Camilo Castelo Branco, Famalicão, 4 October
34. Carlos J. A. P. Martins; “A Física do Big Bang”, Universidade Júnior, CAUP, 10 July
35. Carlos J. A. P. Martins; “A Física do Big Bang”, Universidade Júnior, CAUP, 17 July
36. Carlos J. A. P. Martins; “Aventuras em Astronomia e Física”, E.S. de Santa Maria Maior, Viana do Castelo, 2 April
37. Carlos J. A. P. Martins; “O Lado Escuro do Universo e o CosmoESPRESSO”, E.S. Domingos Sequeira, Leiria, 13 March
38. Carlos J. A. P. Martins; “Supercomputing, Science and Art”, CEIA-PPCB, Paredes de Coura, 13 August
39. Carlos J. A. P. Martins; “The Physics of Energy and Global Warming”, CEIA-PPCB, Paredes de Coura, 5 August
40. Carlos J. A. P. Martins; “The Physics of Life and Aliens”, CEIA-PPCB, Paredes de Coura, 15 August
41. Carlos J. A. P. Martins; “The Physics of Radioactivity and Cancer”, CEIA-PPCB, Paredes de Coura, 8 August
42. Carlos J. A. P. Martins;” A Física da Atmosfera e do Aquecimento Global”, ES Quinta do Marquês, Oeiras, 17 October
43. Catarina Lobo; “A nossa galáxia e as outras: uma viagem através do Universo”, Porto (Escola Secundária Aurélia de Sousa), 20-11-2019
44. Catarina Lobo; “A Via Láctea e as outras galáxias”, Porto (Centro de Astrofísica da Universidade do Porto - Universidade Júnior), 16-7-2019
45. Catarina Lobo; “A Via Láctea e as outras galáxias”, Porto (Centro de Astrofísica da Universidade do Porto - Universidade Júnior), 9-7-2019
46. Catarina Lobo; “Dentro de um enxame... de galáxias!”, Cantanhede (Biblioteca Municipal de Cantanhede), 12-10-2019
47. Catarina Lobo; “Dentro de um enxame... de galáxias!”, Lisboa (jardins do Palácio da Presidência da República), 20-7-2019
48. Daniel F. M. Folha; “A Impressão Digital dos Astros”, Escola Secundária de Felgueiras, Felgueiras, Portugal, 13 March
49. Daniel F. M. Folha; “Astrobiologia: o contexto cósmico da vida”, Escola Secundária das Laranjeiras, Ponta Delgada, São Miguel, Açores, 6 December 2019
50. Daniel F. M. Folha; “Astrobiologia: o contexto cósmico da vida”, Observatório Astronómico de Santana

(OASA), Ribeira Grande, São Miguel, Açores, 6 December 2019

51. Daniel F. M. Folha; “Planetas para além do Sistema Solar”, Ciclo de palestras “Há Estrelas na Fábrica”, Fábrica - Centro Ciência Viva de Aveiro, Aveiro, Portugal, 15 February
52. Daniel F. M. Folha; “Summary of outreach activities and plans for the future”, J. Retrê, D. Folha (2019), IA-ON6, Porto, Portugal, 11 October 2019
53. Fernando Buitrago; “Un Universo hecho de galaxias”, University of Valladolid (Espanha), 26th April 2019
54. Francisco S. N. Lobo; “100 anos de espaço-tempo: Ondas gravitacionais – A sinfonia cósmica que abalou o Mundo”, 17 Maio, 2019 - 21h30, Observatório Astronómico de Lisboa
55. Francisco S. N. Lobo; “Buraco Negros”, Grupo Desportivo e Cultural do Banco de Portugal, 16 November 2019
56. Francisco S. N. Lobo; “Exposição E3 – Einstein, Eddington e o Eclipse”, Noites no Observatório – Buracos Negros: Novos Horizontes, 25 Maio, 2019 - 21h30, Planetário Calouste Gulbenkian - Centro Ciência Viva
57. Francisco S. N. Lobo; “O Prémio Nobel da Física 2019”, Departamento de Física FCUL, 6 November 2019
58. Francisco S. N. Lobo; “Ondas Gravitacionais”, Grupo Desportivo e Cultural do Banco de Portugal, 2 October 2019
59. Hugo Messias; “Física através do Judo”, Pavilhão do Conhecimento, 11 December 2019
60. Hugo Messias; “O papel do ALMA na imagem de M87*”, Escola Secundária da Sé, Lamego, 13 December 2019
61. Hugo Messias; “Uma tertúlia sobre o ALMA e interferometria”, Clube Lamego, 13 December 2019
62. Ilídio A. P. M. Costa; “Missão Possível”, Pedroso, April 4
63. Ilídio A. P. M. Costa; “Na ótica do Sol”, Vila do Conde, June 5
64. Ilídio A. P. M. Costa; “Na ótica do Sol”, Vila Nova de Gaia, May 16
65. Ilídio A. P. M. Costa; “Um dia muito especial”, Gondomar, April 1
66. Ismael Tereno; “100 anos de lentes gravitacionais”, Banco de Portugal, 5 Dec
67. Ismael Tereno; “100 years of gravitational lensing”, Obs Lago Alqueva, 9 Mar
68. J. Retrê; “Future Scientists Communicating Science”; Encontro Ciência 2019; Lisboa, Portugal; 10 July 2019
69. J. Retrê; “Why Communicate Science”; Network of Young Researchers in Instrumentation for Astrophysics Workshop; Lisboa, Portugal; 6 November 2019
70. J. Retrê; “Workshop: Big Ideas in Astronomy: A Proposed Definition of Astronomy Literacy”; IAU C1 astro.EDU Conference; Garching, Germany; 16 September 2019
71. J. Retrê; “Workshop: Escalas no Sistema Solar”; VI Encontro Internacional da Casa das Ciências; Lisboa, Portugal; 12 July 2019
72. J. Retrê; “Workshop: Estimativa da massa de Júpiter por observação das suas luas Galileanas”; VI Encontro Internacional da Casa das Ciências; Lisboa, Portugal; 11 July
73. J. Retrê; “Workshop: How to give a talk”; EPEC Annual Week 2019; Lisboa, Portugal; 22 May 2019
74. J. Retrê; “Workshop: Public Speaking”; Conferência Física Fora da Academia?; Lisboa, Portugal; 16 March 2019
75. Jarle Brinchmann; “As galáxias mais fracas e o seu segredo escuro - Uma história estrelar”, CCV Guimarães, 2019-09-27
76. João P. S. Faria; “CoAstro Dia no PP-CCV”, Porto, 2 February
77. João P. S. Faria; “O CoAstro vai à Escola”, Gaia, 4 June
78. João P. S. Faria; “O CoAstro vai à Escola”, Gondomar, 12 June
79. José Afonso; “A Astronomia da Próxima Geração”, Colégio Helen Keller, Lisboa, 09 October 2019
80. José Afonso; “A Astronomia da Próxima Geração”, EB1 dos Lombos, Lisboa, 07 October 2019
81. José Afonso; “A Astronomia da Próxima Geração”, Pedro Arrupe College, Lisboa, 30 April 2019
82. José Afonso; “A Astronomia da Próxima Geração”, presentation for primary and secondary school students finalists of the Ler+ Espaço project, at its awards Ceremony, Faculty of Sciences of the University of Lisbon, Lisbon, 11 May 2019
83. José Afonso; “O lado brilhante do Universo”, EB23 D. Pedro IV, Lisboa, 08 October 2019
84. José Afonso; “O lado brilhante do Universo”, ES Camarate, Lisboa, 07 October 2019
85. José Afonso; “O lado brilhante do Universo”, ES Portela, Lisboa, 09 October 2019
86. José P. Mimoso; “À Descoberta da Curvatura do Espaço”, Palestra por convite, Jornadas da Matemática, Depto. de Matemática, FCUL, 10/06/2019
87. José P. Mimoso; “Buracos Negros: Ver ou não ver”, Palestra por convite, GDCBP, Banco de Portugal, 02/05/2019
88. Marina Cortês; “Origin of the arrows of time”; Keynote lecture at Einstein Plus; Waterloo, July 2019
89. Marina Cortês; “Our asymmetric Universe”; Keynote lecture at ISSYP; Perimeter Institute, June 2019
90. Nelson J. Nunes; “Surfing a gravitational wave”, Montes Claros, Lisbon, 21 November 2019
91. Nelson J. Nunes; “The Spring’s sky”, Escola Básica 2,3 Ferreira de Castro, Mem Martins, 15 May 2019
92. Nelson J. Nunes; “The Spring’s sky”, Grémio de Instrução Liberal, Lisbon, 3 April 2019
93. Nelson J. Nunes; “The Winter’s sky”, Agrupamento de escolas de Santiago do Cacém, 14 October 2019

94. Nelson J. Nunes; “The Winter’s sky”, Externato António Sérgio, Beringel, 14 January 2019
95. Nelson J. Nunes; The Winter’s sky, Escola B+S Dr. Hernâni Cidade, Redondo, 17 October 2019
96. Nuno C. Santos; “ação sobre Espectroscopia”, Dias Abertos FCUP, 21 February 2019
97. Nuno C. Santos; “Debate: Para além de Marte”, ciclo Marte 2030, Centro Cultural de Belém, Lisboa, 12 January 2019
98. Nuno C. Santos; “Outros mundos no Universo”, Escola CAFE (“CENTROS DE APRENDIZAGEM E FORMAÇÃO ESCOLAR”) de Same, Timor Leste, 12 November 2019
99. Nuno C. Santos; “Planetas”, Escola EB da Ponte, Agrupamento de Escolas Manoel de Oliveira, 3º ano, 11 June 2019
100. Paulo Maurício de Carvalho; “Da Idade da Magia a Galileu”, Básica e Secundária de Airães, Airães, 21 de outubro de 2019
101. Paulo Maurício de Carvalho; “Da Idade da Magia a Galileu”, Colégio de Amorim, Póvoa de Varzim, 23 de outubro de 2019
102. Paulo Maurício de Carvalho; “Da Idade da Magia a Galileu”, EB 2/3 de Jovim e Foz do Sousa, Jovim, 21 de outubro de 2019
103. Paulo Maurício de Carvalho; “Da Idade da Magia a Galileu”, Jardim Escola S. João de Deus, Penafiel, 22 de outubro de 2019
104. Paulo Maurício de Carvalho; “O Universo: Escalas e Conteúdo”, Colégio de Ermesinde, Ermesinde, 30 de outubro de 2019
105. Paulo Maurício de Carvalho; “O Universo: Escalas e Conteúdo”, Escola Secundária da Maia, Maia, 28 de outubro de 2019
106. Paulo Maurício de Carvalho; “O Universo: Escalas e Conteúdo”, Escola Básica da Gafanha da Encarnação, Gafanha da Encarnação, 29 de outubro de 2019
107. Paulo Maurício de Carvalho; “Um Universo de Informação: Propriedades e Aplicações da Luz”, Escola Secundária Carolina Michaëlis, Porto, 8 de outubro de 2019
108. Paulo Maurício de Carvalho; “Um Universo de Informação: Propriedades e Aplicações da Luz”, Escola Básica 2/3 A Ribeirinha, Macieira da Maia, 9 de outubro de 2019
109. Paulo Maurício de Carvalho; “Um Universo de Informação: Propriedades e Aplicações da Luz”, Escola Básica Vallis Longus, Valongo, 9 de outubro de 2019
110. Paulo Maurício de Carvalho; “Um Universo em Expansão - Origem e Evolução”, Colégio Paulo VI, Gondomar, 16 de outubro de 2019
111. Pedro Machado; “A construção de um cientista”, Escola Secundária de Sintra, 13 March 2019
112. Pedro Machado; “Exploração Espacial Marte... a próxima fronteira?”, Escola Pedro Arrupe, Lisboa, 6 April 2019
113. Pedro Machado; “Explorar o Espaço”, Escola Grémio de Campo de Ourique, Semana da Ciência, 4 April 2019
114. Pedro Machado; “Lua Século XXI, O Futuro de uma Pegada com 50 anos”, Centro Cultural de Belém, Lisboa
115. Pedro Machado; “Lua, aqui tão perto...”, Noites do Observatório, NOAL, Planetário Gulbenkian, November 2019
116. Raquel M. G. Albuquerque; “Cientificamente Provável”, EB23 de Arrifana and EB23 Milheirós de Poiares, Santa Maria da Feira, Portugal, 3 April 2019
117. Raquel M. G. Albuquerque; “Dia Internacional das Mulheres e Raparigas na Astronomia”, Escola Secundária Braamcap Freire, Lisboa, Portugal, 11 February 2019
118. Ruben Gonçalves; “Dark Sky Party Alqueva” (invited talk) - July 2019
119. Sérgio Sousa; “À Descoberta de Planetas Extra-Solares”, Espaço vai à escola, Agrupamento D. Pedro IV, Vila do Conde, 7 Oct 2019
120. Sérgio Sousa; “À Descoberta de Planetas Extra-Solares”, Espaço vai à escola, Escola EB 2,3 Pêro Vaz de Caminha, Porto, 7 Oct 2019
121. Sérgio Sousa; “À Descoberta de Planetas Extra-Solares”, Espaço vai à escola, Escola Carolina Michaëlis, Porto, 17 Oct 2019
122. Sérgio Sousa; “À Descoberta de Planetas Extra-Solares”, Espaço vai à escola, Colégio Nova Encosta, Paços de Ferreira, 25 Nov 2019
123. Sérgio Sousa; “À Descoberta de Planetas Extra-Solares”, Espaço vai à escola, Colegio Paulo VI, Gondomar, 17 Oct 2019
124. Sérgio Sousa; “À Descoberta de Planetas Extra-Solares”, FCUP, Olimpíadas de Física, 4 May 2019
125. Sérgio Sousa; “O CoAstro vai à Escola”, 16 June 2019, Amarante
126. Sérgio Sousa; “O CoAstro vai à Escola”, 20 July, CAUP, Porto
127. Sòlene Ulmer-Moll; “Exoplanetas e Sistema Solar”, Afurada, Vila Nova de Gaia, Portugal, 3 June 2019
128. Susana Barros; “Launch of CHEOPS”, Webinar, 17th December 2019
129. Susana Barros; A minha carreira cientifica - Women and Girls in Astronomy Day - IAU 100, Planetario Porto, 10th February 2019
130. Tiago Barreiro; “O lado escuro da força”, Observatório do Lago Alqueva, 11 May 2019
131. Tiago Barreiro; “O lado escuro do eclipse”, Observatório Astronómico de Lisboa, 7 June 2019
132. Susana Barros; Launch of CHEOPS, Press conference Planetario Porto 16th December 2019
133. Tiago J. L. C. E. Campante; “Planetas ao som das estrelas”; Programa Cientificamente Provável, Escola

Básica de Valadares, Vila Nova de Gaia, Portugal, Apr 5 2019

134. Tiago J. L. C. E. Campante; "Relógio de Sol ou de "sombra"?"; Encontro com o Cientista/Escola Ciência Viva, Centro Ciência Viva de Lagos, Lagos, Portugal, Nov 29 2019

## Reports [4]

1. M. Abreu, A. Cabral, D. Alves, ARIEL-IAL-PL-DD-004 Issue 1, 08-Feb-2019, ARIEL OGSE NIR/Visible Source Design Description (33pp)
2. M. Abreu, A. Cabral, D. Alves, PLATO-UOL-PL-RP-0004, Issue 1, Collimator User Manual, October 2019 (23 pp)
3. M. Abreu, A. Cabral, D. Alves, J. Coelho, PLATO-UOL-PL-RP-0002, Issue 3, Collimator Design Report, October 2019 (43 pp)
4. M. Abreu, A. Cabral, D. Alves, PLATO-UOL-PL-RP-0003, Issue 1, RT Collimator Test Specification, October 2019 (17pp)

## External seminars by IA researchers [29]

1. Alexandre Cabral; "MOONS: the next ESO VLT's multi-object spectrograph", Departamento de Física, Faculdade de Ciências da Universidade de Lisboa – 25-09-2019
2. Alexandre Cabral; "The Nobel Prize in Physics 2019: New perspectives on our place in the", Departamento de Física, Faculdade de Ciências da Universidade de Lisboa – 06-11-2019
3. Bruno J. C. B. Barros; "Interactions in the Dark Sector"; Faculdade de Ciências da Universidade de Lisboa, Portugal; 6 December 2019
4. Carlos J. A. P Martins; "CosmoESPRESSO: From Precision Spectroscopy to Fundamental Physics", DFA (U.Porto), 16 May 2019
5. Tom C. Scott; "Evolution of late-type galaxies in galaxy clusters: Cold gas", Edmonton Alberta Canada, 5 March 2019
6. Margarida S. Cunha; "Some notes on buoyancy glitches", University of Birmingham, UK, 25 November 2019
7. Vardan Adibekyan; "Heavy Metal Rules: Exoplanet incidence and metallicity"; University of Bern, Switzerland, 26-29 Nov, 2019
8. Lara G. Sousa; "Probing cosmic superstrings with gravitational waves", University of the Basque Country, Bilbao, Spain, 10 April 2019
9. Tiago J. L. C. E. Campante; "Synergy between asteroseismology and exoplanet science: an outlook"; SAC, Aarhus University, Aarhus, Denmark, May 1 2019
10. Nuno C. Santos; "Top level requirements for astronomical instrumentation: the astronomer's perspective", SPIE Student Chapter, Department of Physics and Astronomy, December 3rd, 2019, Univ. Porto, Portugal
11. Nuno C. Santos; "A Nobel for the discobery of other Worlds", Departamento de Física e Astronomia, Porto, 21 November 2019
12. Nuno C. Santos; "First results from ESPRESSO", IA-ON6 meeting, IA, Porto, 10-11 October 2019
13. António Silva; "Numerical modelling of the large-scale Universe: Euclid baseline model and alternative scenarios", Departamento de Física da Faculdade de Ciências da Universidade de Lisboa (DF-FCUL), 22/05/2019
14. Jorge H. C. Martins; Detecting reflected light from exoplanets with high-resolution spectroscopy; Café com Física, FCTUC, Coimbra, Portugal; 2019-04-24
15. Jarle Brinchmann; "Tracing the dark with light - constraining dark matter in ultra-faint galaxies with MUSE", Institute for theoretical astrophysics, University of Oslo, Norwau, 2019-10-04
16. Doris Arzoumanian; "Understanding the observed properties of interstellar filaments: Insights on the initial conditions of star formation", DRAO, Penticton, Canada, November 10
17. Doris Arzoumanian; "Understanding the observed properties of interstellar filaments: Insights on the initial conditions of star formation", DAO, Victoria, Canada, November 21
18. G. Fanizza; "Next-to-leading order lensing corrections to the CMB spectra"; Dipartimento di Fisica, Università di Padova; Italy, 2019
19. José Silva; Characterising Atmospheric Gravity Waves; ISAS/JAXA, Sagamihara Campus, Japan; 5th of February of 2020
20. João P. S. Faria; "A search for low-mass planets around metal-poor stars"; Birmingham, UK; 14 March
21. Patricio Lagos; "IFU studies of low-metallicity star-forming dwarf galaxies"; Nort-West University, Potchefstroom, South Africa; 2nd May 2019
22. Nelson J. Nunes; "Dark Couplings", Universidad Complutense Madrid, Madrid, Spain, 16 December 2019
23. Marina Cortês; "Energetic Causal Sets in the origin of the arrows of time"; Waterloo; March 2019
24. Marina Cortês; "Towards the Inclusion of Biology in Cosmology – II"; Cosmology Seminar; January 2020
25. Francisco S. N. Lobo; "Extensions of f(R) Gravity: Curvature-Matter Couplings and Hybrid Metric-Palatini Theory", Kazan Federal University, Russia, 3 December 2019
26. Francisco S. N. Lobo; "From the Flamm-Einstein-Rosen bridge to the modern renaissance of traversable wormholes", Victoria University of Wellington, Wellington, New Zealand, 17 December 2019
27. Cirino Pappalardo; "Growing radio-interferometry expertise in Portugal: the PACE", Multi-messenger astronomy with SKA - Aveiro (Portugal), http://mmska2019.av.it.pt/, May 2019

28. Pedro Machado; “Out of this world atmospheres”, Ciências - dia da Investigação, 30 November 2019, FCUL
29. Pedro Machado; “Space Exploration - Universidade de Coimbra”, 13 September 2019

## PhD Completed [5]

1. A. Paulino-Afonso, 2019, Star-Forming Galaxies Structural Evolution Across Cosmic Time and Environment, Doutoramento em Astronomia e Astrofísica (ULisboa), Supervisor(s): David Sobral, **José Afonso**
2. P. A. Quitral-Manosalva, 2019, On using stellar pulsations to constrain atmospheric models of strongly magnetic stars, Doctoral Program in Astronomy (3rd cycle) (UPorto), Supervisor(s): **M. S. Cunha**
3. J. J. Neal, 2019, Towards exoplanetary atmospheres: new data reduction methods for the nIR, Doctoral Program in Astronomy (3rd cycle) (UPorto), Supervisor(s): **N. C. Santos**, **P. Figueira**, C. Melo (ESO)
4. M. S. Silva, 2019, Probing Galaxy Evolution and Feedback using Giant Gaseous Structures associated with High Redshift Active Galaxies, Doctoral Program in Astronomy (3rd cycle) (UPorto), Supervisor(s): **A. Humphrey**, **P. Lagos**
5. I. P. Breda, 2019, The nature and formation history of pseudo-bulges in Galaxies, Doctoral Program in Astronomy (3rd cycle) (UPorto), Supervisor(s): **P. Papaderos**, **J. M. Gomes**

## MSc Projects Completed [12]

1. Miguel Clara, “Ensemble Asteroseismology of Solar-Type Stars with the NASA-TESS Mission”, November 2019
2. Nuno Moedas, “Asteroseismic grid modeling of red-giant stars with the NASA TESS mission”, December 2019
3. Tomas Azevedo Silva, “M dwarf stars with planets: towards the characterization of the smaller planet host stars”, November 2019
4. Eduardo Cristo, “Detecting the atmosphere of exoplanets using high resolution spectroscopy”, November 2019
5. André Silva, “Uma extensão para o pipeline de Dados da missão CHEOPS (ESA)”, September 2019
6. Ana Sofia Chagas Carvalho, “Exploration of unsupervised machine learning methods to study galaxy clustering”, FCUL, December 2019
7. Inês Albuquerque, “Cubic Galileon theory in the Effective Field Theory formalism: a cosmological study”, December 2019
8. Carolina Figueira, “A integração da cultura na comunicação de astronomia: planeamento de um festival de astronomia”, Science Communication MSc. Curricular internship, January 2019
9. Jessica de Lima Trasfi, “Desenvolvimento de uma atividade de astronomia para alunos do secundário”, February 2019
10. Daniela Espadinha, “Akatsuki data for atmospheric dynamvial studies”, December 2019
11. José Ribeiro, “Titan atmosphere’s chemical characterization”, November 2019
12. Hermano Valido, “Mars Global Dust Storm studies”, November 2019

## BSc Traineeships/Projects completed [34]

(under the supervision of IA researchers)

1. Catarina Marques; “Cosmological impact of watching the expansion of the universe in real time”, FCT-UNL, PIIC internship, 21 January – 22 February 2019
2. Léo Vacher; “Astrophysical and Local Tests of the Einstein Equivalence Principle”, U. Grenoble-Alpes, M1 Internship, 27 May/26 July 2019
3. Beatriz Pereira; “Testing dark energy models at high and low Redshift”, IA BIC internship, 20 May/19 August 2019
4. Bernardo Dias; “Computational simulation and visualization of superstrings with GPUs and CUDA”, PEEC 2018-19, November 2018/30 September 2019
5. Vasco Tavares; “Astrophysical tests of rolling tachyons”, PEEC 2018-19, November 2018/30 September 2019
6. Tiago Teixeira; “Testing dark energy models at low and high redshifts”, PEEC 2018-19, November 2018/30 September 2019
7. Adrià Barbecho; “The Dark Side of the Universe”, High school internship, 8-26 July 2019
8. Carlos Serrano; “The Dark Side of the Universe”, High school internship, 8-26 July 2019
9. Margarida Pereira; “Coding the Cosmos”, High school internship, 8-26 July 2019
10. Mariana Encarnação; “Coding the Cosmos”, High school internship, 8-26 July 2019
11. Mariana P. Júlio, “Explorando os dados científicos provenientes do satélite TESS da NASA”, PEEC, 1 February/31 July 2019
12. Bárbara M. T. B. Soares, “Explorando os dados científicos provenientes do satélite TESS da NASA”, PEEC/BIC, 1 February/31 July 2019
13. Veridiano Marques, “SOAP United”, BIC, 20 May/19 August 2019
14. Maria Carolina Barbosa, “Search for transiting planets in K2 light curves”, BIC, 20 May/19 August 2019
15. Alexandre Faria dos Santos, IA BIC grant Ref.: IA2019-03-BIC, 15 May/14 September 2019
16. Daniel Filipe Baptista Gonçalves, IA BIC grant contract Ref.: IA2019-03-BIC, 15 May/14 September 2019

17. Fábio Carmo, “Study of Voids in the Universe”, Departamento de Física, Faculdade de Ciências da Universidade de Lisboa, Begin date: 1 October 2019, End date: 12th February 2020
18. Luís Atayde, “Voids and Clusters: Detection Algorithms and their Cosmological Application”, Departamento de Física, Faculdade de Ciências da Universidade de Lisboa, 1 October 2018/15 February 2019
19. Mariana Júlio, “The dark matter content of ultra-faint dwarfs”, BSc research project; 28 February/4 July 2019
20. Luis Atayde, “Phenomenology of the generalized cubic covariant Galileon model and cosmological bounds, 2019
21. Beatriz Pinto, “An online catalogue of exoplanet data”, BIC, 20 May/19 August 2019
22. Filipe Correia, “Characterization of Blazar candidates”, Laboratório de Astrofísica, October/February 2020
23. Amandine Dolinsky, “Unveiling nebular emission in LEGA-C galaxies”, Internship, June
24. Beatriz Silva, “ALMA serendipitous detection”, IA-BIC, May 2019
25. Marta Madeira, educational short film animations in Astronomy Literacy, B.Sc. curricular internship, July 2018/February 2019
26. Tiago Ramos, educational short film animations in Astronomy Literacy, B.Sc. curricular internship, July 2018/February 2019
27. Fernanda Sousa, educational short film animations in Astronomy Literacy, B.Sc. curricular internship, July 2018/February 2019
28. Jessica Trasfi, Desenvolvimento de uma atividade de astronomia para alunos do ensino secundário, Science Communication MSc. curricular internship, 20 November 2018/20 February 2019
29. Diogo Quirino, Estrutura Térmica e Dinâmica da alta mesosfera e baixa termosfera de Vénus - Projeto MOG (Meteorologia, Oceanografia e Geofísica), Sept. 2018/26 July 2019
30. João Dias, “Estudo da composição química das atmosferas planetárias com base em espectros de alta resolução”, September 2019
31. Constança Freire, “Titan atmosphere’s high-resolution spectroscopy studies”, 2019
32. Sara Nóbrega, “Cloud tracking upon atmospheric storms on Jupiter and Cassini”, 2019
33. Cláudia Bento, “How to study the Mars’ dust storms” (IDL/FCUL), 2019
34. Ana Rita da Silva, “Determination of sulphur abundances in the HARPS GTO planet search sample”, ERASMUS+ internship, 17 September 2018/15 July 2019

COVER PICTURE *Intracluster Light in Abell S1063*, © NASA, ESA, and M. Montes (Univ. of New South Wales, Australia)

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