



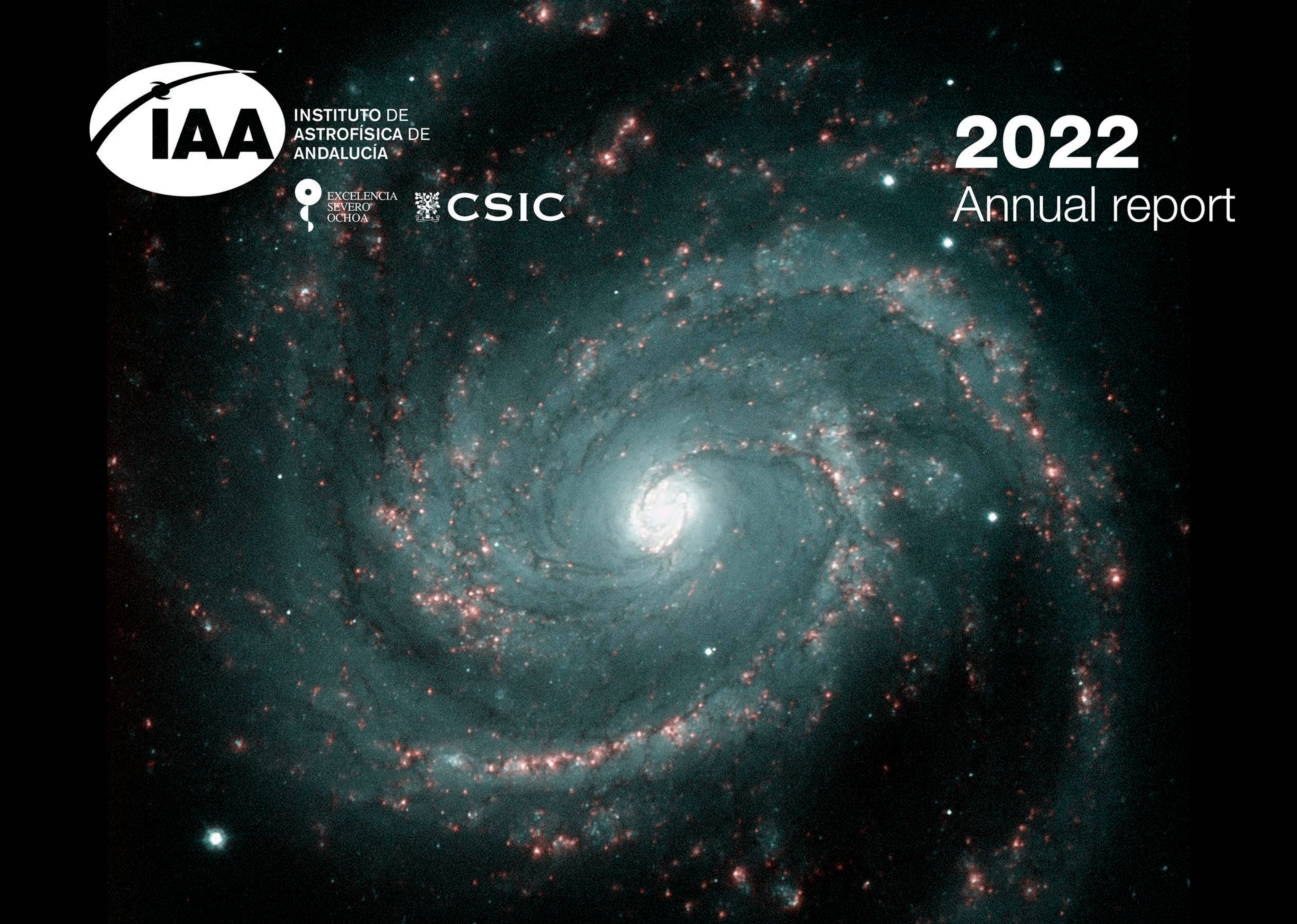
INSTITUTO DE
ASTROFÍSICA DE
ANDALUCÍA



CSIC

2022

Annual report





The **IAA-CSIC 2022 Annual Report** is the result of a collective process of the people who make up the Instituto de Astrofísica de Andalucía. We would like to thank all of them for their dedication and willingness to capture the best possible picture of what we do and what we work for.

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Index

5	Foreword	30	Calar Alto Observatory
8	IAA Organizational Chart	34	Sierra Nevada Observatory
10	IAA overview	36	The ESFRI initiatives
12	The IAA Severo Ochoa Programme	38	Public Outreach
14	Research groups	40	Sky Quality Office
15	Solar Physics	42	Workshops & meetings
16	Planets & minor bodies	44	Gender actions
17	Terrestrial and planetary atmospheres	47	Publications
18	Low-mass stars & exoplanets	48	Awards
19	Stellar variability	50	Funding
20	ARAE		Annexes
21	Stellar systems	52	Committees
22	Physics of the Interstellar medium	53	Staff
24	AGN Jets	56	Ongoing projects
25	Theoretical Gravitation & Cosmology	61	Education & teaching
26	Galaxy Evolution	66	Press releases
28	UDIT	71	List of publications
		96	Visiting scientists

Foreword

Antxon Alberdi
Director IAA-CSIC

Isabel Márquez
Scientific Director SO-IAA Project

In November 2022 the **IAA obtained its second Severo Ochoa Award**, which was excellent news and a great recognition for our center. Let us mention some words from the international evaluation committee:

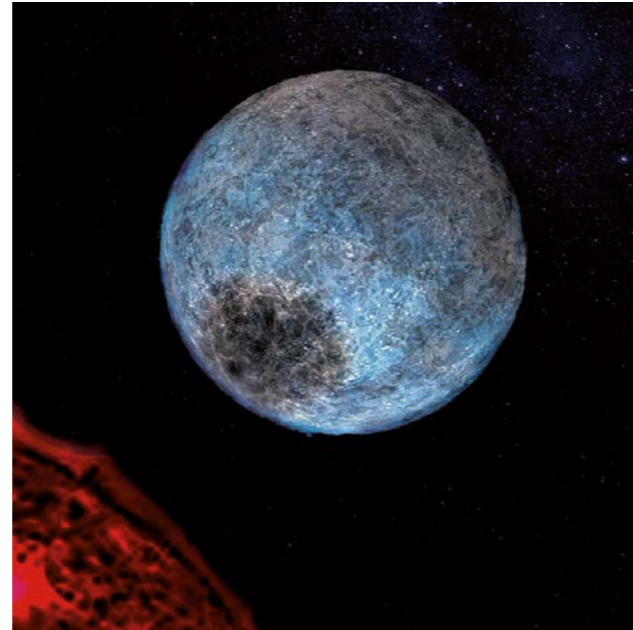
“The IAA is a strong research institute that covers all fields of astronomy, from the solar system to cosmology. Its scientific output is excellent and has been improving. IAA has used the SO project in the period 2017-2021 to expand and consolidate its excellency and international competitiveness. The strategic plan for 2022-2025 is focused and benefits from the experience and developments gained from the previous period. It is well suited to take the institute further, consolidating its profile and correcting some of the weaknesses that persist. The various activities are well-planned and carefully designed to exploit current expertise to ensure future success. Gender issues are forefront, training for younger staff is emphasized in the context of high impact research.”

There are two main messages in these words: (i) the **SO 2017-2022 has meant an enormous leap forward in the scientific-technical life of the center** in many aspects, attracting international talent, increasing the center’s scientific production, strengthening our participation in instrumental projects associated with space missions and ground-based international infrastructures, generating a competitive training program, and consolidating its international excellence; (ii) the new **Strategic Plan for 2023-2026 is considered to be well focused** in order to take the institute further in its excellency. These are very motivating messages that will help us to continue improving day by day.

During 2022, the number of publications of high impact have increased significantly, with almost 400 publications in refereed journals, more than 90% of which in Q1 journals (11% in D1). This implies that the IAA is already producing more than a paper per day!. Let us highlight some of the strongest impact results: the **first image of the Black Hole at the center of our Galaxy**, SgrA*, obtained with the Event Horizon Telescope (EHT). It is dominated by a dark central region (the “shadow”), surrounded by a bright, thick ring, consistent with the expected appearance of a Kerr black hole with a mass 4 million times the mass of the Sun. A comparison with the EHT results for the supermassive black hole M87*



Pulsars could hide one of the keys to understanding how cosmic rays travel
Credit: hubblesite.org



Artistic conception of a water world. Credit: Pilar Montañés

shows consistency with the predictions of general relativity spanning more than three orders of magnitude in central mass. Many new results have been obtained on the **nature of planetary systems and their atmospheres**. It is remarkable that, analyzing all the planets detected in M dwarf stars, it has been found that they may harbor large amounts of water, with compositions of up to 50% rock and 50% water (by comparison, Earth is composed of only 0.02% water). But that water is possibly found beneath the crust, rather than flowing across the surface in the form of oceans or rivers. We had the opportunity to directly observe the injection of relativistic particles into the interstellar medium thanks to the **discovery of gamma-ray halos around pulsars**, characterizing their local and global implications for particle transport within the Galaxy. Many exciting results have also come from the X-Ray satellite IXPE, sensitive for the first time to polarization. IXPE proved unambiguously that **a shock front is the actual mechanism of particle acceleration in blazar jet flows** and is starting to uncover the geometry of the hot X-ray corona in Seyfert galaxies. We took an important part in the miniJPAS survey, a ~ 1 deg² survey of the AEGIS field performed with the JPAS pathfinder camera, a preview of the scientific potential of JPAS. Many other fields of research provided amazing results, that can be followed in this report: variability in planetary nebulae, the detection of the most distant star ever seen, the birth of a planet in a binary stellar system, the

prolific stellar factory at the Galactic Center, outflows in LINERs, Tidal Disruption Events, among others.

The Instrumental and Technological Development Unit (UDIT) develops state-of-the-art instruments for space-borne astrophysical payload instrumentation and ground-based telescopes. The **Sunrise III mission** was launched on July 10th with the instruments Tumag and SCIP onboard. However, due to an unfortunate gondola problem at the very moment of launch, the mission was forced to abort. The scientific payload landed safely on Sweden and was recovered. For the **JUICE mission**, technical support was given to the instruments JANUS and GALA teams for payload activities at spacecraft level. JUICE was ready for launching in April 2023. On January, **ESA's PLATO mission** received the green light to continue its development after successfully passing the review of critical milestones. UDIT also contributed to the instrumentation for the future missions **Comet Interceptor**, **EnVision** and **Vigil**. UDIT started technical activities for the mission **HAYDN** (High-precision Asteroseismology of DeNse stellar fields), a candidate for ESA M7 mission, pre-selected for phase 0. With regard to ground-based instrumentation, UDIT contributed to new instrumentation for the OSN, the ICTS CAHA and the ESFRI initiatives for astronomy. The MAAT IFU for the instrument OSIRIS at the GTC passed the preliminary design review on April 2022.



JWST images of the Southern Ring Nebula, showing the very hot gas surrounding the two central stars (left), and tracing the star's scattered molecular outflows (right). Credits: NASA, ESA, CSA, O. De Marco (Macquarie University), J. DePasquale (STScI)

Regarding CAHA, the **TARSIS construction started**. **TARSIS (Tetra-ARmed Super-Ifu Spectrograph)** is the next generation instrument for the CAHA 3.5 m telescope. UCM and IAA-CSIC jointly lead TARSIS. The combination of a wide field of view (8x8) and a high sensitivity from ultraviolet (in the range known as UV-A) to red optical wavelengths will make TARSIS a unique instrument. The design of TARSIS and the transparency of the Calar Alto sky will allow observing in the full UV-A range, a domain almost unexplored from Earth. The main scientific driver of TARSIS is the study of galaxy clusters, the largest building blocks of the universe on a large scale.

The IAA continued with its participation in **ESFRI** infrastructures for astronomy. As coordinator of **SKA-Spain**, IAA contributed to the negotiation (already finalized) of Spain's adhesion to the SKAO and the approval by the Spanish Ministerio de Hacienda of the financial contribution to the SKAO until 2030. Likewise, the **Spanish prototype SRC of the IAA-CSIC** contributed to defining the requirements of the SKA Regional Center (SRC) network, leading one of the 7 international prototyping teams. SKA is already in the construction phase. Throughout 2022, the preliminary design of the **European Solar Telescope (EST)**, including the basic construction project, was completed. The IAA presented a conceptual design for the three Tunable Imaging Spectropolarimeters (TIS) for the EST. On the other hand, **CTA's first telescope, LST1**, continued to operate normally and its

first scientific publications with the contribution of IAA researchers are in progress. For **ELT**, the participation of the IAA in the technological development of **MOSAIC** included the control system of the cryogenic mechanisms associated with the infrared spectrograph (NIR-SPEC). **For ANDES, UDIT was involved in the mechanical design of the optics supports for its spectrographs.**

Throughout the year we promoted different activities to encourage scientific discussion at the center, which we accompanied with different social activities that promoted interrelationships among the institute's staff. These were carried out on the occasion of the annual internal conference of the Severo Ochoa program, advanced dissemination events related to the institute's projects or the IAA end-of-year conference. Continuing with our goal to tribute to our colleagues reaching retirement age, in December 2022 we paid tribute to our colleagues Antonio López Jiménez, Justo Sánchez del Río, and José Alberto Mirasol. It was a great opportunity to thank them for all their work for the institute and to remind them that our doors will always be open!

We hope you will enjoy reading this report!

IAA Organizational Chart



Picture group at the "IAA Day 2022", celebrated on December 17th

From left to right, Justo Sánchez, José Alberto Mirasol and Antonio López receive the IAA tribute for their retirement

IAA overview

The **Instituto de Astrofísica de Andalucía** (IAA) is the largest Astronomy institute of the **Consejo Superior de Investigaciones Científicas** (CSIC)

The IAA research is supported by twelve active CSIC research groups, covering most of the research topics in modern Astrophysics. This research is carried out within four different departments.

Research Groups

Solar System

- Solar Physics
- Planets and minor bodies
- Terrestrial Atmosphere

Stellar Physics

- Lowmass Stars
- Stellar Variability
- ARAE

Radio Astronomy and Galactic Structure

- Stellar Systems
- Physics of the Interstellar Medium
- AGN jets

Extragalactic Astronomy

- Galaxy evolution
- Theoretical gravitation
- Observational Cosmology
- Cosmology and Astroparticle Physics

The **Instrumental and Technological Development Unit** (UDIT) and the **Computer Center** (CC) provide technical support to the research lines.

The IAA owns the **Sierra Nevada Observatory** (OSN) and is also the CSIC reference research center for the **Calar Alto Observatory** (CAHA).

Staff

253

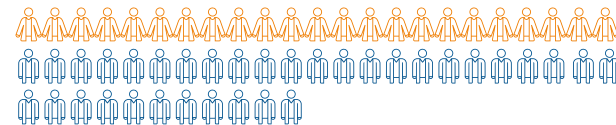
Total member

Category and gender distribution

54 Permanent Staff (12 Female / 42 Male)



57 Postdoc Fellows (23 Female / 34 Male)



48 Predoctoral Researches (14 Female / 34 Male)



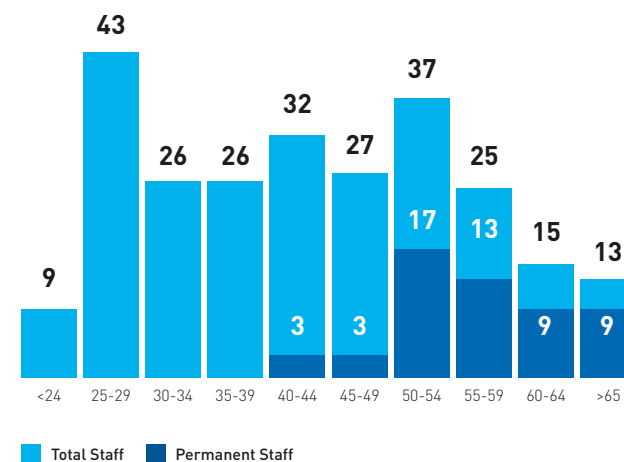
62 Technicians/Engineers (14 Female / 48 Male)



32 Services (17 Female / 15 Male)



Age distribution



Detailed Cientifical and Technical Staff

17 / 4 Scientific researcher / **23 / 5** Senior rscientist / **9 / 1** Research professor / **5 / 2** Permanent doctor contract

52 / 21 Postdoc contract / **4 / 1** Ramón y Cajal / **1 / 1** MSC postdoc

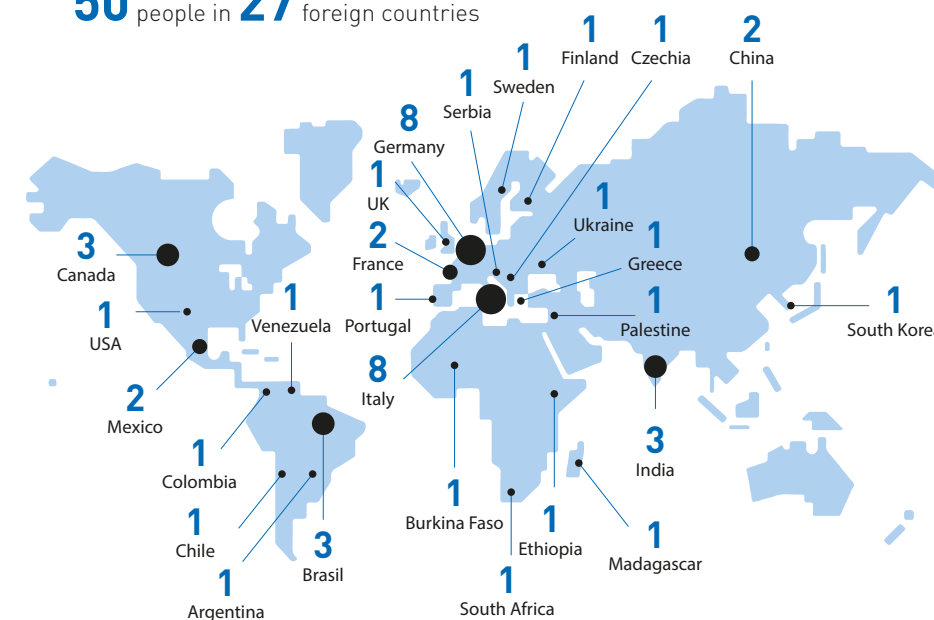
30 / 8 FPI/FPU / **6 / 2** PhD contract / **12 / 4** JAE-Intro

21 / 4 Electronics / **22 / 6** Software / **8** OSN

5 / 2 Mechanics / **5 / 2** Optics

International Staff

50 people in **27** foreign countries



2022 results

398
SCI publications

57
seminars at the IAA

41
press releases

15
meetings and schools

20
theses (PhD, Master, Degree)

35
courses

8
awards

14.8 M€
total budget

The IAA Severo Ochoa Programme



Isabel Márquez
Scientific Director SO-IAA Project



The year 2022 corresponded to the last 12 months of the 1st Severo Ochoa IAA award, that was extended from June to December. Among the relevant results we led in 2022 on the understanding of planetary systems, we provided the **best physical characterisation of the Trans-Neptunian Object Huya** up to date, we showed evidence for the existence of **abundant extrasolar planets composed of ice and rock around dwarf stars**, we found that **planets detected in M dwarf stars may harbor large amounts of water**, we detected **two telluric planets orbiting the nearby star HD 260655**, and observed the primordial material that may be giving birth to **three planetary systems around the binary star SVS 13**, still in its embryonic phase. In the study of star formation in the Milky Way and the Local Universe, we analysed the **variability of the planetary nebula IC4997**, contributed to understanding how cosmic rays travel studying **the role of gamma-ray halos around pulsars**, and revealed the **history of star formation in the center of our galaxy**; we had an outstanding participation in the **obtention of the image of Sagittarius A* with the EHT**, that confirmed the existence of the supermassive black hole in the center of the Milky Way. From the theoretical side, we showed that some of the objects classified as black holes could actually be **ultra-compact stars**. We also led a number of results on galaxy evolution and cosmology, with special focus on active galaxies: we could trace the **central regions of the galaxy OJ287** by combining observations of space and ground-based radio telescopes, and studied in depth a sample of **LINERs**, the least luminous type of active galaxy, showing that half of them produce **ionized gas outflows**.

All our research produced almost 400 publications in refereed journals of the first quartile (Q1), more than one third led or co-led by IAA scientists. They provide a fair representation on the numerous projects we are involved in, among which we could highlight CALIFA, CARMENES, TESS, EHT, J-PLUS, miniJPAS, GALACTICNUCLEUS, GAIA, SOLAR ORBITER, Mars Express, ExoMars, IPHAS, MEGARA, LeMMINGs, SKA pathfinders and precursors...

Concerning our **Spanish prototype of SKA Regional Center (SPSRC)**, it provided computing services for more than 20 research projects in 2022, including those with SKA precursors and pathfinders (MeerKAT, GMRT, e-MERLIN, LOFAR, JVLA, EVN, WSRT/Apertif) but also beyond SKA (differential photometry studies, solar coronal properties with SOHO and Solar

Orbiter, or exospace weather simulations, among others). The SPSRC team also provided user support and organised various training activities. The **IAA-led team** participated in the **2nd SKA Data Challenge** with the support of the SPSRC to several teams; the IAA team reached the 5th position (among 40), and was the only one to receive the **Golden Reproducibility Award** for offering a solution that contained several examples of best practice in Open Science. The SPSRC team also organised a discussion forum on **Artificial Intelligence** and participated in the CSIC Hub on this topic.

We continued our **Colloquia and Web-loquia program (colloquia in virtual format)**, with around 30 high standard talks, that were followed by numerous researchers also from another institutions in Spain and abroad. Our **visiting program** recovered almost pre-pandemic levels, with about ten researchers visiting the IAA-CSIC through the SO-IAA visiting program. Among the SO-IAA **training activities**, I highlight the **Scientific Advanced School** on "Galaxy Evolution", and the remaining modules of our **"SO Advanced School for Instrumentation"**. Overall, almost 30 teachers and 200 students participated in all the Severo Ochoa IAA training activities during 2022. We also strengthened our actions to recruit master students through the **JAE-intro SOMM program**, thanks to which we could host 12 master students who started/finished their projects in the corresponding SO-IAA research fields.

We celebrated our annual **SO-IAA Conference** in July 2022. In October we had the largest SO event, the **IAA Severo Ochoa International Meeting: "Addressing key astrophysical questions from Granada"**; we gathered our web-loquium speakers and other internationally renowned researchers, with the aim of promoting discussions and in-depth interactions between the invited researchers and the IAA scientific staff, on outstanding and open questions that can be tackled in the coming years.

Among our **Gender programme** activities, we organised the course **"Sex and gender analysis in research and innovation"**, the exhibit of **"AstronomAs"** at the City Hall and the Park of the Sciences in Granada, a round-table meeting with secondary schools (11F), the theater show **"Entre sillas"** (8M), and the contribution **"Astronomy, a matter of women"** in the Summer School at the University of Almería. Concerning **outreach**, we highlight the co-organisation of a major event together with CTAO, **"The Universe we will see"**, a round table with the heads of three of the largest astronomical infrastructures on Earth: the Cherenkov Telescope Array Observatory (**CTAO**), the Extremely

Large Telescope (**ELT**) and the Square Kilometre Array Observatory (**SKAO**). The nature of these facilities, which will open new windows on the cosmos in gamma-ray, optical and near-infrared, and radio astronomy, involves major international collaboration and faces unprecedented technological challenges. The session dealt with the current status of CTAO, SKAO and ELT, the novelties they will bring to the scientific community and their technological, energetic and social challenges. The exhibit **"Perspectivas"** was installed at the IAA premises. The SO-IAA personnel recruited in the previous year could introduce themselves in the issue 66 of our IAA (Información y Actualidad Astronómica) outreach journal.

Among our activities within the Severo Ochoa and Maria de Maetzu Alliance (SOMMa), we co-organised and hosted at the IAA-CSIC the **"Second Meeting of Project Managers of SOMMa"**. We actively participated in the meeting **100xCiencia.6 "Science for the future: Building a more just and sustainable horizon"**, organised by the BSC, celebrated in Barcelona in November. In the subsequent SOMMa General Assembly I. Márquez was proposed as 2nd Vice-President of the Alliance. The very same day, we knew that our new proposal for the **Severo Ochoa Excellence award, 2023-2026**, had been selected. Our new Strategic Plan for 2023-2026 prioritizes scientific and technological activities in three strategic lines: a) Planetary systems, atmospheres, and star-planet interactions; b) Accretion, star formation and environment as drivers of galaxy evolution; c) State-of-the-art instrumentation and facilities. We strengthen our international leadership by supporting these three strategic lines via recruitment of talented staff, by fostering synergies and interactions between the groups at the IAA and with external groups at other leading research institutes, and by complementing funds for instrumental and technological development. Cross-fertilization activities within the three strategic lines are instrumental. We consolidate and expand the SO-IAA training and gender programs, our engagement with Open Science and FAIR principles, and consolidate our SO-IAA Technical Office.

The end of 2022 was also the **end of our first Severo Ochoa Accreditation**. A great achievement that was possible thanks to the effort, commitment, enthusiasm and teamwork of the scientific, technological and administrative staff of the IAA.

A four and a half year journey in which we fulfilled our ultimate goal: **to end with a new beginning!**

Research groups



CSIC considers the research groups as specific fundamental units which contribute to achieving the scientific objectives of the institution.

During 2022, the IAA had 12 active research groups, which belong to the global area of "Materia". At the IAA we cover all major fields of astrophysics and space science. Our research is based on the three pillars of modern astrophysics: observation, instrumental development, and theoretical and numerical studies, all of which are firmly established and interconnected. The IAA groups study:

- **The Sun**, via spectropolarimetry, and their magnetic fields from an observational, theoretical and instrumental point of view: "Solar Physics Group".
- **The Earth's atmosphere** and planet atmospheres, including exo-atmospheric studies: "Group of Terrestrial Planet Atmospheres".
- **Planets** and the formation and evolution of minor bodies in the Solar System: "Planets and Minor Bodies Group".
- **The physics of planetary systems** and their low-mass stars: "Physics of low-mass stars, exoplanets and associated instrumentation Group".
- **The variability of stars** and asteroseismology: "Stellar Variability Group".
- **Stellar clusters**, massive stars and the Galactic Center: "Stellar Systems Group".

- **The formation, evolution and death of stars** at different mass and spatial scales and the interstellar medium: "Physics of the Interstellar Medium Group".
- **The structure and evolution of galaxies**, from the inner stellar and diffuse components to their large-scale cosmic distribution and evolution: "Galaxy Evolution Group".
- **Supermassive Black Holes** and their immediate environments, including their associated relativistic jets: "Relativistic Jets and Blazars Group".
- The combination between **General Relativity and Quantum Mechanics** in astrophysical scenarios: "Theoretical Gravitation and Cosmology Group".
- The analysis of **large-scale galaxy clustering mechanisms** and the production of accurate cosmological simulations and galaxy mock catalogs: "Cosmology and Astroparticle Physics Group".
- Multirange observations of **high-energy phenomena** and theoretical stellar evolutionary models: "High Energy Astrophysics and Robotic Astronomy Group (ARAE)".

The following pages present a summary of the results obtained in 2022 by the different research groups. The publications corresponding to the highlights of the research groups are identified in brackets, with the corresponding number in the publication list (from page 71 on).

SOLAR SYSTEM

Solar Physics

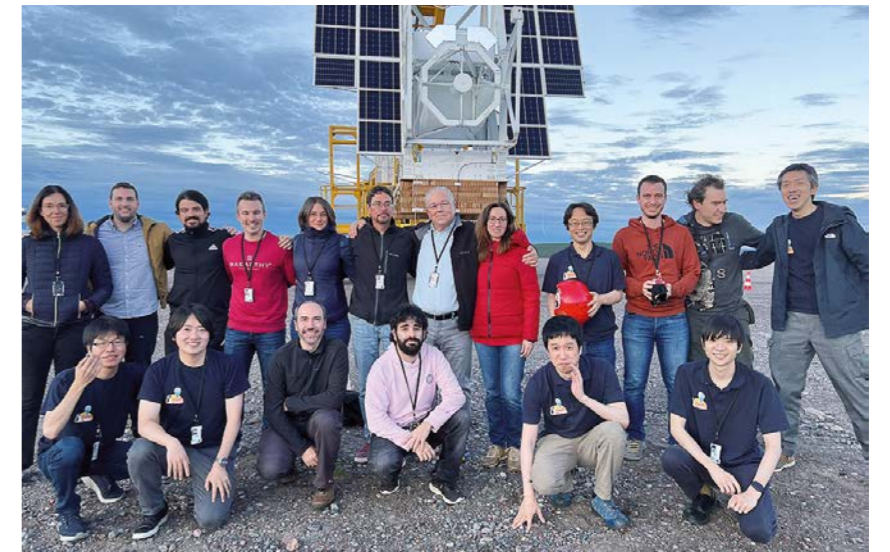
Overview

The IAA's Solar Physics Group (SPG) focuses on solar spectropolarimetry from all the three points of view: theoretical, observational, and instrumental. Investigations and developments are carried out on:

- The radiative transfer equation (RTE) for polarized light in the presence of magnetic fields
- The inversion of the RTE for its use on the interpretation of spectropolarimetric measurements
- The structure and physical nature of all kind of photospheric magnetic structures
- The design, development, and construction of solar instrumentation

Research lines:

- Quiet-Sun and active regions magnetism
- Magnetic coupling of the solar atmosphere
- Diagnostic techniques in spectropolarimetry
- Solar cycle
- Solar instrumentation



Group photo at the ESRANGE Swedish Space Center in Kiruna prior to the SUNRISE III mission launch. SPG members are accompanied by some international colleagues.

Highlights

Science

The magnetic drivers of campfires seen by the Polarimetric and Helioseismic Imager (PHI) on Solar Orbiter [176]. This is the first paper on scientific results with Solar Orbiter, where our group co-leads the PHI instrument.

CASPER: A mission to study the time-dependent evolution of the magnetic solar chromosphere and transition regions [271]. Scientific rationale for a new space mission.

Three advanced proposals on the phase diversity technique [25, 26, 27]

Official creation of the Spanish Space Solar Physics Consortium (led by SPG and including INTA, IDR-UPM, UV, and IAC).

Instrumentation

SUNRISE III (TuMag & SCIP instruments)

- Integration of TuMag and SCIP in the SUNRISE platform.
- SUNRISE flight campaign in Kiruna (Sweden). Unfortunately, flight was aborted because of technical failure.
- Successful recovery of the SUNRISE payload.

VIGIL (PMI instrument)

- B2 phase of the DPU development.
- Design and the DPU development model (DM) design.
- Response to the request for proposal for the whole E-Unit of the PMI instrument.
- Negotiations with ESA started.

SO/PHI

- Support to scientific operations as instrument co-leads.
- First two science orbits successfully completed.

TISes for EST

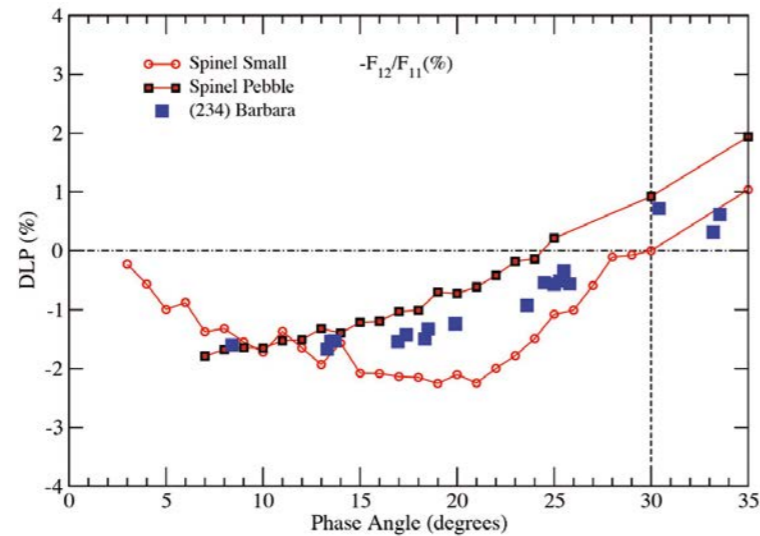
- Group leaders of the international consortium (Spain, Italy, Sweden, Germany) for the development of the three Tunable Imaging Spectropolarimeters (TISes) to work at the European Solar Telescope (EST).

CMAG

- Proposal of an F-class mission to ESA together with the private company SENER, for studying solar coronal magnetic fields.

SOLAR SYSTEM

Planets & minor bodies of the solar system



Degree of linear polarization as a function of phase angle for two spinel laboratory samples, small (empty red circles) and pebble-sized (filled red squares), along with barbarian asteroids values (blue squares), showing similar values in the inversion angle and low minimum of polarization

Overview

The activities of this group are focused on four research lines: planets, minor bodies, exoplanetary atmospheres, and the Cosmic Dust Laboratory (CoDuLab). Broadly speaking, we aim to provide an integrated view of the Solar System and the atmospheres around exoplanets. Observational projects are being conducted from the ground as well as by using instrumentation on board space vehicles. The data interpretation is based on theoretical modeling, numerical simulations, and laboratory studies. We are involved in a number of space missions such as BepiColombo, Exomars, JUICE, Comet Interceptor, EnVision, and DART (Double Asteroid Redirection Test).

Research lines

- Planets and minor bodies of the Solar System
- Dust in the Solar System
- Exoplanetary atmospheres

Highlights

Implications on the comet dust properties from dynamical evolution of non-spherical dust grains subjected to outflowing gas and solar radiative torques [253]

Predictions on the dust tail generated by DART spacecraft after impacting on Dimorphos, the secondary component of the (65803) Didymos system [254].

Determination of the dimensions, geometric albedo, and upper limit of atmospheric pressure and the presence of rings on trans-Neptunian object (38628) Huya [330]

Determination of HCN profile on Titan's atmosphere from submillimeter measurements [302]

Determination of the physical properties (dimensions, geometric albedo) of TNO (84922) 2003 VS2 from stellar occultations [372]

Measurements of the scattering properties of olivine and spinel, which explains the origin of the linear polarization curve of Barbarian asteroids [118]

The reaction between ozone and a key intermediate in the atmospheric chemical cycle of mercury, HgBr, was investigated experimentally for the first time. The rate constants obtained were discussed in the context of the global atmospheric modelling of the chemistry and transport of mercury pollution, where this reaction is now considered to play a critical role [134]

The mechanism of atmospheric iodine gas-to-particle conversion was studied experimentally in a flow tube setup using a mass spectrometer coupled to a chemical ionization source, with a focus on the ion-molecule chemistry of detection of iodine-bearing molecules and clusters. The results obtained are guiding field researchers to interpret chemical ionization mass spectrometry observations of iodine particle nucleation events [135]

SOLAR SYSTEM

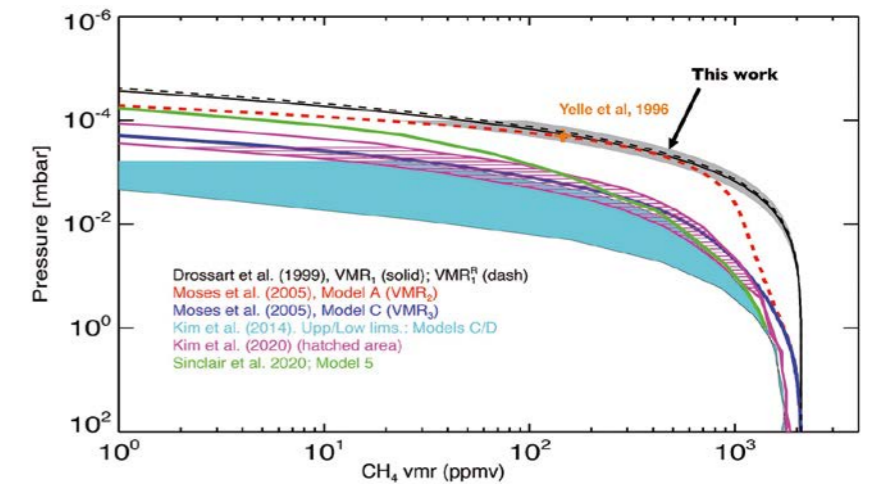
Terrestrial and planetary atmospheres

Overview

We investigate the thermal structure, composition, chemistry, dynamics and electricity phenomena of the Earth and planetary atmospheres. About the Earth, we focus on the study of solar particles and radiation effects on atmospheric composition, trends in temperature and species abundances, and the occurrence and impacts on composition of lightning phenomena. About Mars, we study its temperature structure, dynamics, ionosphere and composition. We use a large variety of models and measurements from instruments on satellites, on ground and in the laboratory. More recently we are studying the planetary formation and evolution and characterising the giant exoplanets' atmospheres by modelling and analysing ground-based and space data.

Research lines

- Drivers of the Earth's middle atmosphere variability and its impact on climate
- Atmospheric Electricity in Planetary Atmospheres
- Thermal structure and composition of the Terrestrial planetary atmospheres. Remote sensing of planetary atmospheres in IR/UV
- Planetary formation and evolution and Characterisation of exo-atmospheres.



Concentration profiles of CH₄ in Jupiter's upper atmosphere. The black dashed profile (VMR1R) and grey shade are derived from ISO measurements using the most recent laboratory measurements of the CH₄ collisional rates. Previous profiles are also shown [72]

Highlights

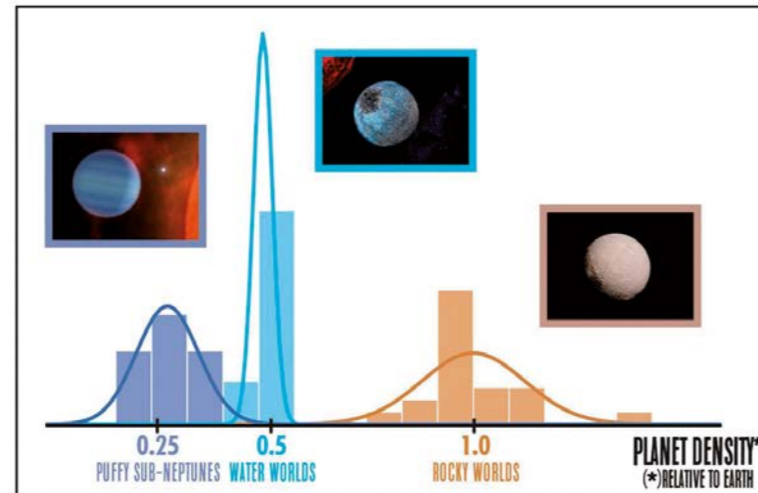
A thunderstorm can accelerate electrons to energies above a kilo-electron volt. To build physical models of this process, we need accurate cross-sections for the interaction of electrons with air molecules. We developed new, fully-quantum methods to compute these cross-sections. Due to the complexity of these calculations, this is a capability that few groups in the world currently possess [332]. In connection with lightning, we developed a new parameterization of long continuing current (LCC) lightning flashes for atmospheric chemistry transport models that allow computing lightning causing large wildfires [282].

Methane was first identified in Jupiter's atmosphere in 1932 and, since then, it constitutes a fundamental compound to understanding the atmospheres of the giant planets (including exoplanets). It is the most radiatively active species in Jupiter's upper atmosphere and hence it largely controls the temperature profile. Further, its drop-off in the upper stratosphere is an indicator of the turbulent processes and of the dynamic of this region. Methane has been measured from its fluorescence emission near 3.3 μm (e.g. with ISO), but this requires an accurate knowledge of its non-LTE populations, largely controlled by collisional relaxation rates. The laboratory measurements of these rates allowed us to accurately derive its concentration in the upper atmosphere, resulting in much larger concentrations than previously obtained. This study will have crucial impacts on the analysis of contemporary JUNO/JIRAM and JWST/NIRSpec observations [335].

Observations of evaporating atmospheres are essential to derive mass-loss estimates and study the planetary evolution of close-in planets. The HeI triplet at 1083.3 nm is a powerful diagnostic to study these phenomena as it traces the hot gas in extended exoplanet atmospheres, it can be observed from the ground, it is located at the bright near-IR stellar continuum, and is very weakly affected by interstellar medium absorption. We analyzed high-resolution transit time series spectra of the highly irradiated hot Jupiter HAT-P-32 b obtained with CARMENES. We detected very large H α and He absorption lines which significantly vary along the transit. Our hydrodynamic modelling yields a very large mass-loss rate and found that its atmosphere is in the energy-limited regime [72].

STELLAR PHYSICS

Low-mass stars & exoplanets



Overview

We study the physics of planetary systems and their low-mass host stars. M dwarfs are interesting by themselves and for their potential for the discovery of temperate rocky planets that could sustain liquid water. We work in several aspects of these systems, from the general statistics and observational distribution of their exoplanets to the asteroseismic modelling and magnetic activity of their host stars. The group has expertise in theoretical studies of stellar structure and evolution, magnetic activity, asteroseismology and technical development of new instrumentation. The group hosts the co-PI of the CARMENES consortium and one of the two PIs of the CARMENES Legacy-PLUS project.

Research lines

- Stellar structure and evolution of very low-mass stars
- Asteroseismology
- Exoplanets. Magnetic activity
- Astronomical instrumentation

Image above

Small-planet demographics around red dwarfs. The three different types of planets, gassy (left), watery or icy (centre) and rocky (right) show very clearly when very precise bulk densities are estimated. Credit: Rafa Luque (U. Chicago), Pilar Montañés (@pilar.monro), Gabriel Pérez (IAC), and Chris Smith (NASA GSFC)

Highlights

CARMENES is a unique, world-leading instrument internationally known for its survey to detect exoplanets around red dwarfs. Its near-infrared channel, designed and built at the IAA, has shown to be a ground-breaking instrument for studying exoplanet atmospheres. Co-led by the IAA, it is, to date, the largest exoplanet survey of red dwarfs. In 2022, the CARMENES Legacy-Plus project continued enlarging and deepening the original survey. The CARMENES-PLUS upgrade project achieved an improved performance for the instrument. The consortium's productivity is exceptional, having published or submitted 100 papers, 18 this year, and discovered or confirmed almost 60 new planets, with another 15 additional firm candidates (see also the list of press releases). These results have increased by 50% the number of planets in the parameter space probed by our instrument. We continued leading the consortium and contributing to its working groups. In addition to the instrumentation project CARMENES-PLUS, we also participate in the new concept for a large-aperture telescope, MARCOT for CAHA, and ANDES for the ELT.

We continued participating in several large exoplanet ground-based surveys in both hemispheres, such as SPECULOOS. We have continued our contribution to NASA's space mission TESS with the confirmation of several exoplanets, such as the sub-Neptune G 9-40 b [218] or the two rocky planets around HD 260655 [217].

These and other results provide precise bulk density determinations, which have allowed us to understand that there are three types of planets forming around M dwarfs, rocky, watery (or icy) and gassy planets [219]. Water worlds are more abundant than previously thought!

We are consolidating our expertise to characterise the magnetic and tidal star-planet interaction. We do so by understanding how magnetic activity affects some of the lines that show in the spectra of our stars [334] and by observing and timing the transits of hot Jupiters and binary stars to understand the impact of tides in their evolution [64,224].

STELLAR PHYSICS

Stellar variability

Overview

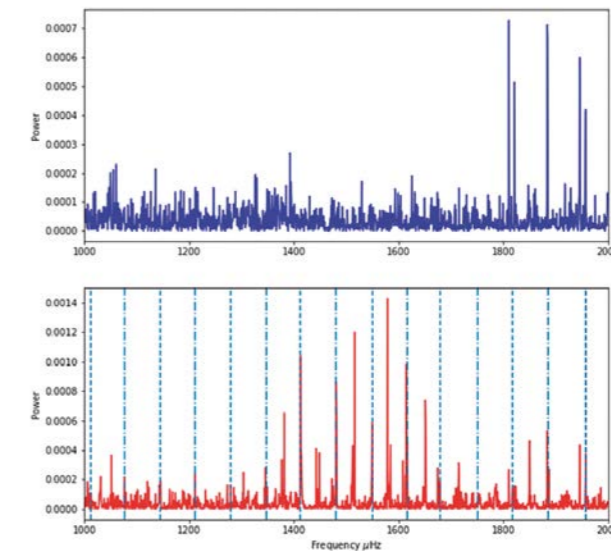
Research at IAA's Stellar Variability Group focuses mainly on the study of stellar structure and evolution and its impact on the characterization of exoplanets, stellar populations, and galactic archaeology, using asteroseismic techniques.

Group members are involved in the development of theoretical models as well as innovative time series analysis techniques that can be applied to extract information from ultra-precise data, especially observations from space satellites. Instrumental developments are the fundamental part of the work of the group's technical team. The group also has a representative in the Sky Quality Office of the IAA.

In the past we participated in the design and exploitation of the CoRoT space mission and, currently, we are strongly involved in the preparation of the future PLATO 2.0 (ESA) space mission.

Research lines

- Stellar Structure
- Stellar Evolution
- Time Series Analysis
- Open Science



Classical (blue, top) and modified (red, bottom) Fourier Transforms of the SoHO data. In the bottom plot are shown the $l=0$ (dashed) and $l=1$ (point-dashed) modes identified from our novel analysis using a quaternion transform.

Highlights

Asteroseismology allows the study of stellar interiors by analyzing how oscillations (manifested at the surface of the star as brightness variations or Doppler shifts) propagate at different depths depending on their frequency. This requires the estimation of the frequency content of those brightness variations (i.e., light curves) or radial velocity measurements of a stellar object. The usual hypothesis is that such a series is harmonic and can be described by a sum of sines and cosines. If this were not the case (e.g., the oscillations of an ellipsoid of revolution) it cannot be guaranteed that the Discrete Fourier transform is the least squares approximation to the time series.

In [127] we studied the effect of extending the Fourier kernel to a particular quaternion and exploring the impact when it is applied to the best time series that we have (GOLF/SoHO) from the closest star, our Sun. The results are consistent with a notable improvement in the signal-to-noise ratio in the low frequency range (see figure). This opens the possibility of detecting the elusive g modes of the Sun in future works.

Technological highlights of PLATO in 2022, where IAA is responsible for the MEU (Main Electronic Unit).

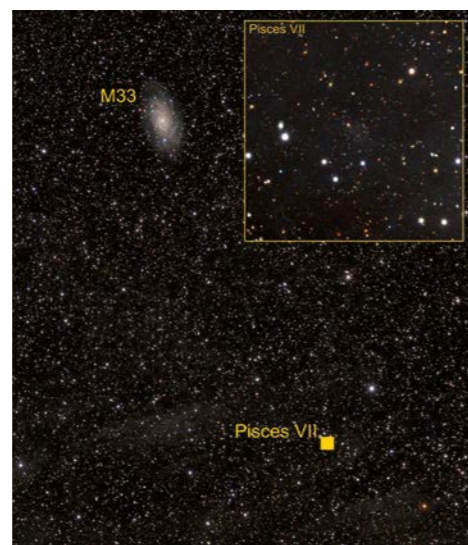
- MEU CDR (Critical Design Review) passed with no blocking actions.
- Delivery of MEU EM (Engineering Model) to the Prime for avionics integration.
- MEU EQM (Engineering Qualification Model) ready to start to populate the PCBs.
- MEU flight components: structure ready, EEE (Electrical, Electronic and Electromechanical) parts nearly completed and PCBs pending.
- Development of PILAS (PLATO IAA Laboratory Software) software for testing MEU in the laboratory for MEU EQM, PFM (Proto Flight Model) and FM (Flight Model) boards.

HAYDN mission (High-precision Asteroseismology of DeNse stellar fields). A candidate for ESA M7. 5 missions pre-selected to phase 0.

STELLAR PHYSICS

ARAE

(Robotic and high-energy Astrophysics)



The location of the Pisces VII dwarf galaxy with respect to the Triangulum Galaxy (M33) as part of the Local Group and a deeper image (insert) zooming on it [236].

Overview

The ARAE research group was founded in 2001, although some of its members had already started their activity in 1990. Scientists and engineers work on a variety of projects, combining their strengths. Research lines are multi-range observations of high-energy phenomena, theoretical stellar evolutionary models and models of stellar population synthesis. Significant technological developments are also carried out, regarding the robotization of small/medium size observatories and astronomical instrumentation development such as the BOOTES Global network of telescopes. We are also involved at space-borne missions such as ARRAKHS and THESEUS. Teaching, public outreach and citizen science are also part of the ARAE activities.

Research lines

- Compact Objects in the Galaxy
- Cosmic Gamma-Ray Bursts (GRBs)
- Gravitational Waves (GW) electromagnetic counterparts
- Dwarf galaxy satellites and stellar tidal streams as dark matter probes in the local Universe Robotic Astronomy
- Astrophysical Transients

Highlights

Pisces VII: discovery of a possible satellite of Messier 33 in the DESI legacy imaging surveys [236]

We report the discovery of an ultra-faint dwarf satellite candidate of the Triangulum galaxy (M33), found by visual inspection of the public imaging data release of the DESI Legacy Imaging Surveys. Pisces VII/Triangulum (Tri) III is found at a projected distance of 72 kpc from M33, and using the tip of the red giant branch method, we estimate a distance of $D=1.0 (+0.3/-0.2)$ Mpc, meaning that this galaxy is the second known satellite of M33. With only one potential satellite detected previously (Andromeda XXII/Tri I), M33 lacks a significant satellite population, in stark contrast to the similarly massive Large Magellanic Cloud. The detection of more satellites in the outskirts of M33 could help to better illuminate if this discrepancy between expectation and observations is due to a poor understanding of the galaxy formation process, or if it is due to the low luminosity and surface brightness of the M33 satellite population which has thus far fallen below the detection limits of previous surveys.

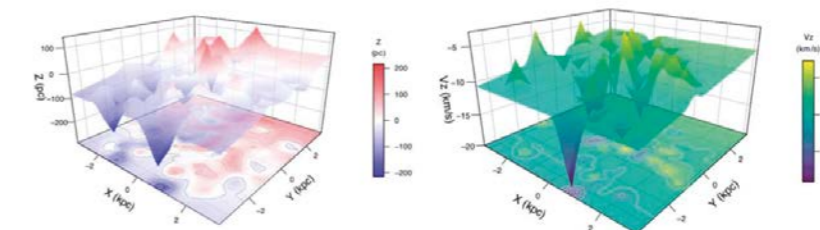
Instrumentation: Deployment of the BOOTES-6 station

The BOOTES-6 station at the Boyden Astronomical Observatory had finally first light in June 2022, after a severe 2-yr delay caused by the Covid-19 pandemic since it was shipped to South Africa in January 2020. BOOTES-6 hosts the 0.6m MPR robotic telescope, named after Mariló Pérez-Ramírez, professor at University of Jaén (Spain) and a long-standing collaborator of our ARAE Team, who passed away on 5 Jan 2015. BOOTES-6, led by IAA-CSIC, is the result of a collaboration between three institutions: IAA-CSIC, University of the Free State in Bloemfontein (SouthAfrica) and University College Dublin (Ireland). BOOTES-6 is part of the BOOTES Global Network of Robotic Telescopes led by IAA-CSIC, and proves the importance of a network of robotic telescopes around the world able to quickly respond to (or even discover) astrophysical transients in the sky.

With the addition of BOOTES-7 in Chile, Spain finally became on 31 December 2022 the first country in the world to host a complete telescope network in the five continents. This work was initiated in 1998 by A. J. Castro-Tirado (PI of the BOOTES Network) with the deployment of the BOOTES-1 station in Huelva (Spain) and accomplished almost 25 yr later by the team.

RADIO ASTRONOMY & GALACTIC STRUCTURE

Stellar systems



4D topography of the Galactic disc inferred from Gaia young open clusters [13]

Overview

The Stellar Systems Group (SSG) was created in 1988. Our research lines are stellar clusters, massive stars, and the Galactic Centre. Currently, the group is studying the connection between star-forming processes and spatial and kinematic structures at different scales, and continues to exploit the large Galactic surveys (including Gaia, GES, OTELO, GALANTE, J-PLUS, WEAVE and 4-MOST). The second focus of our work lies on investigating the structure, kinematics, and formation history of the Galactic Center and massive star formation in this emblematic region of the Milky Way. Please visit our website for more information: <https://ssg.iaa.csic.es/>.

Research lines

- Galactic Centre
- Formation, evolution and destruction of Stellar Systems
- Massive Stars

Highlights

The Galactic Centre Team presented a proper motion study based on the GALACTIC-NUCLEUS survey combined with the HST Paschen- α survey. Our unprecedented catalogue contains roughly 80 000 stars. The rotation of the nuclear stellar disc is apparent in the data and eastward moving stars on its near side are less reddened than westward moving ones on its far side. The velocity dispersion of the nuclear stellar disc is significantly smaller than that of the inner bar, which underlines that those two regions are separate components of the inner Galaxy [337]. We demonstrated how proper motions can help to constrain the line-of-sight distance of molecular clouds in the Galactic Centre, showing that the “Brick” lies inside the nuclear stellar disc, in its front half [235]. We also reported the detection of 105 solar masses of massive young stars in the Sgr B1 region, a significant step forward in understanding recent star formation in the Galactic Centre [264].

The Stellar Systems team continued its research along three main lines: Galactic structure and star formation, formation and destruction of open clusters, and large photometric and spectroscopic surveys. Spatial and kinematic maps $[Z(X, Y)]$ and $[VZ(X, Y)]$ (Fig. 1) of the young Galactic disc were obtained from stellar clusters with ages less than 30 Myr. These maps represent the phase space of star formation taking place in compact, gravitationally bound clusters. The results show for the first time a quasi-linear relationship of the vertical phase diagram (VZ vs Z) affecting a large area of the Galactic plane [13].

The Westerlund 1 stellar cluster, considered to be one of the most massive in the Galactic disc, was analyzed in depth. The study determined that it is located at a distance of 4.2 kpc leading to a stellar mass of about 104 solar masses [262]

The Gaia ESO-Survey project, coming to the end, led to a series of articles compiling the main steps and results of the project. In [45] we outlined the criteria and tools designed, developed and used to select the project cluster targets.

RADIO ASTRONOMY
& GALACTIC STRUCTURE

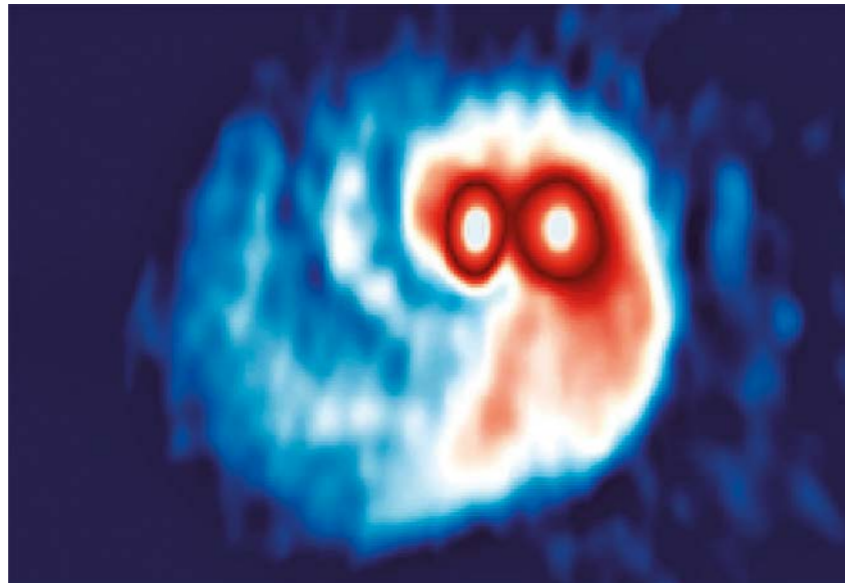
Physics of the Interstellar medium

Overview:

We study the formation, evolution, and death of stars at different mass and spatial scales across different environments. The early stages of star and planet formation, as well as star-planet interactions, are studied through radio interferometric observations and modelling of the observed emission. The final stages of the life of stars are studied by the multi-wavelength characterization of evolved stars and the wind-blown bubbles around them, to understand the processes shaping planetary nebulae and the circumstellar medium around massive stars. Radio interferometric monitoring of supernova (SN) explosions and their distribution in ultra luminous infrared galaxies is also carried out to determine the SN and star formation rates.

Research lines

- Massive stars and their surroundings. SN remnants and wind-blown bubbles
- Star and planet formation and interaction
- Planetary nebulae and their precursors
- Luminous and Ultra Luminous Infrared Galaxies
- Prospective Science work for the SKA



ALMA image of the dust surrounding the SVS 13 protostellar binary system [91]. Two small circumstellar disks and a circumbinary disk with prominent spiral arms are identified

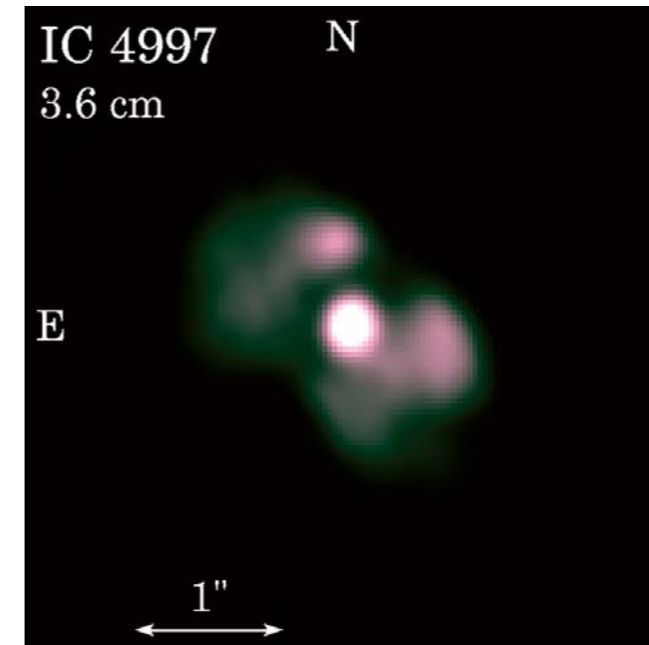
Highlights

The early stages in the formation of a binary stellar system revealed in detail.

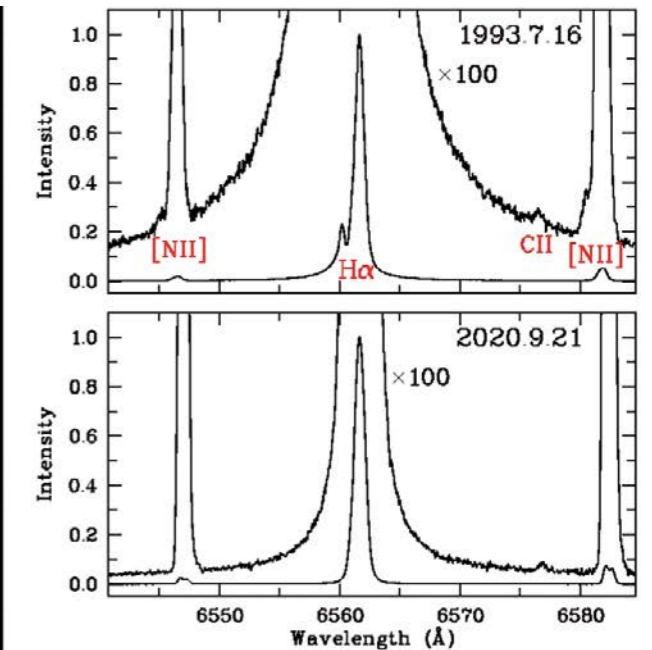
Using the Very Large Array (VLA) and the Atacama Large Millimeter/submillimeter Array (ALMA), we studied the binary stellar system SVS 13, still in its embryonic phase, observing the primordial material that may be giving birth to three planetary systems [91]. Two small circumstellar disks, with radii of about 10 astronomical units in dust and about 30 astronomical units in gas, and with masses in the range 4 to 30 times the mass of Jupiter, were detected. A circumbinary disk with prominent spiral arms extending about 500 astronomical units and with a mass of 52 times the mass of Jupiter appears to be in the earliest stages of formation around both stars. We measured the orbital motion of the protostars using radio data collected over thirty years. Masses of 0.3 and 0.6 times the mass of the Sun were derived for the two protostars. The work made it possible to study the composition of gas, dust and ionized matter. In addition, nearly thirty different molecules were identified around both protostars, including thirteen complex organic molecules precursors of life (seven of them detected for the first time in this system).

Re-encounter with a planetary nebula 30 years later

IC4997 is a young planetary nebula (PN) well known by its variability, and whose origin has not yet been unraveled. High-resolution spectra of IC4997 obtained in 1993 and 2020 reveal changes in the H α emission line profile, which were never reported for this object [244]. The total width of the H α wings has decreased from about 7000 km/s in 1993 to about 3900 km/s in 2020, and the two-peaked profile in 1993 changed to a single-peaked profile in 2020. This implies that, between 1993 and 2020, the wind from the central star of IC4997 largely weakened, and



(left) Image of the planetary nebula IC4997 at 3.6 cm radio continuum. (right) Spectra obtained in 1993 July 16 and 2020 September 21 around the H α emission line. The spectra are shown at two different scales to highlight the changes in the H α line [244].



the electron density in a nebular region very close to the central star noticeably decreased. The changes appear correlated with some episodic (50-60 years) variability already identified in the nebula, suggesting that the main cause of the variability of IC4997 is an episodically variable wind from the central star. An unseen companion star in a highly eccentric orbit around the central star could explain the observed changes if the stars were at their minimum orbital separation around 1993 and at their maximum one around 2020.

New candidates to nascent planetary nebulae

We searched for new cases of PNe with OH maser emission (OHPNe) [50]. These sources are thought to be nascent PNe, and only six have been confirmed so far. We used data from the interferometric follow-up of the Southern Parkes Large-Area Survey in Hydroxyl (SPLASH), carried out with the Australia Telescope Compact Array. In this survey, 933 OH maser sources were identified. We processed the radio continuum data, obtained simultaneously with OH, and searched for spatial coincidences between continuum and maser emission, since PNe are radio continuum emitters, due to free-free processes in their ionized material. We identified four new candidates to being OHPNe, and present an infrared color-color diagram that could help to identify new OHPNe in the future.

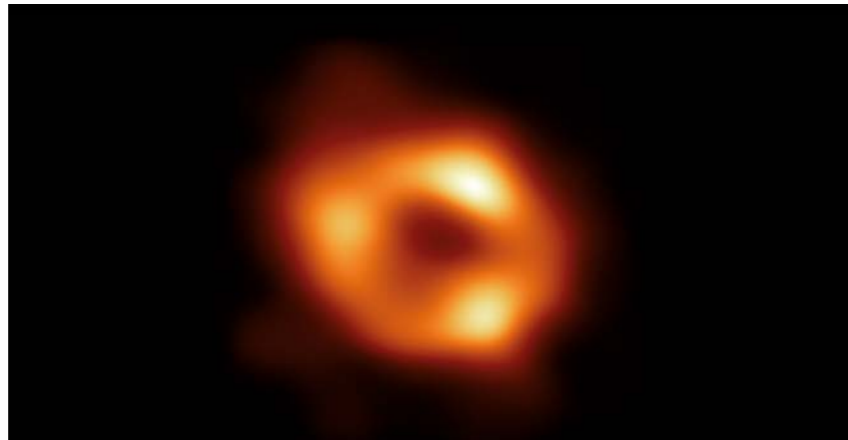
HuBi1, the new born-again planetary nebula

Born-again planetary nebulae represent a fascinating case of peculiar stellar evolution. This event occurs when the central star of a planetary nebula experiences a late thermal pulse at an early time in its cooling track, ejecting highly processed hydrogen-poor material inside the surrounding nebula. The stellar envelope expands and subsequently the star effective temperature and ionizing flux decrease dramatically. Meanwhile, the ejecta expands at high speed inside the old planetary nebula, producing violent shocks. The high metallicity of the ejecta, the lack of ionizing flux and the shock-excitation make born-again planetary nebulae excellent laboratories of complex astrophysical processes that proceed on real time. There are, however, only four bona-fide born-again planetary nebulae, namely A30, A58, A78, and Sakurai's Object. The planetary nebula HuBi1 was proposed as the fifth member of this exclusive class, but an investigation of its chemical abundances were precluded by the bright HI emission of the old nebula. Our work [247] used GTC MEGARA high-dispersion integral field spectroscopy to kinematically resolve the emission of the new ejecta from that of the old nebula. The hydrogen-poor abundances found in this study confirm its born-again nature.

RADIO ASTRONOMY
& GALACTIC STRUCTURE

AGN Jets

Relativistic Jets & Blazars



Overview

The main research topic of our group is the study of supermassive black holes (SMBHs) harbored in the nuclear region of active galaxies. Huge amounts of energy are released from their innermost environment in the form of ultra-relativistic jets, as a consequence of mass accretion onto the SMBH and energy extraction through powerful twisted magnetic fields anchored to it. We study these objects at the maximum achievable angular resolution by means of very long baseline radio interferometric observations with the Event Horizon Telescope (EHT) and the space antenna RadioAstron. Thanks to these instruments, we are able to directly image SMBHs and the jets forming close to them.

Research lines

- Imaging supermassive black holes with the Event Horizon Telescope
- Accretion onto supermassive black holes and the formation of relativistic jets
- Blazar jet multi-wavelength phenomenology from the horizon to parsec scales
- AGN, black hole growth and demographics, binary blackholes and gravitational waves

Image above

The first image of the supermassive black hole at the center of our galaxy, SgrA*, obtained by the Event Horizon Telescope (EHT Collaboration 2022).

Highlights

In 2022 May 12th the Event Horizon Telescope Collaboration released the first-ever image of the Sagittarius A* black hole located in the Galactic Center. Through observations, images, and analysis presented in a special issue of ApJ Letters in 2022, the EHT Collaboration provides new insights into accretion, outflow, and gravitational physics on scales not accessible through any other observation. The SgrA* image reveals the same ring-like structure and shadow seen in the M87* black hole, proving lensed rings to be universal features of black holes and demonstrating consistency in general relativity's predictions across three orders of magnitude in black hole mass. However, the lower mass of Sgr A* introduced significant complexity to imaging and analysis, requiring a number of traditional and novel techniques to correct for its rapid variability and assess the ring's diameter, which was determined to be 52 microarcseconds. Joining the EHT results with extensive multi-wavelength constraints provides a powerful probe of accretion and outflow physics. Infrared astrometry of stellar orbits constrains the mass, distance, and ring diameter of Sgr A* to approximately 1% accuracy, enabling precision explorations of gravitational physics, which showed remarkably good consistency with a black hole described by the Kerr metric and including a genuine event horizon.

Two papers focused on the study of OJ287, the best candidate to harbor a binary supermassive black hole. In [137] we discuss the first polarimetric space very long baseline interferometry (VLBI) observations of OJ 287, observed with RadioAstron, along with contemporaneous ground VLBI observations at different frequencies. These observations suggest that the innermost jet is consistent with being in equipartition between the particles and magnetic field and that it has a predominantly toroidal magnetic field, indicating that the VLBI core is threaded by a helical magnetic field. In [398] we present the first VLBI observations of the blazar OJ 287 carried out jointly with the Global Millimeter VLBI Array (GMVA) and the phased Atacama Large Millimeter/submillimeter Array (ALMA) at 3.5 mm. The images reveal a compact and twisted jet extending along the northwest direction, with two bends within the inner 200 μ as, resembling a precessing jet in projection, and a bimodal distribution of the linear polarization electric vector position angle.

EXTRAGALACTIC
ASTRONOMY

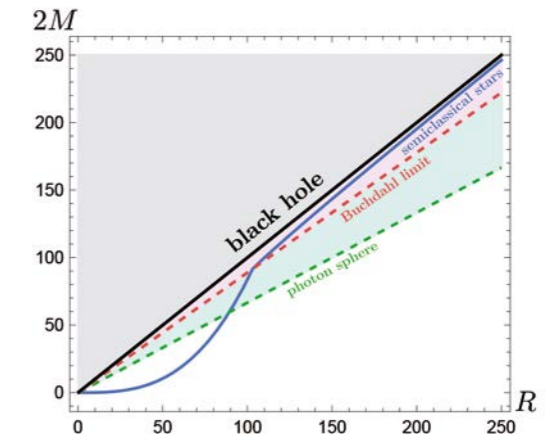
Theoretical Gravitation & Cosmology

Overview

Our group is interested on theoretical gravity, both at the classical level and specially on those situations in which General Relativity (GR) -the best theory of gravity we have- is expected to start failing. The most promising situation in which to observe departures from GR is the physics of gravitational collapse and its end result (black holes in the standard theory). Thus, a large part of our research is centered in analyzing how different situations in standard GR would be modified when going beyond this theory. For instance, we analyze modifications based on semiclassical gravity and those suggested by emergent and analogue gravity scenarios. We study the viability of the new scenarios suggested by these frameworks.

Research lines

- Gravitational collapse and semiclassical gravity
- Black holes and ultracompact objects
- Analogue and emergent gravity
- Group theoretical quantization
- Origin of masses of elementary particle



Phase space diagram of the possible compactness of stellar configurations. The blue line represents our solution

Highlights

Semiclassical relativistic stars [21]

In standard GR there is a limit to how much compact a stellar configuration can be: the so-called Buchdahl limit. The standard lore is that any star surpassing this limit will collapse to form a black hole. However, we have shown that this is no longer correct if one takes into account as a source of gravity the very vacuum polarization of the quantum fields. Then, the resulting modified Einstein equations contain stellar solutions with compactness arbitrarily close to that of black holes.

Classical mass inflation versus semiclassical inner horizon inflation [29]

Any realistic black hole has in its interior an inner horizon in addition to the well-known outer horizon. The result of considering vacuum polarization effects at the outer horizon is the well know Hawking evaporation. We have analyzed instead what are the effects of vacuum polarization at the inner horizon. We have shown that it produces an exponential inflation of this horizon outwards. This result challenges the standard paradigm in which black holes just slowly evaporate.

Warp drive aerodynamics [30]

We analyze the effect of vacuum polarization in realistic warp drives of 3+1 dimensions. We show there is an instability concentrated in one single point of the warp drive bubble and that its severity can be controlled by the form parameters of the bubble. We show that a warp drive can have more or less aerodynamic shapes.

Chronology protection implementation in analogue gravity [31]

In a first look, it appears that one can simulate geometries with temporal pathologies within analogue gravitational systems in the lab. We show here that, on the contrary, this is not possible. Moreover, we explain the reasons underneath this impossibility.

Analogue gravity simulation of superpositions of spacetimes [32]

Most approaches to quantum gravity assume that there exist states representing superpositions of two otherwise classical spacetimes. However, there exist proposals that argue that this is not possible. In this work we analyze an analogue version of superpositions of spacetimes. We find that superposing spacetimes is not an easy task as these configurations are strongly unstable.

EXTRAGALACTIC ASTRONOMY

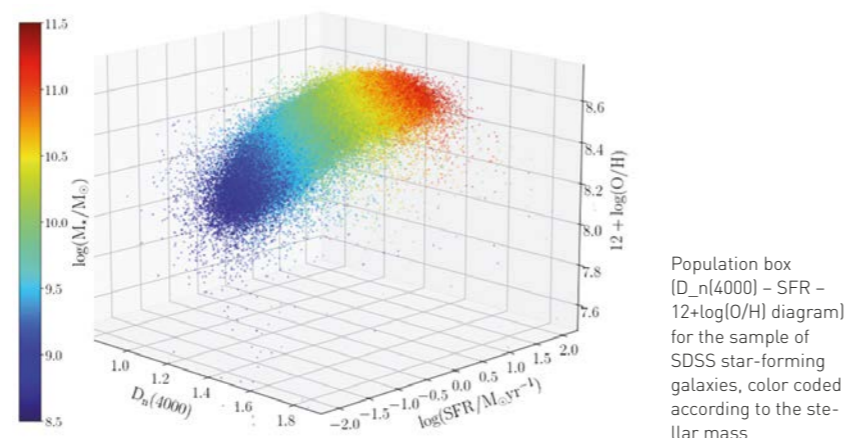
Galaxy Evolution

Overview

The group conducts observational and theoretical studies over a wide variety of issues on galaxy structure and evolution, and cosmology. These range from the inner stellar and gaseous components of galaxies to their large-scale cosmic distribution and evolution. These are complemented with the participation in the research and development of instrumental and technological projects. Observationally, data from 2D spectroscopy, multi-band photometric and HI surveys are used for studies that include the physics of star formation, stellar populations and the diffuse medium in galaxies and galaxy groups and clusters, nuclear activity in galaxies and their interplay with stellar evolution, or the environmental dependence of the structure and evolution of galaxies. These activities include supervising PhD, teaching at master and doctoral level, public outreach conferences, and eScience. Furthermore, we are leading since 2011 the participation of Spain in SKA.

Research lines

- Active Galactic Nuclei
- Astronomical instrumentation
- Cosmic evolution of galaxies
- Open Science
- Physics of Quasars
- Star formation and violent star formation in galaxies
- Synthesis of stellar populations
- The interplay between massive star formation and chemical evolution in galaxies
- The influence of the environment on the evolution of galaxies



Highlights

The miniJPAS survey: Tracing the role of star formation and environment in galaxy evolution

The miniJPAS survey is a pathfinder of J-PAS that consists in one deg² in the AEGIS field observed with 56 narrow bands covering the optical spectral range. With these data we have proved the power of J-PAS for galaxy evolution by studying the role that mass and environment play in quenching the star formation in galaxies.

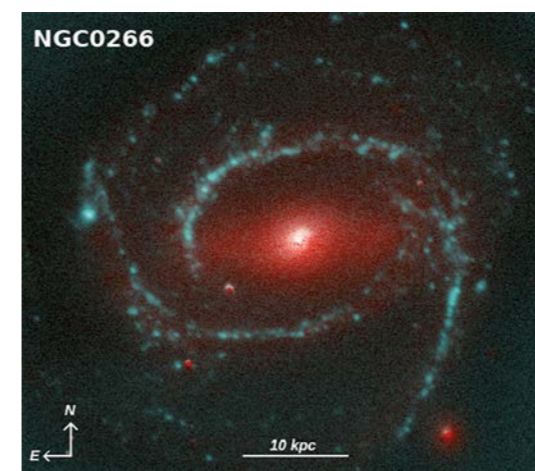
We measure the abundance of these red, and blue/star forming galaxies as a function of the mass and environment in order to investigate the role that groups play in quenching star formation [140]. We find that quenched fraction excess in groups shows a strong dependence on mass; and the galaxy quenching rate in groups shows a modest but significant evolution since $z \sim 0.8$. This implies that the low-mass star forming galaxies in groups/clusters at $z = 1-1.4$ are environmentally quenched.

We identify and characterize the galaxy populations in the most massive galaxy cluster detected in miniJPAS, mJPC2470-1771 at $z = 0.29$ [307]. The distribution of galaxy properties with the cluster-centric distance indicates that galaxy members in the inner regions of the cluster have quenched their star formation faster than the outer ones.

We identify and characterize the population of emission line galaxies from miniJPAS at redshift below 0.35 by using artificial neural networks [237]. We infer [NII]/H α , [OIII]/HB and the equivalent width of H α to obtain that, in the AEGIS field, 73%, 18%, and 9% are star-forming, AGNs, and quiescent galaxies, respectively. This method is applied to get the distribution of star forming, AGNs and red galaxies in clusters and groups, to discriminate between the internal and external process that quench the star formation in galaxies [2].

Understanding nuclear activity in galaxies: from low to high accretion rates

At the lowest AGN luminosities (L_{AGN}), we used imaging and integral field spectroscopy (IFS) observations to trace the complex outflow phenomenon in LINERS (Hermosa-Muñoz's PhD thesis). First, we produced the largest H α atlas of local LINERS so far (70 galaxies) to search for outflow candidates based on their ionised gas morphology (HST and ALFOSC narrow-band imaging). We found that $\sim 50\%$ of LINERS would



Large scale H α image of NGC0266, tracing the ionised gas, that has a bubble-like nuclear morphology in [154].

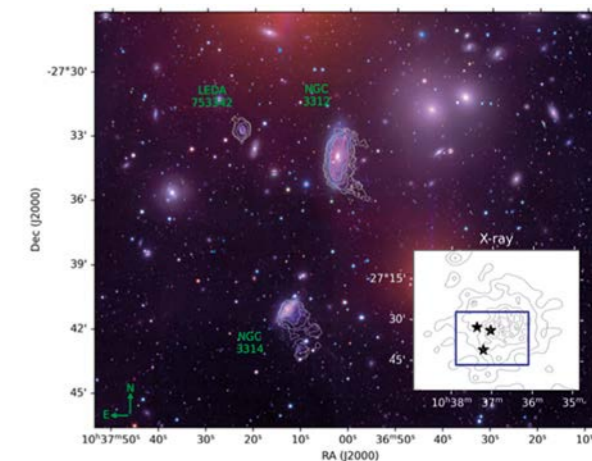
host an outflow [154]. Secondly, our proprietary IFS observations (MEGARA@GTC and MUSE@VLT) of the prototypical LINER NGC 1052 allowed us to detect an ionized gas outflow probably driven by the radio jet, propagating in a region of turbulent gas, and triggering kpc-scale bubbles [55].

At higher L_{AGN} , we characterized AGN-driven outflows by analyzing the ionized gas and stellar kinematics of nearby galaxies observed as part of the MaNGA survey. The analysis targeted 170 AGNs and a well-matched control sample of non-active galaxies. We detected winds up to only a few kpc for strong AGNs. Their kinetic powers are not powerful enough to significantly impact their respective host galaxies [84].

At the highest L_{AGN} of quasars, we identified a virial broadening estimator in the rest frame UV, suitable for black hole mass computation at high redshifts (where the classical virial estimator HB is shifted to the NIR, so difficult to observe). We compared the width of the HB line to those of the AlIII λ 1860Å doublet, over a wide interval of z and luminosity for quasars with intermediate to high Eddington ratios. Both widths resulted to be highly correlated over five orders of magnitude in luminosity. This provides, for the first time, a scaling law for black hole mass estimates up to redshift ~ 5 [240].

Unexpected tails of gas and stars seen in two Hydra Cluster galaxies [157]

Ram pressure stripping is a major mechanism responsible for galaxy transformation in dense cluster environments. Clusters contain hundreds of gravitationally bound galaxies that move within it and interact with the hot gas that forms the intracluster medium (ICM). As galaxies move through the hot ICM, their cold gas is removed through viscous stripping: at the leading edge of galaxies, gas and dust is compressed and can form new stars, while on the trailing



False-color image [optical DECam data, including H α] of the Hydra cluster and HI contours (gray lines) of three galaxies in the foreground group. The small inset shows X-ray contours from ROSAT ALL-Sky Survey data [Voges et al. 1999,A&A, 349, 389].

side, we often see tails of neutral and ionized gas. In the densest clouds in the tail, star formation can occur, but the stars themselves will live their entire life outside the galaxy, and the gas that is lost will become part of the ICM.

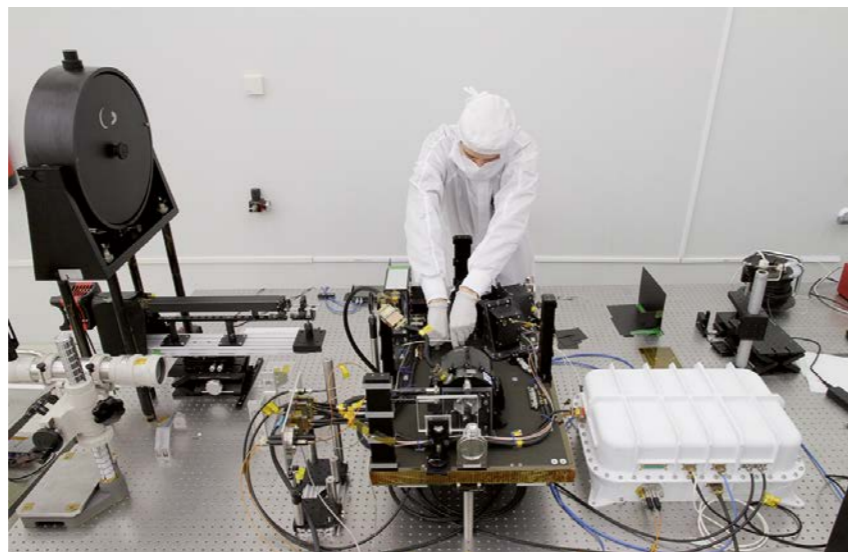
We found that NGC 3312 and NGC 3314a, two galaxies in the Hydra Cluster, have unusually large amounts of gas and star-forming tails. They are the two closest spiral galaxies to the center of a cluster in which such large well-defined tails have been seen and we estimate that the tails make up 8% and 35% of the total gas in the discs. This is unexpected, since gas is normally already lost so close to the cluster center. NGC 3312 and NGC 3314a probably have fallen in the Hydra Cluster as part of a group: the drag observed in their tails reveals that they are part of a substructure moving towards us that has already passed its cluster pericentre. The fact that these galaxies still have a high gas content suggests that the intragroup medium may protect them from the most dramatic effects of ram pressure.

Unveiled how galaxies' Mass-Metallicity Fundamental relation is driven by the stellar population age [98]

From a sample of $\sim 195,000$ SDSS star-forming galaxies with $z < 0.22$, we analyze the behavior of the Mass-Metallicity relation (MZR) with respect to the star formation rate (SFR), taking into account the age of the stellar populations, this last parameterized with the 4000 break, $D_n(4000)$. We observe a complex relation between stellar mass, metallicity, and SFR, across the whole range of stellar mass and metallicity; the slope changes in the metallicity (tracing by the oxygen abundance, O/H) - SFR plane seem to be tuned with the stellar age of the galaxies.

UDIT

Instrumental & Technological Development Unit



Integration of the TuMag instrument flight model for the Sunrise III mission

Overview

The Instrumental and Technological Development Unit (UDIT) is focused on the development of state-of-the-art instruments for ground-based telescopes and space-borne astrophysical payload instrumentation. During more than 40 years, the instruments developed at the UDIT have placed the IAA as a reference center for technological research projects.

The technical production at the UDIT can be split into two major lines:

- Analysis, design, integration, and verification of astronomical instruments for ground-based telescopes in Calar Alto Observatory (CAHA), Sierra Nevada Observatory (OSN), ELT (Extremely Large Telescope), etc.
- Analysis, design, integration, and verification of astronomical instruments for interplanetary scientific space missions and stratospheric balloon observatories

Highlights

Space projects

JUICE (JUper ICy moons Explorer): The activities were focused on providing technical support to the JANUS and GALA teams for the payload testing activities at S/C level. The JUICE mission will be launched in April 2023.

Comet Interceptor. The IAA is responsible for developing the power converter modules for the instruments COCA and MANIAC as well as the power handling unit and the data handling unit for the instruments EnvisS and OPIC. Activities in 2022 were devoted to manufacture and test the Elegant BreadBoard (EBB) for EnVisS and OPIC.

EnVision. The UDIT team worked on the requirements definition for the power supply units (PSU) of the optical spectrometers VenSpec-H and VenSpec-U and for the central power supply unit (PSU) of the VenSpec suite. Preliminary electrical simulations and power supplies performance analysis were also carried out.

PLATO (PLAnetary Transits and Oscillation of stars). The IAA technical team focused in the further testing of the MEU (Main Electronics Unit) engineering model (EM) including 4 Digital Processing Units (DPU) (the final model will include 6). Additionally, one of the engineering models developed was delivered to the prime contractor for avionics integration. The MEU EQM manufacturing started.

DUSTER. The UDIT team started working in DUSTER, a Horizon-CL4 project to be developed during 2023 and 2024. The objective of this project is to deliver an EM to study dust particles. The IAA is in charge of the DPU, the on-board SW and the EGSE.

HAYDN (High-precision Asteroseismology of DeNse stellar fields) was preselected, together with other four missions, as a candidate for an ESA M7 mission. Its objective will be the study of stellar clusters. If the mission is finally selected, IAA will be in charge of the DPU and Boot&safe on-board software development.



Comet Interceptor
Elegant Breadboard
Models electronics for
EnVisS (left), MANiaC
(center), CoCa (right)

SUNRISE III. Activities were devoted to perform the integration and testing of the electronics unit and optical units of the SCIP and TuMag flight models instruments. They were also devoted to perform the calibration and end-to-end testing of the instruments, and to the integration of the gondola to perform the pre-flight tests at MPS and afterwards in the Swedish Space Center Esrange. Sunrise III was launched on 10th July. However, an unfortunate accident at launch, forced to abort the mission. The instruments weren't damaged.

Vigil: The IAA technical team focused on the design of the development model of the DPU for the PMI instrument. The main aim of this development model will be to demonstrate the maturity of the subsystem at the instrument PDR. Activities were also devoted to work on the definition of the PMI electronics and harness as well as to define the instrument requirements.

Solar Orbiter: Activities were devoted to support PHI Solar Orbiter operations.

Ground based instruments:

MOSAIC (Multi-object spectrograph for ELT): The instrument internal kick-off was held beginning 2022. During this year, the first hardware prototype was tested, together with the updated version of the instrument control software. The technical team also worked on the definition of the next testing campaign that will include cryostat and thermal control verifications.

MIMA (Multi-Spectral Imager Mesopause Airglow): The instrument was tested and calibrated. The instrument commissioning and the first light is expected in 2023.

GALIUS (GrAnada Lightning Ultrafast Spectrograph): With the work performed in 2022 a technological paper was published about the temporal evolution of spectroscopic optical emissions along the radial dimensions of lightning-like channels. The technical team also worked in the design and development of a new instrument, TEMPOS, including a discharge camera.

CARMENES-PLUS: The second phase technical improvements was implemented for the CARMENES cooling system, mainly focused on the LN2 pressure control unit and in a continuous power system. With the implementation of these second phase improvements, the instrument obtained unprecedented thermal stability and radial velocity precision in the NIR spectrograph, leading to more ambitious science and new scientific cases.

TARSIS: It was selected as the new instrument for CAHA observatory. The IAA will be in charge of two technical work packages: the instrument control system and the A&G and calibration unit. The instrument control system, including both electronics and software, will perform the following tasks: mechanisms control, monitoring the status of the instrument, receiving and processing data from the detector system and interfacing with instrument subsystems (e.g., telescope, detectors). The UDIT technical team to be involved with TARSIS was formed and the official kick-off meeting took place in October 2022.

Calar Alto Observatory (CAHA)



MARCOT pathfinder at Calar Alto observatory

Overview

The Calar Alto observatory (CAHA) is a key institution for the international astronomical community, for its highly competitive astronomical facilities (telescopes and instrumentation). From 2019 on, the current administration of CAHA includes the Junta de Andalucía and the Spanish CSIC as partners. These two institutions equally manage the operation of the observatory. In this new scenario, the Instituto de Astrofísica de Andalucía (IAA-CSIC) continues playing the role of benchmark institute of the observatory.

As an ICTS (Spanish Unique Scientific and Technical Infrastructure), CAHA offers to astronomers a minimum of 20% of the available observing time on its two main telescopes with apertures 2.2m (T2.2m) and 3.5m (T3.5m). Both are equipped with a suit of instruments, and are the largest of its kind in mainland Europe.

Activities and highlights

Publications and main scientific results

Observations at Calar Alto produced in 2022 more than 120 publications in international peer reviewed journals. This includes not only scientific projects awarded with open time, but also the long-term legacy projects that started in 2021. In addition to the scientific activity, Calar Alto continued its activities for developing new instrumentation as well as basic infrastructures. The most relevant results in 2022 are described below.

Calar Alto participated in the follow-up observations of a stellar explosion which lasted more than a minute, and which cannot be explained with the current theoretical models of such bursts. The scientific team used data from CAFOS@T2.2m, Hubble Space Telescope, and GTC, among others, and concluded that the event had the characteristics of a kilonova, which is produced by the merger of two neutron stars [298]. They agree with the results by another group that, the same outburst with different approaches and observations.

Observations with CAFOS@T2.2m and Omega2000@T3.5m helped to unveil the content and history of W40, a hidden region in our galactic neighborhood where massive stars have been forming in the past few million years [Comeron et al. 2022, A&A, 665, A76]. A close look at W40 suggests a quite complex scenario: W40 does not have a single star but a full cluster, and these observations have shown that massive stars were already present before the cluster and the nebula existed.

An international team of researchers with participation of the IAA-CSIC measured, with unprecedented accuracy, the mass and the radius of Gliese 486 b, an exoplanet of the super-Earth category, discovered in





2021 with the CARMENES@3.5m [49]. This study provided, for the first time, robust predictions on the internal structure and composition of a super-Earth. In particular, the team was able to model the interior of the exo-planet Gliese 486 b, and to estimate the relative sizes of the (metallic) core and the (rocky) mantle. It was the first time that such a detailed study of the possible inner structure of an exoplanet is performed.

An international team led by a researcher from the IAA-CSIC found two telluric planets orbiting, while partially eclipsing the nearby dwarf star HD 260655 [217]. The discovery was made by combining space- and multiple ground-based facilities, in particular with CARMENES@3.5m. These two newly found super-Earths are among the top 10 candidates for follow-up studies of their atmospheres.

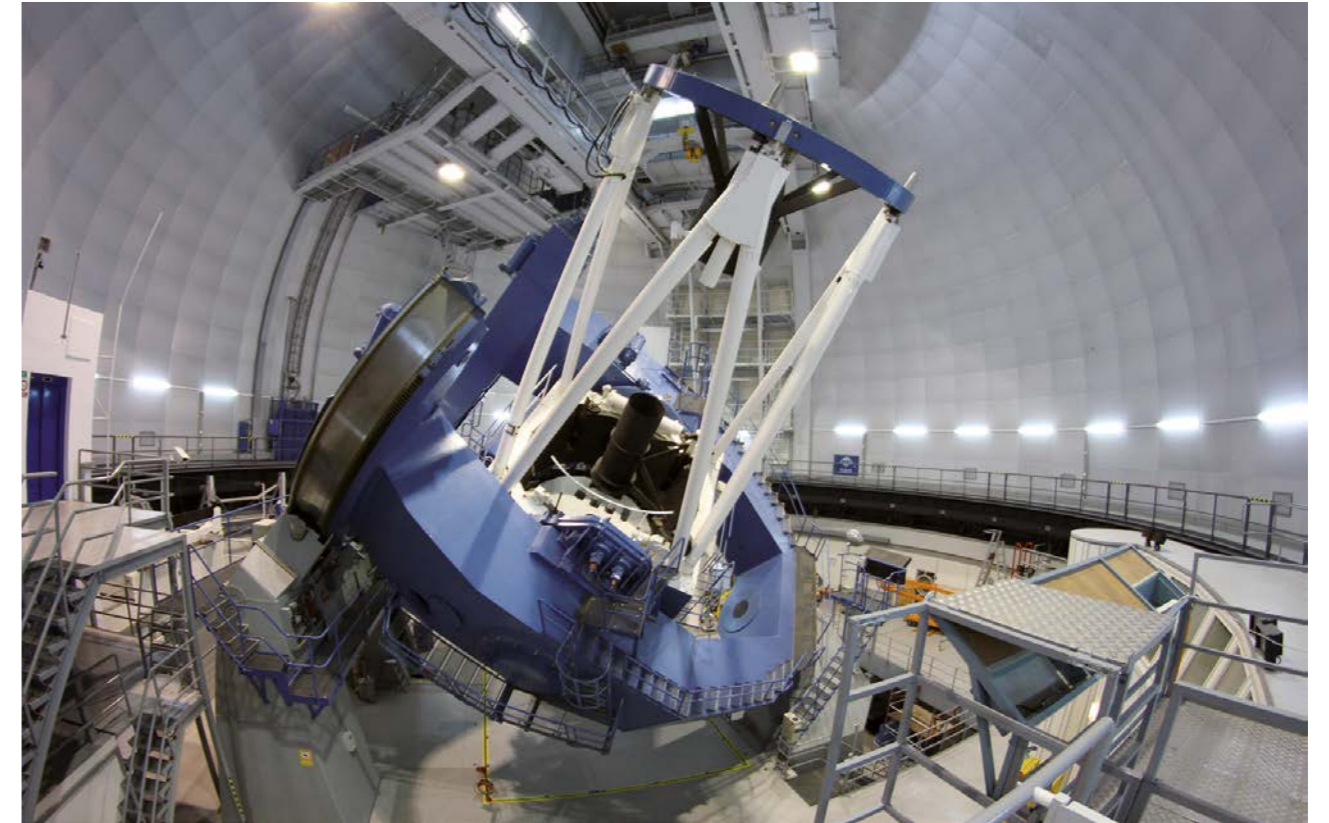
IAA-CSIC led a study based on data obtained with the CAFE@2.2m, showing the variability of the planetary nebula IC4997 [244]. Changes could be seen comparing observations taken nearly 20 years ago with the Coudé spectrograph at the 2.2m telescope. The main conclusion of this work suggests that this planetary nebula probably hides a companion star.

International collaborations

During 2022, Calar Alto continued its participation in the ORP european network, which started in 2021 as a merging of the OPTICON and RadioNet networks. It is currently the largest collaborative network of ground-based astronomy in Europe, which intends to coordinate methods and observational tools, and to provide access to a wider set of astronomical facilities. Calar Alto participates in ORP, together with the IAA-CSIC, Cambridge University (United Kingdom), CNRS (France), and Max-Planck Institute of Radioastronomy (Germany).

The ongoing international long-term observational projects continued during 2022:

- The project SEAMBH (Super-Eddington Accreting Massive Black Hole), in collaboration with Beijing University, is dedicated to the study of supermassive black holes in active galactic nuclei applying the reverberation method, using CAFOS@2.2m.
- The extragalactic survey CAVITY (Calar Alto Void Integral field Treasury survey), devoted to the study of the properties of galaxies in cosmic voids, the most isolated objects in the Universe. This project makes use of the integral field spectrograph PMAS@3.5m.



- The KOBE survey is searching for potentially habitable exoplanets orbiting K-dwarfs, by using the CARMENES@3.5m.
- CARMENES Legacy+, is an extension of the CARMENES survey, and is intended to the detection and characterization of planets around M-dwarfs, the occurrence of long-period giant planets, and the characterization of exoplanet atmospheres.

New technological developments

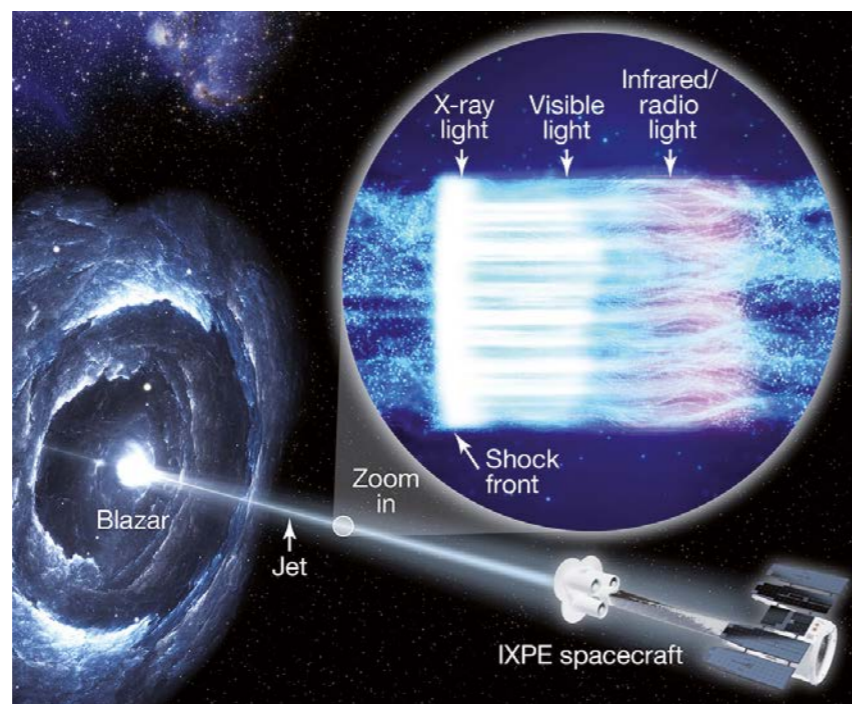
In May 2022, TARSIS (the Tetra-ARmed Super-Ifu Spectrograph) was selected to be the future instrument for the Calar Alto 3.5m telescope. TARSIS, that is co-led by IAA-CSIC and UCM, has unique characteristics, like its capacity to detect near ultraviolet (down to 320 nm) light, and its unprecedented field of view (~8 sq. arcmin). TARSIS, and its associated science project, CATARSIS, an ambitious observational survey of galaxy clusters that will occupy most of the first years of operation of the instrument, will maintain the largest optical telescope in the European mainland at the forefront of Astronomy.

CAHA is involved in a project to carry out the conceptual design and establish a plan for the construction of a new European telescope concept with a large effective aperture and low cost, MARCOT (Multi-Ar-

ray of Combined Telescopes). MARCOT is conceived as a modular astronomical infrastructure for high resolution spectroscopy and large field of view, high dynamic range imaging at subarcsecond spatial resolution. The idea consists in the combination of multiple identical elements (identical mirrors or optical assemblies), resulting in a large effective aperture. The photons are collected by individual optical fibers attached to each optical assembly, which are finally combined by a novel multimode photonic lantern into a single fiber, which feeds a high-resolution spectrograph. Additionally, each optical assembly is equipped with a detector with low readout noise (used for guiding and centering), and the images from the detector can be combined later. This generates a single frame with a signal to noise ratio identical to that of a single large aperture telescope, but with improved resolution, dynamic range and larger field of view. Among the scientific goals to be pursued by MARCOT are the search for Earth-like exoplanets and the characterization of their atmospheres for a large sample of stars. To achieve these goals, a high-resolution spectrograph operating simultaneously in the visible and near-infrared wavelengths is required.

OSN

Sierra Nevada Observatory



Artistic view of how particle acceleration occurs in blazar jets. Credits: NASA/Pablo Garcia.

Overview

OSN is a high mountain observatory located at 2896m in the Sierra Nevada National Park. It belongs to CSIC and it is operated by the IAA. It houses two optical telescopes with 1.5m and 90cm apertures, named T90 and T150. Like many other medium-sized astronomical observatories, the OSN compensates the limited access to observing time at large observatories by providing great flexibility to serve programs that require rapid response or intense temporal coverage, either in terms of sampling or extension. Indeed, OSN focuses on covering long-term follow-up and target of opportunity programs, currently in support of the IAA's research lines. Its privileged location also makes it an ideal site for mid-upper atmosphere sounding and as a test bed for external instrumentation.

Highlights

In 2022, the T90 and T150 telescopes were equipped with two 4Mp cameras. T150 was out of service since July, as explained below. The Albireo spectrograph underwent technical actions. The OSN also housed the SATI spectrometer, dedicated to the study of the mesopause region, and instruments from the IAA Sky Quality Office, as well as external equipment, namely a meteoroid detection station and a GPS station. Among the activities we highlight:

Observation programs

OSN observations dedicated to **blazar polarimetry and photometry**, contributing to the MAGIC and WEBT collaborations, crystallized in a Nature publication where they discovered that polarized blazar X-rays imply particle acceleration in shocks [209]. The figure above represents how, when particles hit, the shock wave (white bar) become energized and emit X-rays as they accelerate. Moving away from the shock, they emit lower-energy light: first visible, then infrared, and radio waves (see the circle in the figure).

OSN **CARMENES** target follow-ups are key to characterizing M dwarfs stars and discarding false positives for exoplanet detection. This program helped CARMENES to characterize a multi-planetary system around the M dwarf star TOI-1238, which includes two super-Earths [141].

The follow-up of **gamma-ray bursts** to study their temporal evolution yielded interesting results about the extraordinarily bright GRB 221009A, with relevant implications for fundamental physics.



Credits: J.L. de la Rosa (IAA-CSIC)

As part of the **SN2** project, which focuses on building a spectrophotometric sample of Type Ia supernovae, the Hubble constant was obtained using two sibling Type Ia supernovae in the galaxy NGC 4414 [124].

Stellar occultations by TNOs and Centaurs observed from OSN are used to constrain the physical properties of distant solar system icy bodies. Occultations by TNOs 2003VS2 and Huya allowed the 3D shapes and physical properties of both objects to be obtained. No rings or atmospheres were detected in these occultations [372,330].

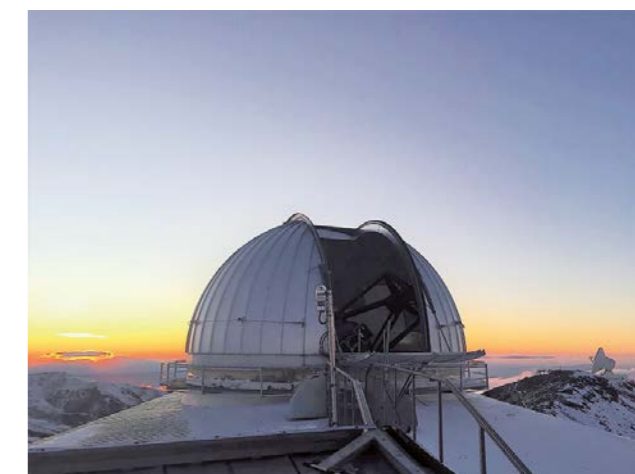
Other programs running at OSN included the **exoplanetary transits** project, which provides very useful data for inferring the properties of exoplanets, the **TESS follow-up** project to confirm or reject exoplanet candidates detected by that satellite, and the **TNO photometry** program to obtain rotational properties of TNOs and Centaurs.

Main Technical Activities

In a coordinated effort by UDIT and OSN, the three mirrors of T150 were transferred to CAHA for aluminizing in July, after the removal of the mirror coating. Due to minor damages detected on M2, the mirror was not aluminized and T150 was been out of service for the remainder of the year. In late August 2022, Tecnica 6000 SL began upgrading the T90's control electronics, which is expected to be completed in 2023.

External collaborations

- SMART Project (Univ. Huelva), analysis of inter-planetary matter impacting our planet with five robotic cameras at OSN.
- L3AMetSurf Project (Univ. Granada), testing of samples to study material properties and search for patentable anti-icing solutions.
- Topo-Iberia station (Univ. Barcelona), a GPS station used for integrated studies of topography and 4-D evolution.
- Master in Astronomy and Astrophysics (Valencia International Univ.), for which observing practices are carried out under an agreement.



Credits: F.J. Aceituno (IAA-CSIC)

The ESFRI initiatives



Credits: CTAO, Akihiro Ikeshita, Mero-TSK, International

Cherenkov Telescope Array (CTA)

CTA, with its large collecting area and wide sky coverage, will be the largest and most sensitive high-energy gamma-ray observatory in the world. It will exceed the performance of existing instruments in terms of angular resolution, energy coverage and field of view. The formal application to the European Commission to establish the CTAO (CTA Observatory) ERIC was submitted. CTA is an ESFRI landmark.

In 2022, the **Gammapy** open source software package, in whose development the IAA played an important role, and on which CTAO's official scientific analysis tools are based, was awarded by the French Ministry of Higher Education, Research and Innovation with the **Jury Prize** during the **Open Science Awards for Open Source Research Software**. CTA's first telescope, LST1, continued to operate normally and started preparing its first scientific publications, with IAA leadership.

Extremely Large Telescope (ELT)

ESO is developing the ELT, a revolutionary ground-based telescope that will have a 39-meter main mirror, making it the world's largest visible-light and infrared telescope. In 2021, the official start of two new second-generation instrumental projects for the ELT, ANDES and MOSAIC, both with IAA participation, was approved by the Council of ESO.

The participation of the IAA-CSIC in the technological development of MOSAIC includes the control system of the cryogenic mechanisms associated with the infrared spectrograph (NIR-SPEC), both the control electronics and the high and low level software. To this end, during 2022 the design and implementation of the first prototype was performed, whose testing in cryostat is in progress. On the other hand, UDIT was involved in the mechanical design of the optics supports for two of its fibre-fed spectrographs. For ANDES, UDIT was involved in the mechanical design of the optics supports for its spectrographs.



Credits: ESO, ELT project

Square Kilometer Array (SKA)

The SKA project, an ESFRI landmark, will be the world's most sensitive radio telescope, able to conduct transformational science in different scientific fields. The SKA Observatory (SKAO) is the world's second intergovernmental organisation (IGO) dedicated to astronomy. Its construction began in 2021. Spain has been pre-allocated several contracts related to band receivers, timing distribution and dish manufacture, with IAA's contributing to the associated negotiations.

In 2022, there were groundbreaking opening ceremonies in South Africa and Australia, where SKA-mid and SKA-low will be located. On the Spanish side, the negotiation for the Spain's accession to the SKAO was almost finalized, and the Spanish Ministry of Finance approved the financial contribution to the SKAO until 2030. SKAO will require a network of regional centers (SRCs) that will constitute its scientific core, providing access to data, analysis tools and computational resources. Likewise, the Spanish prototype SRC, led by the IAA as part of its Severo Ochoa Strategic Program, contributed to defining the requirements of the SRC network, also leading one of the seven international prototyping teams. It was the only team to achieve the **gold credential for reproducibility** in the second SKA challenge.

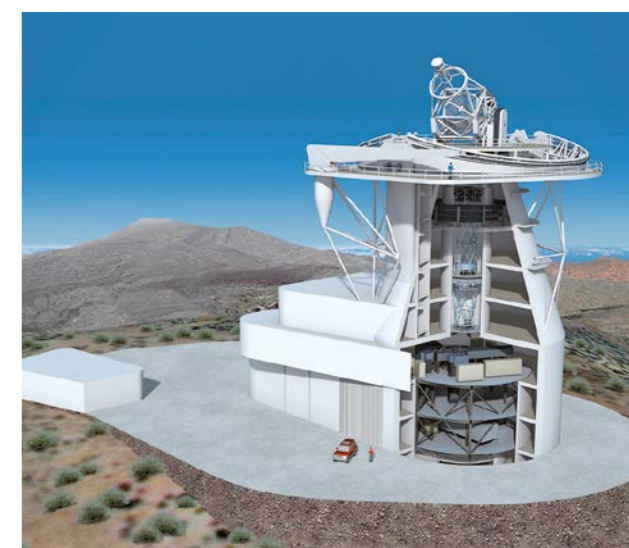


Credits: SKA Observatory

European Solar Telescope (EST)

The EST, an ESFRI landmark, will be the largest solar telescope in Europe. With a 4.2-meter primary mirror and state-of-the-art technology, it will provide astronomers with a unique tool to understand the Sun and study space weather conditions.

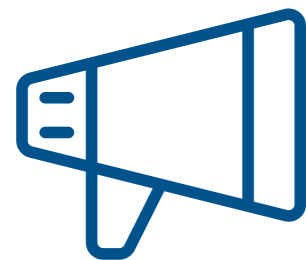
Throughout 2022, the preliminary design of the EST, including the basic construction project at the Roque de Los Muchachos Observatory, was completed. This preliminary design will be reviewed by an international committee of experts in 2023. In parallel, the design of the instruments progressed at a good pace. The IAA, as responsible for the three **Tunable Imaging Spectropolarimeters** of EST, presented a conceptual design that is currently being worked on. On the other hand, the **IAA-CSIC maintains the EST Communication Office** in Granada beyond the preparatory phase.



Credits: EST project, Gabriel Pérez (IAC)

Public Outreach

The activities of the IAA-CSIC Communication, Education and Public Outreach Unit cover almost all existing formats to communicate science.



Popular Science Journal IAA: Información y Actualidad Astronómica. Issued once every four months, it is devoted to high school and university students, as well as general public interested in astronomy. Issues in 2022: 63, 64, 65.

Lucas Lara popular talks. These conferences are held since in 1995. We celebrate nine talks every year.

The European Researchers' Night takes place every year all over Europe the last Friday of September. The IAA-CSIC took part in the event in Granada on Friday 24th September.



PIISA Project. A multidisciplinary project designed to allow high school students work with scientists. The IAA-CSIC is the founder of the project.

Course "Astrophysics in the classroom, 2nd edition" for primary and secondary school teachers in collaboration with the Granada Teacher Training Centre (CEP Granada) and participation in for CESAR courses (INTA) for teachers.



Social Networks.

Twitter, facebook, youtube and Instagram profiles managing.

- https://twitter.com/iaa_csic
- <https://www.facebook.com/iaa.comunicacion>
- <https://www.youtube.com/user/iaaudc>
- https://www.instagram.com/iaa_csic



"MARS in a box" is an educational project aiming at introducing European secondary school students to fundamental science through cutting-edge research on Mars. <https://marsinbox.eu/>



PRE-EST project (European Solar Telescope). Communication support and recording of the videogame "Solar Mission" and different communication activities.

Desgranando Ciencia science festival. Coorganization.

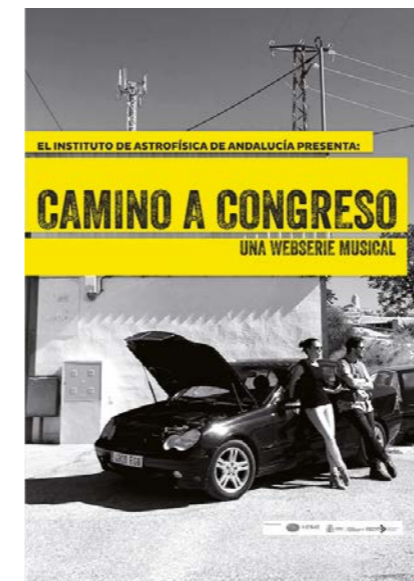
11 February, International Day of Woman and Girls in Science. Conferences and workshops with students. <https://www.iaa.es/noticias/dia-internacional-mujer-y-nina-en-ciencia-2022>.

8 March, International Day of Woman.

Astronomía Accesible. This project aims to enhance the popularization of astronomy among blind and low-vision people.

Camino a Congreso.

Audiovisual project that is committed to a new format, the music webseries, which combines fiction, science outreach and music. Six episodes. PRISMAS award for the best audiovisual.



Desgranando Ciencia

Organization of the "Scientific communication techniques course 5th edition" at Desgranando 2022.

Presentation of the book **"La Contaminación Luminica"** written by Alicia Pelegrina (IAA-CSIC) CSIC editorial.

Calar Alto Observatory Communication. The IAA-CSIC Communication, Education and Public Outreach Unit helps develop communication strategies and press releases for the observatory.

Revista Astronomía.

The IAA maintains a monthly collaboration with the magazine, the only one with a commercial circulation specialised in astronomy.

TAI#tatgranada

#TATGranada 2021.

International conference on twitter. The IAA is participating as a global partner with a specialised speaker on Artificial Intelligence and Astronomy.

Participation in the **AMANAR project** with a visit of children in Saharawi refugee camps to Calar Alto Observatory.

Granada Book Fair 2022

Organization of the "Area de la Ciencia", a stand for science outreach activities at the Granada Book Fair 2022.

Participation in the **Gravite Festival** and "Viajero en el Tiempo" award.

"Astrosound" festival in collaboration with the Granada Sound Festival.



Participation in **"Granada: ciudad de la Ciencia y la Innovación"**, a FECYT funded project of the largest institutions in Granada to bring science and knowledge closer to citizens.

Production of several audiovisuals and numerous exhibitions of the television series **"Territorio Gravedad"** and presentation of the documentary **"Reaching for the Sun"**.



"Entre Sillas" event organized by the Institute of Astrophysics of Andalusia (IAA-CSIC) and the Department of Equality of the Granada City Council .

"The Universe in Words" a series of videos describing images (audio description) of some popular objects of our sky.



"The Universe we will see" round table, with the participation of the general managers of ESO, CTAO and SKAO. Organized by IAA-CSIC and CTAO Communication Office.

Collaboration with **"Hablando de Ciencia"** association and participation in different courses and workshops about science communication.

Sky Quality Office

(OCC-IAA)



Panoramic view of the Milky Way from Puebla de Don Pabrique (Granada), near Murcia. Credits: Máximo Bustamante-Calabria (OCC-IAA)

Overview

The OCC was created in 2016 as an instrument to preserve the astronomical sky quality at the Sierra Nevada and Calar Alto observatories against the threat of light pollution. Due to an increase of night sky brightness in recent years, the office aims at serving as a scientific reference for institutions and agents in the protection and improvement of the dark sky, in addition to advising and promoting the best practices for correct outdoor lighting. Illuminating properly and sustainably is essential to preserve the nocturnal ecosystem and minimize the harmful effects to human health. To monitor the sky brightness, the OCC has installed different types of photometers at the Sierra Nevada Observatory and at the IAA buildings.

Highlights and Activities

Research. Two scientific papers were published in 2022 by members of the OCC. The first one is a review on the environmental impacts of artificial light at night (ALAN) as a consequence of the general increase in the use of LEDs which emit mainly in blue wavelengths [128]. The second paper shows the importance of the citizen science by offering the possibility of obtaining information about the colour of outdoor lighting using pictures taken with our mobile phones [259].

New equipment. A TESS-4C multicolor photometer was installed at the Sierra Nevada Observatory to measure sky brightness. This instrument equipped with GRB filters is allowing us to compare the measurements with the other types of devices and filters already existing in the observatory, such as the ASTMON (All-Sky Transmission MONitor) and SQM (Sky Quality Meters).

Institutional collaborations. At the end of 2022, a scientific-technical report of the results obtained from an extensive study on the night sky quality within the Granada Geopark territory was published in collaboration with the Granada Provincial Council [*]. Thanks to this project, a new methodology for night sky quality assessment was developed, combining ground-based measurements with the analysis of remote images from space [**]. Additionally, several collaborations were carried out mainly with institutions located in Granada and Almería, and in particular, those related to the Natural Parks of Sierra Nevada and Cabo de Gata-Níjar. The OCC proposed the inclusion of the night sky as part of the natural heritage in the environmental planning of Sierra Nevada Park.

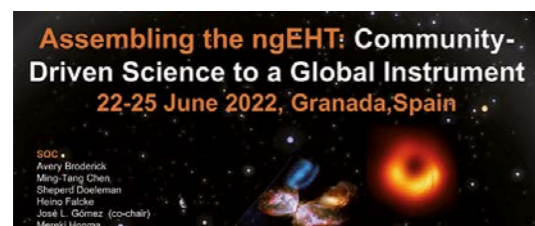
The participation in **educational and outreach activities** is one of the main tasks of the OCC with the aim of raising public awareness on the threat of light pollution. A book was published on light pollution that explains this environmental problem and analyses its main causes in a simple and entertaining way [***]. The publication was accompanied by a number of talks, interviews and TV reports.

Publications

- [*] S. Martín-Ruiz, M. Bustamante-Calabria, A. Sánchez de Miguel. Geoparque de Granada Estudio de la Calidad de su cielo nocturno, <https://doi.org/10.5281/zenodo.7688544> [2022].
- [**] M. Bustamante-Calabria. Caracterización del alumbrado público de diversos núcleos a través de las emisiones lumínicas medidas a partir de imágenes tomadas desde la ISS, Trabajo Fin de Máster, Universidad de Nebrija [2022]
- [***] A. Pelegrina. La contaminación lumínica, Colección ¿Qué sabemos de? [CSIC – Catarata] (abril, 2022).



Workshops & meetings



International Meetings

Assembling the ngEHT: Community-Driven Science to a Global Instrument

Granada, June 22-26, 2022

IAA MEMBERS OF THE SCIENTIFIC ORGANIZING COMMITTEE:

J.L. Gómez

IAA MEMBERS OF THE LOCAL ORGANIZING COMMITTEE:

A. Alberdi, I. Cho, R. Dahale, M. Foschi, A. Fuentes, J.L. Gomez, R. Lico, A. Pelegrina, T. Toscano, T. Traianou, G.-Y. Zhao

<https://www.ngeht.org/ngeht-meeting-june-2022>

41st European Symposium on Occultation Projects (ESOP)

Granada, Sep 09 - 11, 2022

IAA MEMBERS OF THE SCIENTIFIC ORGANIZING COMMITTEE:

P. Santos-Sanz, J. Ortiz, R. Duffard, M. Kretlow, M. Vara

IAA MEMBERS OF THE LOCAL ORGANIZING COMMITTEE:
P. Santos-Sanz, M. Kretlow, N. Morales, R. Duffard, J. Ortiz, M. Vara

<https://iota-es.de/esop41/index.php>

Europlanet Science Congress 2022

Granada, Sep 18-23, 2022

IAA MEMBERS OF THE LOCAL ORGANIZING COMMITTEE:

L.M. Lara, E. Perez-Montero, M. López-Puertas, M. García Comas, P. Gutiérrez, D. Guirado, A. Pelegrina, O. Muñoz, I. Márquez, F. González-Galindo, J.C. Gómez, D. Shulyak, M.A. López-Valverde

<https://www.epsc2022.eu>

IAA Severo Ochoa Meeting: Addressing key astrophysical questions from Granada

Granada, Oct 18 - 21, 2022

IAA MEMBERS OF THE SCIENTIFIC ORGANIZING COMMITTEE:

I. Márquez (chair), A. Alberdi, J. Masegosa, O. Muñoz, J. Ortiz, R. Schoedel, J. Vilchez

IAA MEMBERS OF THE LOCAL ORGANIZING COMMITTEE:

I. Márquez, M. González, A. Pelegrina

<https://www.granadacongresos.com/severochoa>

VIII Meeting on Fundamental Cosmology

Granada, Nov 02 - 04, 2022

IAA MEMBERS OF THE SCIENTIFIC ORGANIZING COMMITTEE:

F. Prada (co-chair)

IAA MEMBERS OF THE LOCAL ORGANIZING COMMITTEE:

J. Ferrer Ezeza

<https://home.iaa.csic.es/fundcosmo22/>

Schools

IAA-SO Advanced School on Galaxy Evolution

Granada, May 23 - 27, 2022

IAA MEMBERS OF THE ORGANIZING COMMITTEE:

J.M. Vilchez

IAA MEMBERS OF THE LOCAL ORGANIZING COMMITTEE:

A. Pelegrina, M. González

<https://www.granadacongresos.com/galevol>

SO Instrumentation School VII. Metrology with PC-DMIS on a portable Romer Absolute Arms

Granada, Jan 17 - 21, 2022

<https://forms.gle/tTwNDBXBEB3WSD1L7>

SO Instrumentation School VIII. Signal Integrity and Electromagnetic Compatibility in Electronic Devices

Granada, Apr 04 - 08, 2022

<https://forms.gle/jzi3B6QTakBaVX8X6>

SO Instrumentation School IX: Opto-mechanical systems and mechanical design of IR instrumentation

Granada, Feb 07 - 18, 2022

<https://forms.gle/xHppq7h8uosWeitd6>

Spanish for beginners at the IAA-CSIC

Granada, Oct 21, 2021 - Jan 22, 2022

English for Academic Purposes

AN ONLINE WORKSHOP SERIES FOR YOUNG RESEARCHERS

Granada, Mar 14 - 18, 2022

<https://forms.gle/89h5FYQqCsazga8n6>

PySnacks - Introductions to Astrophysical Python Packages

On line, Mar 21 - Apr 01, 2022

<https://forms.gle/3XsuaJyT9eHC4ZS8>

Gender Analysis in Research

Granada, May 17 - 18, 2022

<https://www.iaa.csic.es/meetings/gender-analysis-research>

Course on Dissemination Techniques. Recreational and Training Days

Granada, May 20 - 22, 2022

<https://granada.hablandodociencia.com/curso/>

PySnacks - Matplotlib for Beginners II

On line, Jun 15 - 17, 2022

<https://forms.gle/woGcRssZ4H6QQ3kA7>



Gender actions



Overview

The IAA is characterized by its support of inclusive initiatives in Gender Equality. This trajectory crystallized in the creation of the Institute's Gender Equality Commission and the elaboration and approval of the First Gender Equality Plan of the IAA-CSIC (GEP), in 2017. Here we present the main activities for the year 2022. The Equality Commission continued its work of advising on the necessary or appropriate measures to actively integrate the principle of gender equality between women and men in the daily life of the centre, as well as organizing events to raise awareness of the role of women in science.

Highlights

In addition to ensuring the gender equality measures, the Gender Equality Commission of the IAA-CSIC acts as the **Gender Working Group** of the gender equality plan drawn up by the Severo Ochoa project.

Within the **Vera Rubin Colloquium programme**: 8 colloquia, out of the 24 offered, were given by female researchers.

Gender Activities in 2022 in the center:

- Production of the annual statistics segregated by gender.
- Activities for the **International day of Women and girls in Science (11 February)**.

Conferences: Different informal meetings with women researchers, engineers and technicians at the IAA were held for educational centers in Granada with the aim of highlighting the role of women in the different branches of science. They included open discussions about gender roles and the existing stereotypes in science, technology and engineering.

Meeting with Female Researchers: In 2022 this activity was carried out jointly with the Science Park and the Granada Teachers' Center.

Astronomical round tables: Organised every year to confront secondary school students with astronomers, allowing them a rich exchange of information from the different areas of knowledge at the institute. In 2022 the IAA personnel were Alicia Pelegrina, Teresa Gallego, Camilla Danielski, Beatriz Agís and Yolanda Jiménez, who interacted with a group of about 30 students from the Zaidín-Vergeles Secondary School.

"Is that question for me?": Schoolchildren from two primary schools posed questions about astronomy, that were answered by the astronomers Laura Hermosa, Azaymi Su, Sara Cazzoli and Maria Passas in a very accessible and funny format. The recording of this event is available at the IAA-CSIC youtube channel (<https://youtu.be/DuU2i5IFqto>)



Exhibition "AstrónomAs": (<http://astronomas.org>), with the participation of astronomers from the IAA-CSIC was installed in the hall of the City Council and the Science Park in Granada.

"Contrapuntos - Pepa Masegosa": We started a series of interviews, combining text and audio, with colleagues of the IAA-CSIC who have much to say beyond their own scientific work. Five voices talked about their experiences closer to their personal history than to the last result they have published. The series "Contrapuntos" was one of the works carried out by Lucía Casas during her stay at the IAA. Coinciding with the celebration of February 11, we published the first episode, in which our colleague Pepa Masegosa was interviewed (<https://www.iaa.es/noticias/contrapuntos-pepa-masegosa>).

The astronomers Isabel Márquez and Josefa Masegosa were invited to participate in the round table **"Mujeres Granadinas que hacen Ciencia"**, organized by the Department of Equality of the Granada City Council, and broadcasted through the local TV channel TG7 (<https://www.youtube.com/watch?v=tXmCNxavV8M>)



The European Solar Telescope (EST) project joined UNESCO's **International Day of Women and Girls in Science**. Twelve female solar astronomers and engineers from the EST consortium met and share their work and life experiences with high-school students in Italy and Spain (<https://www.est-east.eu/component/content/article/22-english/1163-11f-international-day-of-women-and-girls-in-science-2022?highlight=WyJpbmRlcm5hdGlvbmFslwiZGF5liwiaW50ZXJuYX-Rpb25hbCBkYXkiXQ==&Itemid=659>)

- Activities from the International **Women's Day (8 de Febrero)**:

Susana Guerrero Salazar, professor of Spanish language at the University of Malaga, gave the lecture **¿Favorece el lenguaje el empoderamiento de las mujeres?** (Does language help women's empowerment?). This conference was organized by the IAA-CSIC, and the Spanish Astronomical Society was invited to participate.



“Entre Sillas”: This outreach event on March 8th was offered to the Granada society at the theater “Isidro Olgoso” of Zaidín, organized by the IAA-CSIC and the Department of Equality of the Granada City Council. “Entre Sillas” was a meeting between six female voices from the world of acting, photography, sports, journalism, and science. We had the journalist Susana Escudero, the actress Nerea Cordero, the researcher Isabel Márquez, the footballer Ana Urrea, the science communicator Alicia Pelegrina, and the photographer Patri Díez. Six women who talked about their life and work experiences, about their way of facing the world and, in short, about themselves. The event was conducted by the IAA researcher Sara Cazzoli, and featured performances by the theatre improvisation group “El Apeadero”.

- Activities for the *International Day for the Elimination of Violence Against Women, 25th November*:

Cineforum “Pint a scientist”: The screening of the documentary “Picture a scientist” was followed by a debate with the invited speakers Lourdes Verdes-Montenegro (IAA-CSIC), Elena Gómez-Díaz (IPBLN-CSIC) and Luisa María Sandalio (EEZ-CSIC).

- Other activities:

The SO training session *Sex and gender analysis in research and innovation* was given by the Professor of Sociology Capitolina Díaz, in which practical details on the inclusion of the gender perspective in research projects were discussed.

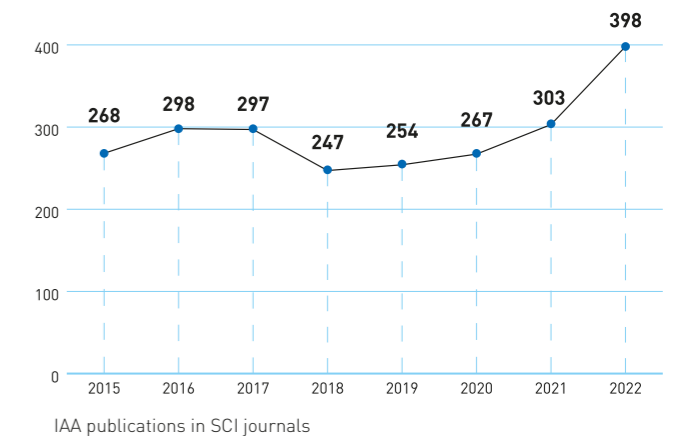
We continued our collaborations with scientific outreach magazines and the newspapers *El País*, *Granada Hoy* and *Ideal*. In the IAA magazine *Información y Actualidad Astronómica*, several articles were published with the aim of making visible female scientists who have contributed significantly to the development of Astronomy.

- **CSIC Gender Equality Commission Meetings:** We participated in the II Meeting of equality committees of the CSIC centers, held on 12th April 2022.

- **SOMMA Gender Equality Commission Meetings:** We participated in the three online meetings organized along the year. As a result, a survey of the SOMMA centers was elaborated. The 3rd SOMMA Gender Working Group event took place in a hybrid format on May 26th with the participation of the CSIC and the Science Ministry.

- **Awards:** Lourdes Verdes-Montenegro was awarded with “Ada Lovelace prize for women in technology”. Josefa Masegosa Gallego was awarded with the prize of Research from the Almería’s City Hall, and with the prize “Mariana Pineda a la igualdad entre hombres y mujeres” from the Granada City Council.

Publications



The research activity carried out at the IAA-CSIC during 2022 can be measured by the number of publications in scientific journals included in the Science Citation Index (SCI), i.e., international journals recognized by their quality and impact. In 2022, this activity resulted in **398 papers published** in journals of the SCI.

The complete list of the IAA-CSIC publications in 2022 is given in the Annex at the end of this report. The evolution of the number of SCI publications since 2015 is shown below. Along the years, the number of publications had fluctuated around an average value of 280 papers per year, but it has significantly increased in the last two years.

The publications of the IAA-CSIC are mostly distributed in high impact journals. About 85% of our publications appeared in journals of the first quartile (top 25% journals, or Q1). Among these publications, 8% appeared in the first decile (top 10% journals, or D1); 19 papers were published in journals from the Nature/Science editorial groups. Most of the IAA-CSIC scientific results are published in *Astronomy & Astrophysics* and *Monthly Notices of the Royal Astronomical Society*, the main European astronomical journals. A significant fraction of our results is published in *Astrophysical Journal*, the most important American astronomical journal. Among these publications, 95% have open access through the CSIC repository.

Another aspect of the scientific research of the IAA and its quantitative results is the leadership of these publications. **In about 19% of the IAA SCI 2022 publications their first author belongs to our institute.** This is consistent with the leadership of the IAA in the last 5 years.

Number of publications by journal

- 128** Astronomy and Astrophysics
- 71** Monthly Notices of the Royal Astronomical Society
- 36** Astrophysical Journal
- 23** Astrophysical Journal Letters
- 11** Astronomical Journal
Astrophysical Journal Supplement Series
- 9** Journal of Geophysical Research, Planets
- 8** Nature Astronomy
Frontiers in Astronomy and Space Sciences
- 7** Nature
Geophysical Research Letters
Galaxies
- 6** Experimental Astronomy
- 5** Planetary and Space Sciences
- 3** Science
Journal of Geophysical Research, Atmospheres
Journal of Geophysical Research, Space Physics
Atmospheric Measurement Techniques
Astronomische Nachrichten
Planetary Science Journal
Remote Sensing
- 2** Astronomy and Computing
European Physical Journal C
Journal of Cosmology and Astroparticle Physics
Journal of Astrophysics and Astronomy
Journal of the American Chemical Society
Publications of the Astronomical Society of Australia
Scientific Reports
Sensors
- 1** Others

Awards



Deusto
Premio Ada Byron
a la mujer tecnóloga

Lourdes Verdes-Montenegro
Premio Ada Byron 2022

Julia Guiomar Niso Galán
Premio Ada Byron Joven 2022

Deusto Microsoft Bizkaia DANOBATGROUP Innobasque BASQUE HEALTHCLUSTER

Lourdes Verdes-Montenegro was awarded with the Senior category of the *Premio Ada Byron a la Mujer Tecnóloga 2022*, IX Edition. Organised by the Faculty of Engineering of the University of Deusto. This award was created to value the work of women technologists and encourage female vocations in technology.

Francisco Bailén was awarded in 2022 with the 2021 *IAU PhD Prize* in the category "Facilities, technologies and data science" for his thesis entitled "Spectropolarimetric and Imaging Properties of Fabry-Pérot Etalons. Applications to Solar Instrumentation". The IAU PhD Prize recognises outstanding scientific achievement in Astrophysics around the world.

Antonio Fuentes and **Rocco Lico** obtained 2022 *EHT Early Career Awards*, "for his outstanding contributions to both the EHT static and dynamic imaging of SgrA*", and "his significant contributions and leadership to the calibration and imaging of SgrA* data", respectively.

Josefa Masegosa was awarded with the *Premio Mariana Pineda de Igualdad 2022* from the Ayuntamiento de Granada, recognising her professional career and her permanent activity of promotion and visibility of the role of women in science and astronomy.

Emilio J. García and **Manuel González** received the award for the best video work in the 2022 edition of the *Prismas Casa de las Ciencias a la Divulgación* for the musical webseries *Camino a Congreso*. The jury pointed out that the series is "an audiovisual fiction of great technical quality that portrays the day-to-day life of a scientific team with humour".

Enrique Pérez Montero received the *Jury's Special Prisma award* for "promoting a form of popularisation that brings science closer to the visually impaired and makes society as a whole reflect".

Francisco Nogueras was awarded with the *Premio Extraordinario de Doctorado 2018-2019* from the Universidad de Granada, for his PhD thesis entitled "The structure and stellar population of the nuclear bulge of the Milky Way", developed at the IAA.

The IAA-CSIC was awarded with the *IV Premio Viajero en el Tiempo* (4th Time Traveller Award) by the *Gravite Festival*. This award recognised the IAA as a centre that, in addition to the excellence of its research, has a permanent vocation for scientific dissemination, and is a clear example of Science and Humanities being parts of the same whole.



Josefa Masegosa was awarded with the Premio Mariana Pineda de Igualdad 2022



The IAA-CSIC was awarded with the IV Premio Viajero en el Tiempo by the Gravite Festival.



Enrique Pérez Montero received the Jury's Special Prisma award



Francisco Bailén was awarded with the 2021 IAU PhD Prize

Funding



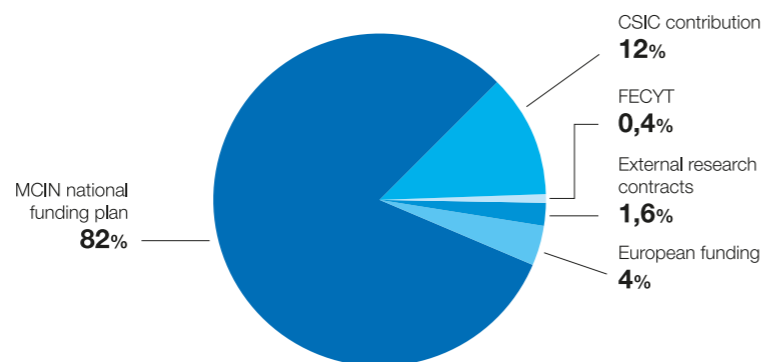
The IAA obtains most of its funding through competitive European and Spanish grants (**9,6 million €**).

During 2022, IAA had a total budget of **14,8 million €**, from which **7,4 million €** (50%) come from competitive projects and CSIC investments; the other **7,4 million €** (50%) correspond to the permanent staff total cost and common expenses.

The yearly evolution of the IAA budget in the last 5 years is shown below, including the different concepts.

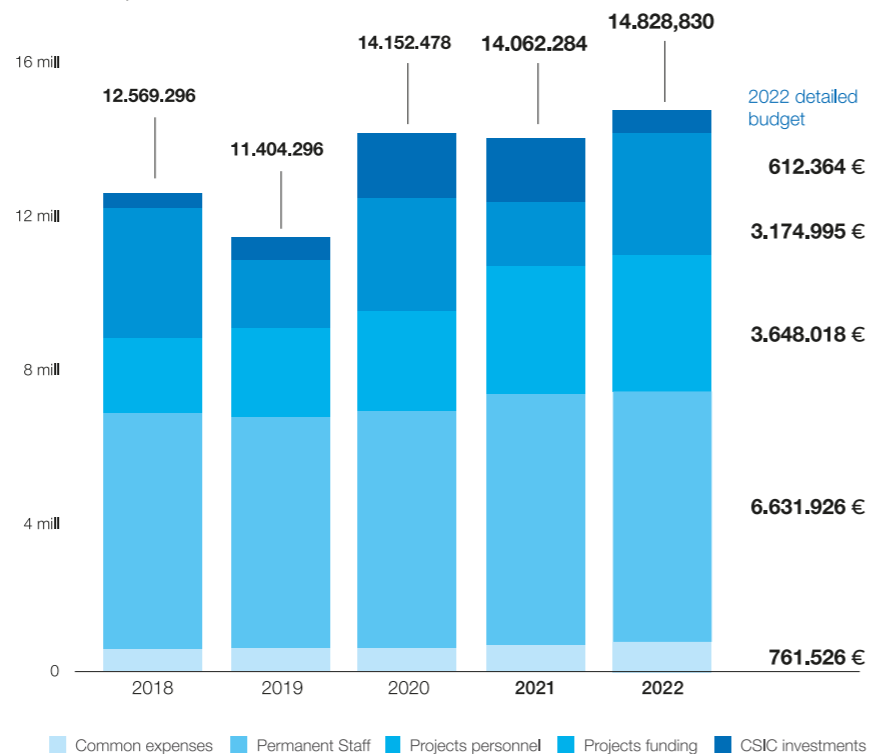
IAA 2022 competitive fundings

Total:
9,6 million €

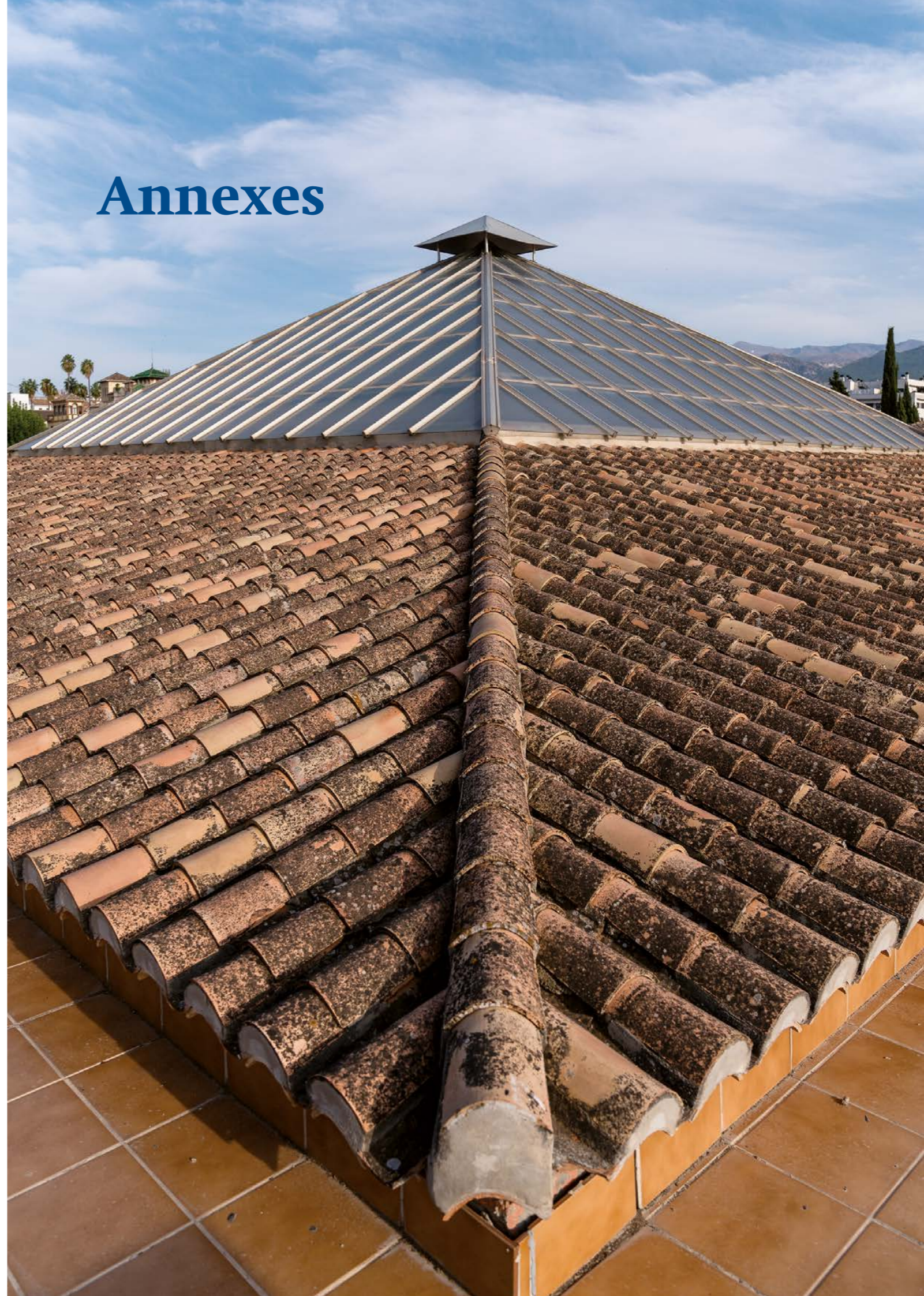


IAA budget yearly evolution

Total 2022:
14,8 million €



Annexes



Committees



IAA Council (Junta de Instituto)

President: A. Alberdi (*Director*)
Secretary: F.J. Tapia (*IAA Manager*)
 I. Márquez (*Deputy Science Director*)
 L.M. Lara (*Deputy Technology Director up to July 2022*)
 R. Duffard (*Head of Solar System Dpt., DSS*)
 P.J. Amado (*Head of Stellar Physics Dpt., DFE*)
 E. Alfaro (*Head of Radio Astron. & Galactic Str. Dpt., DRAEG*)
 R.M. González-Delgado (*Head of Extragalactic Astronomy Dpt., DAE*)
 M. González (*Personnel representative*)
 M. Osorio (*Personnel representative*)
 D. Pérez-Medialdea (*Personnel representative*)
 J.F. Rodríguez (*Personnel representative*)
 J. Moldón (*Postdocs representative*)
 L. Hermosa-Muñoz (*Predocs representative*)

UDIT Management Committee

L.M. Lara (*Deputy Technology Director up to July 2022*)
 M. Balaguer (*Head of UDIT*)
 A. López (*UDIT*)
 M. García Comas (*DSS*)
 J. Iglesias (*DAE*)

Gender Equality Commission (at 31 Dec 2022)

J. Masegosa (*Chair*)
 B. Agis
 B. Aparicio
 E. García
 Y. Jimenez-Teja
 M. Passas
 A. Alberdi

PhD Monitoring Committee

L.F. Miranda (*Chair, DRAEG*)
 J. Masegosa (*DAE*)
 M. Caballero (*DFE*)
 G. Gilli (*DSS*)
 F.J. Bailén (*UDIT*)
 T. Toscano (*Predocs representative*)

IAA Work Quality Committee

F.J. Tapia (*Head*)
 F. Álvarez (*Coordinator*)
 I. Bustamante
 A.J. García Segura
 C.E. Madrid

OSN Time Allocation Committee

M. L. García Comas (*Chair / OSN Scientific Director up to Nov. 2022*)
 P. Santos-Sanz (*Chair / OSN Scientific Director since Nov. 2022*)
 O. Muñoz (*DSS, up to Nov. 2022*)
 P. Gutiérrez (*DSS, since Nov. 2022*)
 R. García Benito (*DAE*)
 S. Martín (*DFE*)
 A. Sota (*DRADyEG / UDIT*)

SO-IAA Executive & Scientific Committee

I. Márquez (*Chair, Scientific Director SO-IAA project*)
 A. Alberdi (*IAA Director*)
 F.J. Tapia (*IAA Manager*)
 J. Masegosa (*Gender Coordinator*)
 J.L. Ortiz (*Coordinator Pillar 1*)
 R. Schoedel (*Coordinator Pillar 2 & SO Training Coordinator*)
 J.M. Vilchez (*Coordinator Pillar 3*)
 O. Muñoz (*Coordinator Pillar 4*)

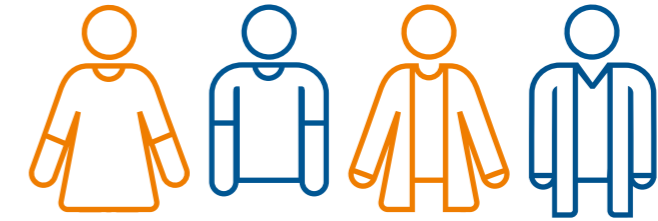
SO-IAA “Garantes” Committee

I. Márquez (*Chair, Scientific Director SO-IAA project*)
 E.J. Alfaro
 A. del Olmo
 R. Duffard
 R.M. González-Delgado
 J.L. Gómez
 L.M. Lara
 M. López-Puertas
 M.A. López Valverde
 E. Pérez Jiménez
 E. Pérez Montero
 J.L. Ortiz
 J.M. Vilchez

External Scientific Advisory Board (ESAB)

Prof. Silvia Torres Peimbert. Universidad Nacional Autónoma de México, México. (*Chair*)
 Prof. You-Hua Chu. Academia Sinica, Institute of Astronomy and Astrophysics, ASIAA, Taiwan.
 Prof. Athena Coustenis. CNRS LESIA, Paris-Meudon, Francia.
 Prof. Ángeles I. Díaz. Universidad Autónoma de Madrid, España.
 Prof. Holland Ford. Johns Hopkins University, EEUU.
 Prof. Valentín Martínez Pillet. National Solar Observatory, EEUU.
 Prof. Michael Perryman. University College, Dublin, Ireland.
 Prof. Luis Felipe Rodríguez. CRYA, Universidad Nacional Autónoma de México, México.
 Prof. Eduardo Ros. Max Planck Institut für Radioastronomie, Alemania.
 Prof. Nicholas Thomas. Universidad de Berna, Physikalisches Institut, Suiza.

Staff



Assigned research group

- ^[1] Solar Physics
- ^[2] Planets and minor bodies
- ^[3] Terrestrial atmosphere
- ^[4] Low-mass stars
- ^[5] Stellar variability
- ^[6] ARAE
- ^[7] Stellar systems
- ^[8] Physics of the interstellar medium
- ^[9] AGN jets
- ^[10] Galaxy evolution
- ^[11] Theoretical gravitation and cosmology
- ^[12] Cosmology and particle physics
- ^[13] Observational cosmology

STAFF RESEARCHERS

Research Professors

Alberdi Odriozola, Antonio María ^[8]
 Castro Tirado, Alberto Javier ^[6]
 del Toro Iniesta, Jose Carlos ^[1]
 Garrido Haba, Rafael ^[5]
 González Delgado, Rosa María ^[10]
 López Puertas, Manuel ^[3]
 Pérez Jiménez, Enrique ^[10]
 Prada Martínez, Francisco ^[12]
 Vilchez Medina, José Manuel ^[10]

Scientific Researchers

Aceituno Castro, Jesús ^[10]
 Alfaro Navarro, Emilio Javier ^[7]
 Anglada i Pons, Guillem Josep ^[8]
 Bellot Rubio, Luis Ramón ^[1]
 Funke, Bernd Rainer ^[3]
 Gómez Fernández, José Luis ^[9]
 Guerrero Roncel, Martín ^[8]
 Lara López, Luisa María ^[2]
 Márquez Pérez, Isabel ^[10]
 Masegosa Gallego, Josefa ^[10]
 Moreno Danvila, Fernando ^[2]
 Ortiz Moreno, José Luis ^[2]
 Pérez Montero, Enrique ^[10]
 Pérez Torres, Miguel Angel ^[8]
 Rodríguez Martínez, Eloy ^[4]
 Schoedel, Rainer ^[7]
 Verdes-Montenegro Atalaya, Lourdes ^[10]

Senior Scientists

Agudo Rodríguez, Juan Iván ^[9]
 Amado González, Pedro José ^[4]
 Barceló Serón, Carlos ^[11]
 Claret dos Santos, Antonio ^[4]
 del Olmo Orozco, Ascensión ^[10]
 Duffard, René Damián ^[2]
 Fernández Hernández, Matilde ^[4]
 García Benito, Rubén ^[10]
 García Comas, Maia Leire ^[3]
 Gómez Rivero, José Francisco ^[8]
 Gordillo Vázquez, Francisco José ^[3]
 Gutiérrez Buenestado, Pedro José ^[2]
 Iglesias Páramo, Jorge ^[10]
 López González, María José ^[3]
 López Jiménez, Antonio Carlos ^[1]
 López Valverde, Miguel Angel ^[3]
 Luque Estepa, Alejandro ^[3]
 Miranda Palacios, Luis Felipe ^[8]
 Muñoz Gómez, Olga ^[2]
 Olivares Martín, José Ignacio ^[5]
 Perea Duarte, Jaime David ^[10]
 Rodríguez Gómez, Julio Federico ^[5]
 Ruedas Sánchez, José ^[13]

Permanent doctor contract

Guirado Rodríguez, Daniel ^[2]
 González Galindo, Francisco ^[3]
 Osorio Gutiérrez, Mayra Carolina ^[8]
 Rodríguez López, Cristina Teresa ^[4]
 Santos-Sanz, Pablo ^[2]

Ongoing projects



AGENCIA ESTATAL DE INVESTIGACIÓN

Title: Apoyo a Centros de Excelencia Severo Ochoa

Ref.: SEV-2017-0709

Pl: Isabel Márquez Pérez

Dur.: Jul 01, 2018 - Dec 30, 2022

Title: Space science and technology for the exploration of comets and rocky planets EnVision mission PCU

Ref.: PCI2022-135027-2

Pl: Luisa María Lara López

Dur.: Dec 12, 2022 - Dec 11, 2025

Title: Space solar physics and space weather PMI instrument

Ref.: PCI2022-135009-2

Pl: Jose Carlos del Toro Iniesta

Dur.: Sep 01, 2022 - May 31, 2025

Title: Un enfoque sostenible para los centros de datos de la infraestructura de Big Data del SKA: el prototipo español de Centro Regional del SKA

Ref.: TED2021-130231B-I00

Pl: Julian Garrido Sánchez

Dur.: Sep 01, 2022 - Aug 31, 2025

Title: Cometary and Asteroidal dust Science

Ref.: PID2021-1233700B-I00

Pl: Olga Muñoz Gómez, Juan Carlos Gómez Martín

Dur.: Sep 01, 2022 - Aug 31, 2025

Title: AMIGA8: Estudio con precursores de SKA de la evolución de galaxias en entornos extremos regulada a grandes escalas. Nuevas tecnologías para SKA y su Red de Centros Regionales

Ref.: PID2021-1239300B-C21

Pl: Kelley Michelle Hess, Lourdes Verdes-Montenegro Atalaya

Dur.: Sep 01, 2022 - Aug 31, 2025

Title: Física solar espacial y tiempo espacial

Ref.: PID2021-1253250B-C51

Pl: Jose Carlos del Toro Iniesta, David Orozco Suárez

Dur.: Sep 01, 2022 - Aug 31, 2025

Title: Tests de modelos cosmológicos con las medidas de BAO y H0 realizadas con DESI y MAAT

Ref.: PID2021-126086NB-I00

Pl: Francisco Prada Martínez

Dur.: Sep 01, 2022 - Aug 31, 2025

Title: Ciencia y tecnología espaciales para la exploración de cometas y planetas rocosos

Ref.: PID2021-126365NB-C21

Pl: Pedro José Gutiérrez Buenestado, Luisa María Lara López

Dur.: Sep 01, 2022 - Aug 31, 2025

Title: Un nuevo instrumento de campo integral para el espectrógrafo OSIRIS en el Gran Telescopio Canarias

Ref.: EQC2021-007105-P

Pl: Francisco Prada Martínez

Dur.: Jun 01, 2021 - Dec 31, 2024

Title: Física de los objetos transneptunianos y poblaciones relacionadas

Ref.: PID2020-112789GB-I00

Pl: José Luis Ortiz Moreno

Dur.: Sep 01, 2021 - Aug 31, 2024

Title: Sistemas planetarios a lo largo de la evolución estelar

Ref.: PID2020-114461GB-I00

Pl: Guillem Josep Anglada i Pons, José Francisco Gómez

Dur.: Sep 01, 2021 - Aug 31, 2024

Title: Búsqueda de corrientes estelares de marea en el universo local con cartografiados de imagen

Ref.: PID2020-114581GB-C21

Pl: David Martínez Delgado

Dur.: Sep 01, 2021 - Aug 31, 2024

Title: De los exoplanetas a los agujeros negros supermasivos: la exploración de las fronteras

Ref.: PID2020-117404GB-C21

Pl: Miguel Ángel Pérez-Torres, Antonio Alberdi

Dur.: Sep 01, 2021 - Aug 31, 2024

Title: El universo cuántico gravitacional: espaciotiempos efectivos y sus fluctuaciones cuánticas

Ref.: PID2020-118159GB-C43

Pl: Carlos Barceló Serón

Dur.: Sep 01, 2021 - Aug 31, 2024

Title: Detección de fenómenos transitorios haciendo uso de instrumentación robótica con alta resolución temporal

Ref.: PID2020-118491GB-I00

Pl: Alberto Javier Castro Tirado

Dur.: Sep 01, 2021 - Aug 31, 2024

Title: Galaxias en 3D y sus propiedades integradas: sinergia entre J-PAS/J-PLUS e IFS

Ref.: PID2019-109067GB-I00

Pl: Rosa María González Delgado

Dur.: Jun 01, 2020 - Nov 30, 2024

Title: Unpuzzling the milky way S nucleus - kinematics as key to structure, history, and star formation

Ref.: EUR2022-134031 UNPUZZLING

THE MILKY WAY S NUCLEUS -

Pl: Rainer Schoedel

Dur.: Dec 01, 2022 - Nov 30, 2024

Title: Participación del IAA-CSIC en la misión espacial PLATO2.0. fases C/D-1. Operación NOMAD-EXOMARS

Ref.: PID2019-107061GB-C63

Pl: Rafael Garrido Haba, Julio

Federico Rodríguez Gómez

Dur.: Jun 01, 2020 - May 31, 2024

Title: Astronomía de rayos gamma con MAGIC y CTA-NORTE - contribución del IAA-CSIC

Ref.: PID2019-107847RB-C44

Pl: Juan Iván Agudo Rodríguez

Dur.: Jun 01, 2020 - May 31, 2024

Title: Comprensión de la actividad nuclear en galaxias: de las bajas a las altas tasas de acreción

Ref.: PID2019-106027GB-C41

Pl: Isabel Márquez Pérez, Ascensión del Olmo Orozco

Dur.: Jun 01, 2020 - Feb 29, 2024

Title: Agujeros negros supermasivos y jets relativistas

Ref.: PID2019-108995GB-C21

Pl: José Luis Gómez Fernández

Dur.: Jun 01, 2020 - Feb 29, 2024

Title: Contribución del IAA a la explotación científica de ASIM: experimentos, observaciones desde suelo, análisis de datos y modelización

Ref.: PID2019-109269RB-C43
Pl: Francisco José Gordillo Vázquez
Dur.: Jun 01, 2020 - Dec 31, 2023

Title: Atmosfera y clima de la tierra y exo-planetás

Ref.: PID2019-110689RB-I00
Pl: Bernd Rainer Funke, Manuel López Puertas
Dur.: Jun 01, 2020 - Nov 30, 2023

Title: Estallidos de formación estelar a lo largo de la evolución el universo

Ref.: PID2019-107408GB-C44
Pl: José Manuel Vílchez Medina, Jorge Iglesias Páramo
Dur.: Jun 01, 2020 - May 31, 2023

Title: Detección y caracterización de los sistemas planetarios en estrellas enanas M: Entendiendo su estrella y sus planetas

Ref.: PID2019-109522GB-C52
Pl: Pedro José Amado González
Dur.: Jun 01, 2020 - May 31, 2023

Title: Los galácticos de la galaxia: estrellas masivas, cúmulos estelares y el centro galáctico

Ref.: PGC2018-095049-B-C21
Pl: Rainer Schoedel, Emilio Javier Alfaro Navarro
Dur.: Jan 01, 2019 - Dec 31, 2022

Title: Física oculta en la evolución en tiempo real de las nebulosas gaseosas en torno a estrellas evolucionadas de masa baja e intermedia

Ref.: PGC2018-102184-B-I00
Pl: Martín Guerrero Roncel
Dur.: Jan 01, 2019 - Dec 31, 2022

Title: AMIGA7: gas y campos magnéticos en entornos extremos de galaxias con los precursores de Ska - desde el diseño del flujo de datos hacia su construcción

Ref.: RTI2018-096228-B-C31
Pl: Lourdes Verdes-Montenegro Atalaya
Dur.: Jan 01, 2019 - Dec 31, 2022

Title: Física solar espacial

Ref.: RTI2018-096886-B-C51
Pl: Jose Carlos del Toro Iniesta, David Orozco Suárez
Dur.: Jan 01, 2019 - Dec 31, 2022

Title: Red temática para la participación científica y tecnológica española en el SKA

Ref.: RED2018-102587-T
Pl: Lourdes Verdes-Montenegro Atalaya
Dur.: Jan 01, 2020 - Dec 31, 2022

Title: Legado del proyecto SMALL BODIES NEAR AND FAR

Ref.: RTI2018-098657-J-I00
Pl: Pablo Santos-Sanz
Dur.: Jan 01, 2019 - Dec 21, 2022

Title: Modelo de repuesto y de vuelo de subsistemas de JANUS y GALA. Formación y evolución de sistemas planetarios: desde cuerpos menores a exoplanetas

Ref.: PGC2018-099425-B-I00
Pl: Luisa María Lara López
Dur.: Jan 01, 2019 - Sep 30, 2022

Title: Caracterización de la atmósfera de Marte con los instrumentos NOMAD y ACS a bordo de TGO/EXOMARS

Ref.: PGC2018-101836-B-I00
Pl: Miguel Ángel López Valverde
Dur.: Jan 01, 2019 - Sep 30, 2022

Title: Experimentos de laboratorio, observaciones y modelos de polvo cometa: una nueva estrategia

Ref.: RTI2018-095330-B-I00
Pl: Olga Muñoz Gómez, Juan Carlos Gómez Martín
Dur.: Jan 01, 2019 - Sep 30, 2022

Title: Una perspectiva planetaria sobre cambio(s) climático(s) Marte y la evolución del agua

Ref.: RTI2018-100920-J-I00
Pl: Francisco González Galindo
Dur.: Oct 01, 2019 - Sep 30, 2022

Title: GRBphot - Base de datos fotométricos de explosiones de rayos gamma

Ref.: RTI2018-098104-J-I00
Pl: David Alexander Kann
Dur.: Sep 01, 2019 - Aug 31, 2022

Title: Cielos y universos para los grandes cartografiados de galaxias: explotación científica

Ref.: PGC2018-101931-B-I00
Pl: Francisco Prada Martínez
Dur.: Jan 01, 2019 - Aug 31, 2022

REGIONAL GOVERNMENT JUNTA DE ANDALUCÍA

Title: Acciones para el fortalecimiento del IAA-CSIC para la adquisición del sello "Severo Ochoa"

Ref.: SOMM17/5208/IAA
Pl: Antonio María Alberdi Odriozola
Dur.: Jan 01, 2019 - Feb 28, 2022

Title: LUCA: Revelando la estructura fina de las galaxias del Universo Local con espectroscopía 3D

Ref.: P18-FRJ-2595
Pl: Rubén García Benito
Dur.: Dec 01, 2020 - Nov 30, 2023

Title: Stellar Tidal Streams in the Local Universe as Cosmological Diagnostic

Ref.: TASE-136
Pl: David Martínez Delgado
Dur.: Oct 01, 2020 - Sep 30, 2023

Title: Supermassive black holes and blazar jets

Ref.: P18-FR-1769
Pl: José Luis Gómez Fernández
Dur.: Jan 01, 2020 - Jun 30, 2023

Title: Excelencia científica y tecnológica en el IAA-CSIC: OSN, UDIT y Centro de cálculo

Ref.: IE19_242_C SIC-I AA
Pl: Antonio María Alberdi Odriozola
Dur.: Dec 28, 2020 - Apr 30, 2023

Title: Estudiando galaxias jóvenes con tecnología de vanguardia: piezas clave de la evolución del Universo

Ref.: P18-FR-2664
Pl: Jorge Iglesias Páramo
Dur.: Jan 01, 2020 - Mar 31, 2023

Title: IAA4SKA. Contribution of the Instituto de Astrofísica de Andalucía to the Square Kilometre Array (SKA): Open Science and Engineering to reinforce the leadership of the Spanish participation in the SKA.

Ref.: P18-RT-3082
Pl: Lourdes Verdes-Montenegro Atalaya, Antonio María Alberdi Odriozola
Dur.: Jan 01, 2020 - Mar 31, 2023

Title: Objetos Transneptunianos y otros remanentes de la formación del sistema solar

Ref.: P20_01309
Pl: José Luis Ortiz Moreno
Dur.: Oct 05, 2021 - Mar 31, 2023

Title: Descifrando la Vía Láctea: Minería de datos y herramientas numéricas para la explotación de grandes cartografiados galácticos

Ref.: P20_00753
Pl: Emilio Javier Alfaro Navarro
Dur.: Oct 05, 2021 - Mar 31, 2023

Title: Imaginología y polarimetría en el ultravioleta cercano para aplicaciones espaciales (NUVIP)

Ref.: P20_01307
Pl: David Orozco Suárez
Dur.: Oct 05, 2021 - Mar 31, 2023

Title: Construction of the Calar Alto Schmidt-Lemaître Telescope (CASTLE), a technology demonstrator for curved detectors

Ref.: P20_00737
Pl: Francisco Prada Martínez
Dur.: Oct 05, 2021 - Mar 31, 2023

Title: Propiedades físicas del polvo cometa y aplicaciones biomédicas

Ref.: P18-RT-1854
Pl: Fernando Moreno Danvila, Olga Muñoz Gómez
Dur.: Jan 01, 2020 - Dec 31, 2022

Title: Detección y caracterización de los sistemas planetarios en estrellas enanas. M: Entendiendo su estrella y sus planetas

Ref.: P20_00737
Pl: Pedro José Amado González
Dur.: Oct 05, 2021 - Dec 31, 2022

Title: Aprendizaje artificial aplicado a simulaciones de transporte Montecarlo: aplicación a la producción de rayos X en descargas eléctricas

Ref.: P20_00831
Pl: Alejandro Luque Estepa
Dur.: Oct 05, 2021 - Dec 31, 2022

Title: Explorando la formación y supervivencia planetaria en condiciones extremas

Ref.: P20_00880
Pl: Mayra Carolina Osorio Gutiérrez
Dur.: Oct 05, 2021 - Dec 31, 2022

Title: Acciones para la optimización de observatorios astronómicos en Andalucía

Ref.: IE-2017-5298

Pl: Antonio María Alberdi Odriozola

Dur.: May 01, 2020 - Apr 30, 2022

Title: High-cadence monitoring of the sky and additional developments in Robotic Astronomy

Ref.: P20-01068

Pl: Alberto J. Castro Tirado

Dur.: May 05, 2021 - Dec 21, 2022

EUROPEAN PROGRAM FUNDS

Title: ROle and impAct of Dust and clouds in the Martian Atmosphere: from lab to space (ROADMAP)

Ref.: 01004052 H2020-LEIT-SPACE/0753

Pl: Olga Muñoz Gómez

Dur.: Nov 01, 2020 - Oct 31, 2023

Title: SOLARNET - 824135- Integrating High Resolution Solar Physics - H2020

Ref.: 824135

Pl: Luis Ramón Bellot Rubio

Dur.: Jan 01, 2019 - Dec 31, 2022

Title: ESCAPE-European Science Cluster of Astronomy & Particle physics ESFRI research infrastructures

Ref.: 824064 - H2020-INFRA/0489

Pl: Lourdes Verdes-Montenegro Atalaya

Dur.: Feb 01, 2019 - Jul 31, 2022

Title: CICLE - Unveiling the formation and evolution of galaxy clusters through the intracluster light and multidisciplinary techniques of image processing and big data analysis

Ref.: H2020-MSCA-IF-2019 -- 898633

Pl: Yolanda Jiménez Teja

Dur.: Apr 01, 2020 - Jan 21, 2024

MINISTERIO DE CIENCIA E INNOVACIÓN

Title: Coordinación de la participación científica y tecnológica de España en el Square Kilometre Array. Oficina española del SKA.

Ref.: 201950E125

Pl: Lourdes Verdes-Montenegro Atalaya

Dur.: Dec 01, 2019 - Nov 30, 2022

Title: Ayuda del MICIIN para la coordinación de la participación en SKA-España

Ref.: OTR07653

Pl: Lourdes Verdes-Montenegro Atalaya

Dur.: Jan 01, 2021 - Jun 30, 2022

CDTI

Title: Convenio CSIC-CDTI para la ejecución del Proyecto «Modelos de Vuelo para la MEU (Unidad de la Electrónica Principal) de Plato»

Ref.: ICTP-20210005

Pl: Julio Federico Rodríguez Gómez

Dur.: Dec 06, 2021 - Dec 05, 2026

CSIC

Title: Contribución del CSIC al proyecto ESFRI Telescopio Solar Europeo

Ref.: INFRA20014

Pl: Luis Ramón Bellot Rubio

Dur.: Jun 01, 2022 - May 31, 2024

FECyT

Title: IM=PR(0) Divulgar ciencia desde el teatro de improvisación

Ref.: FCT-2021-16702

Pl: Manuel Jesús González García

Dur.: Jul 01, 2022 - Sep 30, 2023

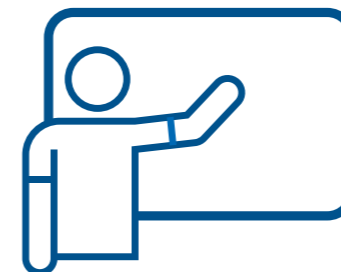
Title: Astrofísica aumentada

Ref.: FCT-21-17345

Pl: Emilio José García Gómez-Caro

Dur.: Jul 01, 2022 - Jun 30, 2023

Education & teaching



PhD Theses

Title: Identification and characterization of emission line objects in J-PAS using artificial neural network

Author: Ginés Martínez Solaeche

Sup.: Rosa González Delgado & Rubén García Benito

Univ.: Universidad de Granada

Date: 19 October 2022

Title: High-Resolution Imaging of Relativistic Jets and Supermassive Black Hole

Sup.: Antonio Fuentes Fernández

Univ.: Granada

Date: 25th November 2022

Title: Outflows in Low Luminosity Active Galactic Nuclei

Author: Laura Hermosa-Muñoz

Sup.: Isabel Marquez & Sara Cazzoli

Univ.: Granada

Date: 30th November 2022

Title: Evolution des propriétés physiques des galaxies centrales les plus brillantes des amas de galaxies

Author: Aline Chu

Sup.: Florence Durret & Isabel Marquez

Univ.: Sorbonne Université

Date: 7th December 2022

MASTER Theses

- Title:** Evolución cósmica de la relación masa-metalicidad en el muestreo zCOSMOS
Author: Didac Invernón Campoy
Sup.: Enrique Pérez Montero & Rubén García Benito
Univ.: Universidad Internacional de Valencia
Date: 25/05/2022
- Title:** Design and implementation of a broker for Cloud Computing services
Author: Jorge Prieto Martos
Sup.: Manuel Parra-Royón and José Manuel Benítez Sánchez
Univ.: University of Granada
Date: 22/09/22
- Title:** X-ray and radio properties of far-infrared green valley active galaxies
Author: Samuel Bogale Worku
Sup.: Mirjana Povic
Univ.: Addis Ababa University and Space Science and Geospatial Institute, Ethiopia
Date: 15/11/2022
- Title:** Diseño de teleobjetivos en instrumentación astronómica espacial
Author: Javier Sánchez Barranquero
Sup.: Francisco Javier Bailén Martínez
Univ.: Universidad Complutense de Madrid
Date: octubre 2022
- Title:** Fase de explotación de datos de la red de telescopios robóticos BOOTES
Author: David Lopez Bellon
Sup.: Maria Dolores Caballero Garcia
Univ.: Universidad Internacional de Valencia - VIU
Date: 01.10.2021-04.04.2022
- Title:** PSF photometry algorithms in high resolution infrared observations of the galactic center
Author: Rafael Moriana Rodríguez
Sup.: Rainer Schoedel
Univ.: Universidad de Granada
Date: 14/7/2022
- Title:** Derivation of CH₄ abundances in Jupiter upper atmosphere from Juno/JIRAM non-LTE near-IR limb radiances
Author: Lorenzo Fabris
Sup.: Manuel López Puertas
Univ.: University of Namur, Bélgica (Erasmus+)
Date: 16 May 2022

- Title:** Evolución cósmica de la relación masa-metalicidad en el muestreo zCOSMOS
Author: Didac Imbernón Campoy
Sup.: Enrique Pérez Montero & Rubén García Benito
Univ.: Universidad Internacional de Valencia
Date: 05/05/2022
- Title:** Modelling of telescope primary mirror deformations for aberrated wavefront correction
Author: Oriol Calpe Blanch
Sup.: David Pérez Medialdea
Univ.: Valencia International University (VIU)
Date: November 9th, 2022
- Title:** Extrapolación de las matrices de scattering generadas en el COsmic DUst LABoratory: Implementación con T-matrix
Author: Pablo Aguadero Garrido
Sup.: Daniel Guirado Rodríguez
Univ.: Universidad Internacional de Valencia
Date: May 6, 2022
- Title:** Estructura interna del cúmulo M67
Author: Clara Cabanillas de la Casa
Sup.: Emilio J. Alfaro Navarro
Univ.: Universidad de Granada
Date: September, 2022
- Title:** Broker based on Computational Intelligence for the optimal selection of Cloud resource provisioning services
Author: Jorge Prieto
Sup.: Manuel Jesús Parra Royón
Univ.: Universidad de Granada
Date: 22/09/22
- Title:** Propiedades físicas y abundancias químicas de todas las regiones HII de la galaxia M101 observadas en el cartografiado digital del cielo Sloan (SDSS). Análisis 2D y gradientes
Author: Lorena Aragüete Riesco.
Sup.: Salvador Duarte Puertas (U. Laval), José M. Vilchez Medina (IAA)
Univ.: Valencia International University
Date: 24 May 2022
- Title:** Exploring the close environment of the extreme emission-line galaxies in the SDSS survey
Author: Gloria Torres Ríos
Sup.: José M. Vilchez Medina
Univ.: University of Granada
Date: 14 July 2022

- Title:** Shedding light on the problem of frequency extraction for classical pulsators
Author: Cristián Rodrigo
Sup.: Javier Pascual Granado, Sebastià Barceló Forteza
Univ.: VIU
Date: 07/11/22
- Title:** Evolución estelar en tiempo real en modelos de evolución y oscilación
Author: Gloria Liñán Rodríguez
Sup.: Antonio García Hernández, Javier Pascual Granado
Univ.: VIU
Date: 09/11/22

Courses

- Title:** Analysis of integral-field spectroscopic data
Teach.: Rubén García-Benito
Prog.: Seminarios de Investigación del Master de Astrofísica
Univ.: Universidad Autónoma de Madrid
Hours: 2
Date: 27/10/2022
- Title:** The process of Digital Transformation in farming companies
Teach.: Manuel Jesús Parra Royón
Prog.: "Master in International Agribusiness Management"/"Master Internacional en Gestión de Agronegocios"
Org.: ISAM (International School of Agriculture Management)
Hours: 10
Date: July 2022
- Title:** Digital Transformation and Smart Agriculture
Teach.: Manuel Jesús Parra Royón
Prog.: "Master in International Agribusiness Management"/"Master Internacional en Gestión de Agronegocios"
Org.: ISAM (International School of Agriculture Management)
Hours: 10
Date: July 2022
- Title:** Modern Observational Techniques in Astronomy
Teach.: Mirjana Povic
Prog.: PhD in Astronomy and Astrophysics

- Org.:* Space Science and Geospatial Institute, Ethiopia
Hours: 46 hours, 6 ECTS
Date: 01/11/2022 - 20/02/2023
- Title:** Introduction to the world of galaxies from multi-wavelength data perspective
Teach.: Mirjana Povic
Prog.: Postgraduate (MSc/PhD) training during the Sub-Saharan Africa Advanced School of Astronomy
Org.: Max Planck Institute in collaboration with Mbarara University, Uganda
Hours: 9 hours
Date: 19-30/09/2022
- Title:** Observational Techniques in Astronomy
Teach.: Mirjana Povic
Prog.: Master in Astronomy and Astrophysics
Org.: Space Science and Geospatial Institute, Ethiopia
Hours: 40 hours, 6 ECTS
Date: 01/04/2022 - 15/07/2022
- Title:** Scientific writing
Teach.: Mirjana Povic
Prog.: Postgraduate (MSc/PhD) training
Org.: Space Science and Geospatial Institute, Ethiopia
Hours: 8 hours
Date: 19-26/05/2022
- Title:** Introduction to scientific writing
Teach.: Mirjana Povic
Prog.: Postgraduate (MSc/PhD) training
Univ.: Samara University, Ethiopia
Hours: 5 hours
Date: 16/05/2022
- Title:** Modern Observational Techniques in Astronomy
Teach.: Mirjana Povic
Prog.: PhD in Astronomy and Astrophysics
Org.: Space Science and Geospatial Institute, Ethiopia
Hours: 46 hours, 6 ECTS
Date: 01/11/2021 - 01/03/2022
- Title:** Observational Techniques in Astronomy
Teach.: Mirjana Povic
Prog.: Master in Astronomy and Astrophysics
Univ.: Mbarara University of Science and Technology, Uganda
Hours: 60 hours
Date: 24/01/2022 - 04/02/2022

Title: Técnicas Observacionales en Astrofísica (High-energy astrophysics)

Teach.: María Dolores Caballero García
Prog.: Master en Física y Matemáticas FISYMAT
Univ.: Universidad de Granada
Hours: 17
Date: 20.04.2022 - 12.05.2022

Title: Astrobiología y planetas extrasolares.

Teach.: Manuel López Puertas
Prog.: Máster Universitario en Física: Radiaciones, Nanotecnología, Partículas y Astrofísica
Univ.: Universidad de Granada
Hours: 10
Date: May 2022

Title: Ionized gas in the interstellar medium

Teach.: Enrique Pérez Montero
Prog.: Master of Theoretical Physics
Univ.: Universidad Autónoma de Madrid
Hours: 15
Date: 01/02/2022 - 01/06/2022

Title: Polarized RTE Radiative Transfer

Teach.: David Orozco Suárez
Prog.: Course in Spectropolarimetry
Org.: National Solar Observatory (Boulder, Colorado, USA)
Hours: 12 hours
Date: August 2022

Title: Radioastronomy

Teach.: Angela Gardini, Daniel Espada
Prog.: Master in Physics and Mathematics (FISyMAT)
Univ.: Universidad de Granada
Hours: 60
Date: September 2022-March 2023

Title: Radioastronomy

Teach.: José Francisco Gómez, Antonio Alberdi, Guillem Anglada, Angela Gardini
Prog.: Master in Physics and Mathematics (FISyMAT)
Univ.: Universidad de Granada
Hours: 60
Date: September 2021-March 2022

Title: Radiative transfer models for protoplanetary disks around binary stars

Teach.: Mayra Osorio
Prog.: Master in Sciences de l'Univers et Technologies Spatiales
Org.: Observatoire de Paris
Hours: 294 h of official practical training of Clara Puerto Sánchez
Date: From 24th April 2022 to 30th June 2022

Title: Radiative transfer models for accretion disks

Teach.: Mayra Osorio
Prog.: Master in Astrophysics
Univ.: University Complutense of Madrid
Hours: 192 h of official practical training of Rafael Navarro Carrera
Date: From January 2022 to May 2022

Title: Protoplanetary disks

Teach.: Mayra Osorio
Prog.: Master in Physics and Mathematics (FisyMat)
Univ.: Universidad de Granada
Hours: 1.5 h
Date: 13 December 2022

Title: Planet formation under extreme conditions

Teach.: Mayra Osorio
Prog.: Course for teachers of primary, secondary, high school and vocational training
Univ.: European Space Agency
Hours: 1.5 h
Date: 24 May 2022

Title: FPGAs para entornos espaciales

Teach.: Beatriz Aparicio del Moral
Prog.: Master universitario en ingeniería de telecomunicación
Univ.: Universidad de Granada
Hours: 1
Date: 19 October 2022

Title: Física de Detectores

Teach.: Jorge Iglesias Páramo
Prog.: Máster Universitario en Física: Radiaciones, Nanotecnología, Partículas y Astrofísica
Univ.: Universidad de Granada
Hours: 6
Date: 2021-2022

Title: Descubriendo el Cosmos

Teach.: Jorge Iglesias Páramo
Prog.: Universidad de Mayores
Univ.: Universidad de Almería
Hours: 8
Date: January/February 2022

Title: Tú también eres astrónom@

Teach.: Jorge Iglesias Páramo
Prog.: Curso de verano
Univ.: Universidad de Almería
Hours: 4
Date: July 2022

Title: Herramientas para la reproducibilidad del análisis científico (aula virtual)

Teach.: Moldón, J., Parra, M., Darriba, L., Sánchez S., Garrido, J., & Mendoza, M.A.
Prog.: Plan de formación CSIC 2022
Org.: CSIC
Hours: 15
Date: 30 March - 11 May 2022

Title: PySnacks 1: Astronomical Data Science with Python.

Teach.: Moldón, J., Darriba, L.
Prog.: Severo Ochoa Training Program
Org.: IAA-CSIC
Hours: 12h
Date: 22 March - 1 April 2022

Title: Cosmología y Galaxias

Teach.: Emilio J. Alfaro Navarro (Galaxias)
Prog.: Master. Radiaciones, Nanotecnología, Partículas y Astrofísica (M44/56/2)
Univ.: Universidad de Granada
Hours: 10
Date: January, 2022

Title: Origin and evolution of the chemical elements

Teach.: José M. Vílchez Medina
Prog.: Master in Physics
Univ.: Universidad de Granada
Hours: 12
Date: 7-21 March 2022

Title: Dust and Metals

Teach.: José M. Vílchez Medina
Prog.: Advanced School of Galaxy Evolution
Org.: Severo Ochoa program, IAA-CSIC
Hours: 4
Date: 23-27 May 2022

Title: Organization of "Advanced School of Galaxy Evolution"

Coord.: José M. Vílchez Medina
Prog.: Advanced School of Galaxy Evolution
Org.: Severo Ochoa program, IAA-CSIC
Date: 23-27 May 2022

Title: Radioastronomía en el aula

Teach.: Villaverde, M.
Prog.: Curso de formación de profesorado "La Astrofísica en el Aula: Actualización Científica. Infantil, Primaria y Secundaria"
Org.: CEP (Centro del Profesorado) de Granada
Hours: 1 h
Date: 16th March 2022

Title: Introduction to Github/Gitlab

Teach.: Moldón, J.
Prog.: SKA Regional Centre Training Event Series. "Hands-on Containerization"
Org.: Square Kilometre Array Observatory
Hours: 20 min
Date: 31st January 2022

Title: Github / Gitlab (intermediate)

Teach.: Moldón, J.
Prog.: SKA Regional Centre Training Event Series. "Hands-on Containerization"
Org.: Square Kilometre Array Observatory
Hours: 40 min
Date: 7th February 2022

Title: Introduction to singularity

Teach.: Parra, M.
Prog.: SKA Regional Centre Training Event Series. "Hands-on Containerization"
Org.: Square Kilometre Array Observatory
Hours: 40 min
Date: 31st January 2022

Title: Hands-on: Gitlab

Teach.: Parra, M.
Prog.: SKA Regional Centre Training Event Series. "Hands-on Containerization"
Org.: Square Kilometre Array Observatory
Hours: 20min
Date: 31st January 2022

Press releases

Acces to all news at:

<https://www.iaa.csic.es/en/news>



ESPRESSO and CARMENES discover two exo-Earths in the habitable zone of a star close to the Sun

15/12/2022

The IAA-CSIC participated in the discovery of a multiple planetary system around GJ1002.

The James Webb Telescope reveals that four to five stars were involved in the formation of the Southern Ring nebula

14/12/2022

The IAA-CSIC participated in a study that points to the interaction of a multiple star system in the formation of the nebula. It was featured on the cover of the journal Nature Astronomy.

WEAVE first light

13/12/2022

The IAA-CSIC participates in the WEAVE scientific team, whose first observations already showed the high quality of the data that the spectrograph provides.

A stellar collision that shone for almost a minute complicates the stellar explosion scenario

07/12/2022

The IAA-CSIC participates in the study of a gamma-ray burst (GRB) whose characteristics required a revision of the theoretical framework to explain these bursts.

Detected a jet of matter emerging from a supermassive black hole as it devours a star

30/11/2022

The IAA-CSIC participated in two papers that analysed these Tidal Disruption Events (TDEs).

Determined how particle acceleration occurs in the jets of a supermassive black hole

23/11/2022

The IAA-CSIC participated in a IXPE observational study that suggests that shock waves could be at the origin of the acceleration of particles in the jets.

The IAA-CSIC was awarded the Severo Ochoa Centre of Excellence distinction for the second time

08/11/2022

The distinction, which provides centres with one million euros per year for four years, aims to finance and accredit institutions that demonstrate impact and leadership at an international level.

The IAA-CSIC participates in ARRAKIHS, the European Space Agency's mission to study dark matter

03/11/2022

This is the first mission of the ESA Scientific Program coordinated by Spain. The IAA-CSIC will carry out the coordination of the observational strategy of the mission.

The construction of TARSIS, the next generation instrument for the Calar Alto 3.5-metre telescope, started

26/10/2022

TARSIS has unique features, in particular its ability to detect light in the near ultraviolet and its unprecedented field of view.

IAA Severo Ochoa Meeting: Addressing Key Astrophysical Questions from Granada

13/10/2022

The IAA-CSIC organized a meeting with specialists from all over the world which will deal with key issues in different fields of Astrophysics.

Study points to the existence of stars as compact as black holes

10/10/2022

The IAA-CSIC led a theoretical study that shows that some of the objects classified as stellar black holes could actually be ultra-compact stars.

The astronomy of the future will be collaborative, multi-wave, more diverse and green

06/10/2022

The IAA-CSIC hosted a round table with the heads of three of the largest astronomical infrastructures on Earth: the Cherenkov Telescope Array Observatory (CTAO), the Extremely Large Telescope (ELT) and the Square Kilometre Array Observatory (SKAO).

The largest European meeting on planetary sciences was held in Granada

20/09/2022

More than a thousand specialists participated in the "European Planetary Science Conference (EPSC)", organized locally by members of the IAA-CSIC and held at the Palacio de Congresos.

Study revealed that water worlds may be more common than expected

08/09/2022

The IAA-CSIC led a study that found evidence that many of the planets known as super-Earths or mini-Neptunes may harbour large amounts of water (compositions of up to 50% rock and up to 50% water).

First look at the prolific stellar factory at the center of the Milky Way

25/08/2022

A study, part of the GALACTICNUCLEUS project, coordinated by the IAA-CSIC, revealed the history of star formation in the center of our Galaxy.

Possible galactic fossil found near Andromeda

07/07/2022

An unusual ultrafaint dwarf galaxy was discovered, within the framework of a project led by the IAA-CSIC, in the outer limits of the Andromeda galaxy. Named Pegasus V, it contains very few heavy elements and is likely to be a fossil of the earliest galaxies.

The best studied terrestrial planet outside the Solar System

[21/06/2022](#)

An international scientific team, with the participation of the IAA-CSIC, measured with unprecedented precision the mass and radius of Gliese 486 b, a “super-Earth” type exoplanet, discovered in 2021 with the CARMENES instrument at Calar Alto observatory.

Two hot, rocky exoplanets detected transiting a nearby star

[15/06/2022](#)

An international team led by the IAA-CSIC detected two telluric planets orbiting the nearby star HD 260655.

Diana Morant visited the Institute of Astrophysics of Andalusia

[10/06/2022](#)

The Minister of Science and Innovation highlighted the contribution of its research staff in capturing the first historic image of the black hole at the centre of the galaxy.

Lourdes Verdes-Montenegro, researcher at IAA-CSIC, won the Ada Byron Award from the University of Deusto

[06/06/2022](#)

The Ada Byron Award, with editions in six countries, was created by the Faculty of Engineering of Deusto to acknowledge the work of women in technology and encourage women in STEM.

An isolated dwarf galaxy, unexpectedly affected by its environment

[25/05/2022](#)

The finding, its strong interaction with the intergalactic medium, with the participation of the IAA-CSIC, forced a change in the conception of isolated galaxies.

The Ministry of Science and Innovation earmarked 2.5 million euros for the international Square Kilometre Array radiotelescope

[25/05/2022](#)

The Square Kilometre Array (SKA) will make ground-breaking contributions to astrophysics, astrobiology and fundamental physics. It will enable progress to be made in the search for signs of life in the galaxy and in the observation of pulsars, black holes and gravitational waves. The technical coordination of the Spanish participation in the project is carried out by the IAA-CSIC.

Westerlund 1 cluster: a nursery of giant stars emerging from the darkness

[25/05/2022](#)

The IAA-CSIC participated in the study of the most massive young cluster of stars in the Milky Way. This stellar swarm brings together different types of giant stars in different evolutionary phases, and constitutes a first-class laboratory for the study of the formation and evolution of massive stars.

TARSIS, the next generation instrument for the Calar Alto 3.5-meter telescope

[24/05/2022](#)

UCM and IAA-CSIC co-lead TARSIS, the future instrument for the 3.5 m telescope selected by the Calar Alto Executive Committee. TARSIS has unique characteristics, in particular its capacity to detect near ultraviolet light and its unprecedented field of view.

IAA-CSIC engineer Francisco Bailén won the 2021 award for the best thesis from the International Astronomical Union (IAU)

[18/05/2022](#)

Francisco Bailén, engineer at the IAA-CSIC, has obtained the IAU PhD Prize in the category of “Facilities, Technologies and Data Science”.

Astronomers revealed the first image of the black hole at the heart of our galaxy

[12/05/2022](#)

This object, called Sagittarius A*, four million times more massive than the Sun, was captured by the Event Horizon Telescope (EHT) international project. The finding, which had the outstanding participation of the IAA-CSIC, confirmed the existence of the black hole and helps to understand these gravitational ‘monsters’ from which nothing can escape, not even light.

The European Solar Telescope will boost research on the Sun in Europe

[03/05/2022](#)

The new infrastructure will have a mirror with a diameter of 4.2 meters and a height of 44 metres, and will be the largest solar telescope in Europe. Construction is scheduled to begin in 2024 at the Roque de los Muchachos Observatory, on the island of La Palma, and it could be operational in 2029.

An atlas of active galaxies showed that outflows are common even in the most dormant galaxies

[27/04/2022](#)

The IAA-CSIC studied in depth a sample of LINERs, the least luminous type of active galaxy, and found that half of them produce gas outflows.

MAGIC telescopes detected the explosion of a “vampire” star

[14/04/2022](#)

The IAA-CSIC participated in the discovery of very high-energy gamma rays from a recurrent nova in the Milky Way. The result, published in Nature Astronomy, identified novae as a new type of very high-energy gamma-ray source.

Nkalakatha megamasser found, revealing a large galaxy collision

[07/04/2022](#)

The IAA-CSIC participated in the discovery of the radio emission produced by a galactic collision via the detection of hydroxyl megamasers emission.

The most distant star ever seen

[30/03/2022](#)

The Hubble space telescope set a new record by capturing the light from a star that shone in the first billion years after the Big Bang. The IAA-CSIC was involved in the discovery, which provides a detailed view of the dawn of the universe.

R Aquarii: a symbiotic star with active galaxy features

[23/03/2022](#)

The IAA-CSIC participated in the X-ray analysis of R Aquarii, a double star formed by a red giant star and a white dwarf. The system shows a very complex morphology, with a bipolar S-shaped jet emerging from the white dwarf and an extensive nebula with filaments and cavities.

Bernardelli-Bernstein confirmed to be the largest Oort-cloud comet in the Solar System

[14/03/2022](#)

The IAA-CSIC participated in the study with the ALMA radiotelescope (Chile) of comet C/2014 UN271 Bernardinelli-Bernstein, which determined its size and albedo, or surface reflectivity. With 137 kilometres, it is the largest known comet, and perhaps one of the most pristine.

The start of the birth of planets in a binary star system observed

[10/03/2022](#)

The IAA-CSIC led the study of the binary star SVS 13, still in its embryonic phase. Astronomers observed primordial material that may be giving birth to three planetary systems around a binary star.

First results of the MASCOT project suggested that galaxies “turn off” from the inside out

[04/03/2022](#)

The IAA-CSIC participated in MASCOT, a large-scale study of the cold gas in galaxies, an essential element for understanding how galactic evolution works.

Structure of the supermassive black hole at the center of our galaxy revealed

22/02/2022

The IAA-CSIC led a study that reveals the almost circular shape at 1.3 and 0.7 cm wavelengths of Sagittarius A*, the supermassive black hole located in the center of the Milky Way. The shape indicates that the axis of rotation of the flow of matter surrounding the black hole (or a possible jet) may be pointing toward Earth.

Pulsars could hide one of the keys to understanding how cosmic rays travel

14/02/2022

The IAA-CSIC led a study that analyzed the role of gamma-ray halos around pulsars in order to understand how cosmic rays travel.

Second Trojan asteroid detected around Earth

01/02/2022

Trojans are asteroids that share an orbit with a planet around its stable Lagrangian points, which are located sixty degrees ahead and behind the planet in its orbit. Widely studied on other planets, such as Jupiter, which has several thousand, only one has so far been found around the Earth.

Highest resolution image of the OJ 287 galaxy suggests it harbours a binary supermassive black hole

19/01/2022

The IAA-CSIC led a work that combines observations of space and ground-based radio interferometers to study the central regions of the galaxy OJ 287.

Plato exoplanet mission got green light for next phase

17/01/2022

On January 11, ESA's PLATO mission, in which the IAA-CSIC participates, received the green light to continue its development after successfully passing the review of critical milestones.

Re-encounter with a planetary nebula 30 years later reveals changes and a possible companion star

13/01/2022

The IAA-CSIC led a study based on data from Calar Alto Observatory (CAHA), showing the variability of the planetary nebula IC4997.

List of publications



Acces to all entries at:

<https://www.iaa.csic.es/en/publications>

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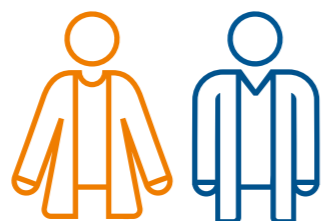
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Observatório do Valongo
08/11/2021 - 08/02/2022

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Chiba University
26/11/2022 - 31/01/2023

Rubén López Coto

Istituto Nazionale di Fisica Nucleare
01/12/2021 - 31/05/2022

Adriana Ocampo Uria

NASA Ames Research Center
01/04/2022 - 31/05/2022

Alexander Smith

Durham University
04/03/2022 - 05/04/2022

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Universidad Nacional Autónoma de México
03/04/2022 - 31/05/2022

Víctor van Rooijen

Leiden University
01/10/2021 - 31/07/2022

Binbin Zhang

Nanjing University
11/07/2022 - 07/10/2022

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17/01/2022 - 15/02/2022
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CSIC
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U. Liège
01/07/2022 - 22/11/2022

Oier Baraibar Larraza

Universidad del País Vasco
02/11/2022 - 02/11/2023

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Universidad de Granada
22/02/2022 - 01/02/2023

Shimeles Terefe Mengistue

Ethiopian Space Science and Technology Institute (ESSTI)
07/09/2022 - 25/12/2022

Ingrid Bjorge-Engeland

University of Bergen
14/09/2022 - 22/12/2022

Zachary Flimon

Royal Belgian Institute for Space Aeronomy
12/09/2022 - 12/12/2022

Rohan Arun Dahale

EHT
01/07/2022 - 31/08/2022

Lucía Fullana García

Universidad Complutense de Madrid
01/06/2022 - 31/07/2022

Zuri Gray

Armagh Observatory
01/02/2022 - 31/07/2022

Margarete Huisinga

Freie Universität Berlin
10/05/2022 - 31/07/2022

Ángel Melguizo Baena

Universidad de Granada
06/06/2022 - 15/07/2022

David Eduardo Millán Calero

Universidad de Granada
13/07/2018 - 13/07/2022

Dennis Bouwman

Centrum Wiskunde Informatica (CWI)
07/03/2022 - 20/05/2022

David Rosado Belza

Instituto de Astrofísica de Canarias (IAC)
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Tianrui Sun

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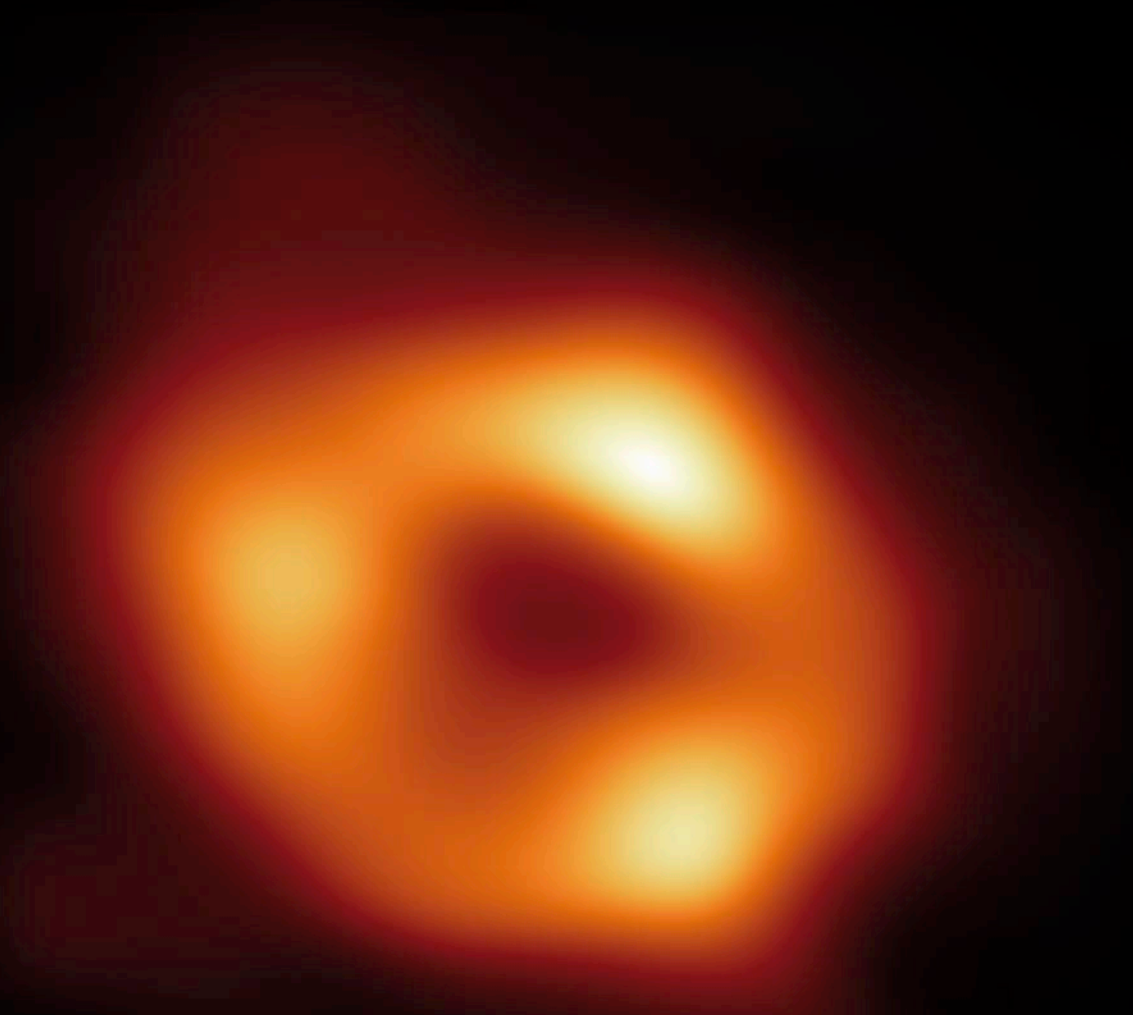
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16/06/2022 - 29/07/2022
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Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS)
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Institut d'Astrophysique de Paris
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Royal Astronomical Society
30/05/2022 - 04/06/2022
Sandino Estrada Dorado
Instituto de Radioastronomía y Astrofísica, UNAM
07/10/2022 - 07/10/2022
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Institute of atmospheric sciences and climate (ISAC)
30/05/2022 - 03/06/2022
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