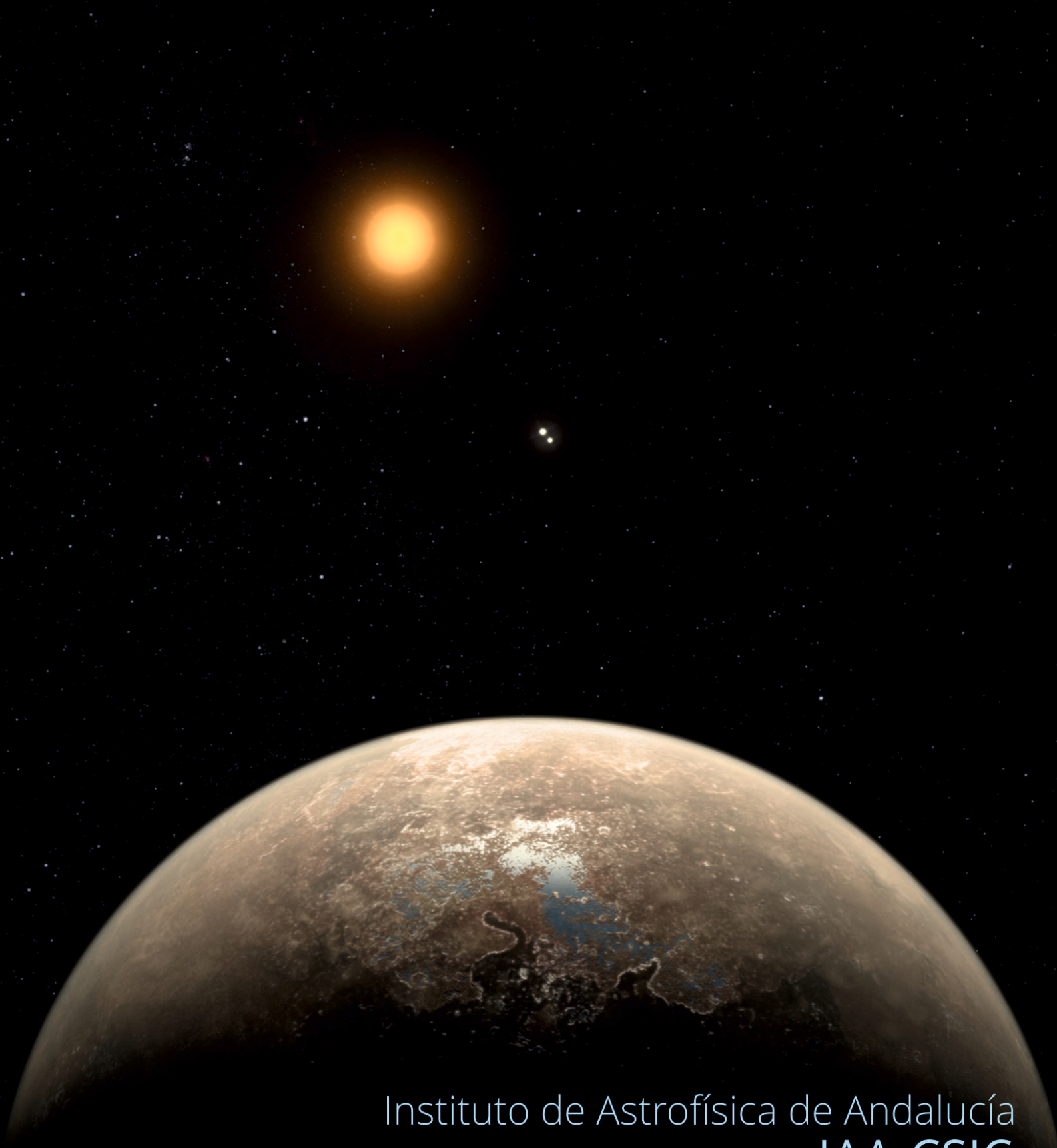

Instituto de Astrofísica de Andalucía

IAA-CSIC

ANNUAL REPORT 2016

INSTITUTO de ASTROFÍSICA de ANDALUCÍA
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CSIC

Cover Picture

NEAR Horizon. The IAA had a strong contribution in the study of a warm terrestrial planet discovered in the vicinity of Proxima Centauri, the star nearest to the Sun, names *Proxima B*. This planet is located in the habitable zone (the regions around a star where conditions would allow for liquid water) and its mass is only somewhat greater than that of the Earth. The discovery, made in the context of the Pale Red Dot observation campaign, was published in *Nature*.

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Director's Foreword

The year 2016 was excellent for the IAA Science and Technology. It was, without any doubt, the year of **Proxima B**, the planet around Proxima Centauri, the closest star to us. The data analysis indicated the existence of a planet with a mass at least 1.3 times that of the Earth orbiting around Proxima Centauri every 11.2 days at a distance of only 5% the distance separating the Earth from the Sun. But Proxima Centauri is much colder than the Sun, and the habitable zone is subsequently much closer to it than we are to our own star. The participation of the IAA was essential, with 7 co-authors of the institute in the Nature paper and a relevant participation both in the preparation of the observational campaigns and the data analysis. This discovery was also a social event being on the front page of general information newspapers, and in the header news of televisions and radio stations. For some days, Astrophysics was present in the life of all the world citizens, and our IAA colleagues have an active participation in all the media explaining the importance of the discovery. New research avenues were opened, and our scientists prepared to contribute to them.

2016 was the year of the final Data Release of the **CALIFA survey**, which provides the largest and most comprehensive wide-field IFU survey of galaxies carried out to date, addressing fundamental issues in galaxy evolution. 2016 was also the year of the **Rossetta**'s *Grand Finale*. The mission, launched in 2014, has given us the most detailed image of a comet nucleus. Fantastic results like the detection of outburst seen streaming from the comet's nucleus are still coming. On the other hand, new peojects were in their first steps. 2016 is the year where **CARMENES** became fully operational in the CAHA Observatory and also was the year in which **ExoMars**, a mission to study the atmosphere and subsoil of the red planet and specifically to finding possible biological significance gases, is already in orbit around Mars. The IAA has designed part of the **NOMAD** instrument, designed to study methane, a gas present on Earth mostly due to living beings and whose discovery on Mars was a surprise in 2004. 2016 was also the year in which the project **ORISON**, with the goal to study the feasibility of creating an observation infrastructure in the stratosphere based on instruments carried by balloons, was launched. It was also in 2016 that the the IAA initiated its participation in the development of the **HIRES spectrograph for ELT** and in the scientific exploitation of MOS and HIRES.

During 2016, the IAA publications included a number of scientific results of great interest that show the variety and quality of the Science we produce. Among others, the discovery of a miniature planetary formation disk around the **young star XZ Tau B**, which will enable observation of planetary gestation in real time; the discovery that **novae** are the main source of lithium in the Universe; the obtention of the first image of the galactic nucleus **BLLac** with a space radiointerferometer with an equivalent size of 30 times the diameter of the Earth, providing an angular resolution of 20 microarcseconds.

The IAA also pursued its work on the **Square Kilometre Array** (SKA), the world's largest scientific infrastructure on Earth once built, with a collecting area of 1 square kilometre, distributed over a distance of at least 3000 km. It is currently in the final stages of design, while construction will start in 2019. The IAA coordinates the scientific and technological participation of Spain in the SKA, providing support to the scientific community as well as to technological groups from academia and industry, and collaborating with CDTI. As a result of this work, the Evaluation of the participation of Spain in the SKA by the Secretary of State got a positive outcome, and was followed by open and fluent on-going negotiations with SKA DG and Board.

The **Calar Alto observatory (CAHA)**, jointly operated by the IAA and the MPIA from Heidelberg, continued with its normal operation. A workshop was held in October to begin with the discussions about future instruments and projects for CAHA. Referring to the future of the Observatory, it is worth to mention that the president of **Junta de Andalucía**, Susana Díaz, has committed the support

from her govern, within the scope of its competences, for the observatory continuity after the end of the agreement with the German partner.

Many of the content, numbers and plots you may find in this report have been produced with our Management Information System IRIA (Interface for Report Intranet Application), a tool developed at the IAA and accounting for our very specific needs in information extraction. It centralizes the diverse information issued from the Administration Department into a structured inter-related system that eases the treatment of the data and enables the flexible generation of reports and plots, providing a detailed in-sight of the IAA activity.

Finally, we should mention that this is the first foreword presented by the new Directorate of the IAA. Our previous Director, **José Manuel Vílchez**, **and his team** made an excellent job leading the IAA. Let me thank them for their commitment during all these years. After 4 years of hard work, the IAA is, without any doubt, a better institute!

Prof. Antxon Alberdi Odriozola

Director of the Instituto de Astrofísica de Andalucía

Septembre 2017

RESEARCH ACTIVITY

The Instituto de Astrofísica de Andalucía (IAA) is the largest and most productive Astronomy center of the Consejo Superior de Investigaciones Científicas (CSIC). The research activity of IAA is carried out in the framework of four different departments:

1. Extragalactic Astronomy

2. Radioastronomy and Galactic Structure

3. Solar System

4. Stellar Physics

This research is supported by a number of research groups devoted to different astrophysical topics. The Instrumental and Technological Development Unit (UDIT), the Computer Center (CC), and the Observatory of Sierra Nevada (OSN) provide technical and scientific support to each research line.

The description of the research activity and highlights of our research groups, units and observatory during 2016 are next presented.

Additional information on the Observatory of Calar Alto is included in this report, since the IAA is the CSIC reference center for this international astronomical observatory.

This report includes the activities of the following research lines:

- AGN jets
- ARAE
- Evolution of Galaxies
- HETH
- Low-mass stars and exoplanets
- Physics of the Interstellar Medium
- Planets and Minor Bodies
- Solar Physics
- Stellar Systems
- Terrestrial planets' atmospheres
- Theoretical gravitation and cosmology

AGN JETS

Overview

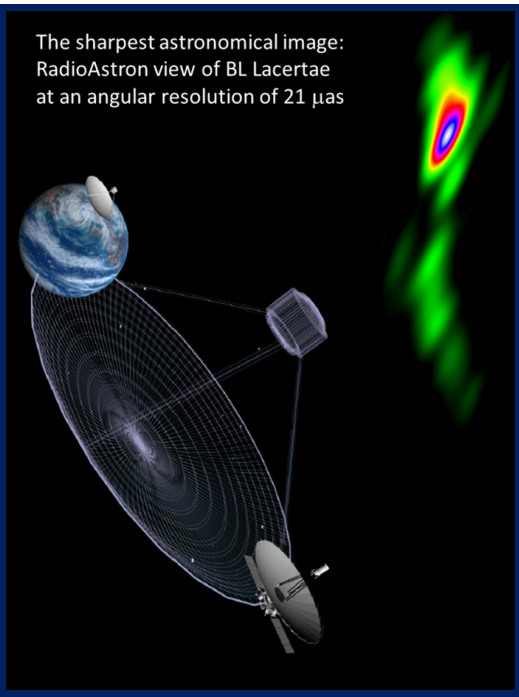
Our research group is focused on the study of relativistic jets, commonly present in multiple astrophysical sites, from active galactic nuclei (AGN), to microquasars and GRBs. For AGN, huge amounts of energy are released as a consequence of mass accretion onto supermassive black holes (SMBH), lurking in the center of these galaxies. The accretion leads to the formation of pairs of powerful and highly collimated relativistic jets, extending far beyond the size of the host galaxy.

Relativistic jets have probably an electromagnetic origin, in which helical magnetic fields may play an important role. Relativistic electrons in the jet, threaded by a magnetic field, radiate most of their energy as synchrotron and perhaps inverse Compton emission across the entire spectrum, from radio to gamma-rays. However, there are still fundamental questions related to the nature of relativistic jets that remain unsolved. Our research group is focused on obtaining a better understanding of these basic questions, and in particular to deep into our knowledge of the innermost regions, where jets are formed and the high energy emission (X and gamma-rays) are produced.

Our observational study is based on very long baseline interferometry (VLBI) observations at millimeter wavelengths and with the orbiting antenna RadioAstron, which allows the study of the innermost jet regions with an angular resolution of the order of few tens of microarcseconds. Multi-waveband observations across the whole electromagnetic spectrum, including radio, millimeter, optical, X and gamma-rays, provide the necessary information to study the origin, location, and properties of the emission at all spectral ranges registered by current instrumentation, and new facilities that are still coming (CTA, SKA), in which our group participates. Interpretation of the observations is carried out through the comparison with our numeric relativistic magnetohydrodynamic and non-thermal emission simulations.

Highlights in 2016

Among the different results obtained during 2016 we can highlight the space VLBI observations obtained with the Russian RadioAstron mission of the **jet in BL Lacertae** (106). Thanks to the combination of multiple radio telescopes around the world and the 10 m orbiting antenna of the RadioAstron mission we were able to synthesize an antenna with the equivalent size of 7.9 times the Earth diameter. This allowed us to image the jet in BL Lacertae with an angular resolution of 21 microarcseconds, the highest achieved in astronomy to date. The image reveals that the jet is originated by a large scale helical magnetic field, that extracts the material from the disk surrounding the central black hole, and injects it in the form of twin relativistic jets.



Radio-continuum image (in colors) of the relativistic jet in BL Lacertae

Our observations of BL Lacertae with RadioAstron also reveal an unusually high brightness temperature in the core of the radio jet, which defies our current understanding for the origin of the non-thermal emission in AGN jets.

MEMBERS

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INVITED RESEARCHERS

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LINES OF RESEARCH

Multi-wavelength observations of AGN jets

Relativistic MHD and non-thermal emission simulations

ARAE (Astrofísica Robótica y de Altas Energías)

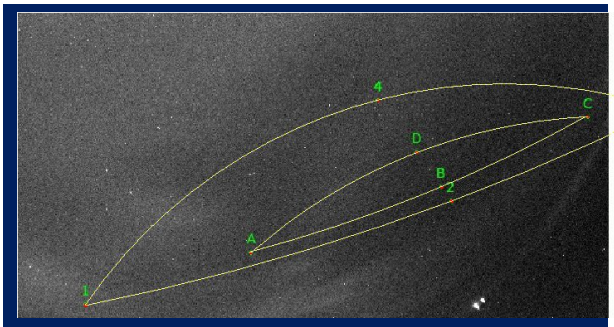
Overview

The ARAE research group (http://arae.iaa.es) was founded in 2001, although some of its members have already started their activity in 1990, and belongs to the Andalusian Research Plan (PAI). Scientists and engineers are working on a variety of projects, combining their strengths. Half of the members are foreigners from all over the world, what it is also an added value. Research areas 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 (ground-based and space-borne). Public outreach and citizen science are also part of the ARAE activities.

Highlights in 2016

- A gravitational-wave (GW) transient was identified in data recorded by the Advanced Laser Interferometer Gravitational-wave Observatory (LIGO) detectors on 2015 Sep 14. This event (dubbed **GW150914**), is described in detail elsewhere. By prior arrangement, preliminary estimates of the time, significance, and sky location of the event were shared with 63 teams of observers covering all wavelengths with ground- and space-based facilities. We provided the only real-time image in the direction of the source, obtained by the CASANDRA3 all-sky camera at our BOOTES-3 station in New Zealand (1).

- Gamma-ray bursts (GRBs) are generated from relativistic jets launched from catastrophic events such as massive star core collapse or binary compact star coalescence. We reported a discovery that similar light curve patterns exist within individual bursts for at least some GRBs. Applying the Dynamic Time Warping method, similarities of light curve patterns between pulses of a single burst or between the light curves of a GRB and its X-ray flare can be identified. This suggests that the central engine of at least some GRBs carries "memory" of its activities. We also showed that the same technique can identify memory-like emission episodes in the flaring emission in soft gamma-ray repeaters (SGRs), which are believed to be Galactic, highly magnetized neutron stars named magnetars. Such a phenomenon challenges the standard black hole central engine models for GRBs, and suggest a common physical mechanism behind GRBs and SGRs, which points toward a magnetar central engine of GRBs (296).



The large LIGO error box for GW150914 as simultaneously imaged by the CASANDRA-3 all sky camera at the BOOTES-5 station in Lauder New Zealand on 14 Sep 2015

- We presented a study of red dwarf flaring stars including the optical and X-ray long-term evolution of the emission by the super-flare from the red-dwarf star DG CVn observed with BOOTES in 2014.

- We developed a variant of the numerical method which we previously introduced in order to evaluate the gravity-darkening exponents. The stellar evolutionary models, which are necessary to obtain the physical conditions of the stellar envelopes and/or atmospheres inherent to the numerical method, are computed via the code GRANADA. In addition, we derive an equation that relates the locus of constant convective efficiency in the Hertzsprung-Russell (HR) diagram with gravity-darkening exponents. (46).

MEMBERS

A.J. Castro-Tirado, M. Cerviño Saavedra, A. Claret dos Santos, R. Cunniffe, F. Espartero Briceño, Y. Hu, S. Oates, R. Sánchez-Ramírez, J.C. Tello Salas and B. Zhang.

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LINES OF RESEARCH

Robotic Astronomy
High-Energy Astrophysics
Astrophysical Transients
Theoretical Stellar Evolutionary models
Models of stellar population synthesis

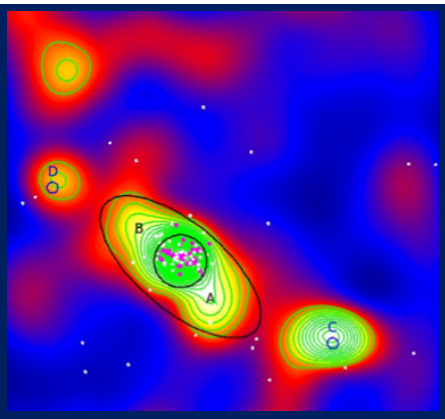
EVOLUTION OF GALAXIES

Overview

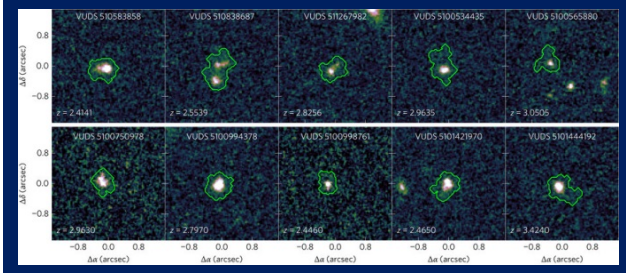
The goals of the Galaxy Evolution group encompass observational and theoretical studies over a wide range of problems of galaxy structure and evolution and cosmology, from their inner stellar and diffuse ISM components to their large scale cosmological distribution and evolution. This research is complemented with an active participation in instrumental and technological projects. Our main topics include the physics of star formation, the diffuse medium in stellar clusters and galaxies, the nuclear activity in galaxies, the environmental dependence of the structure and evolution of galaxies (isolated, in groups, etc). Additional activities include supervising PhD doctoral studies, teaching Master courses, an active public outreach, and eScience.

Highlights in 2016

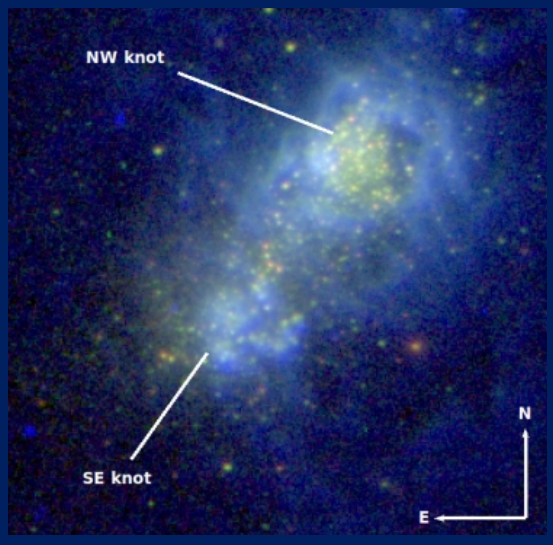
- Based on the CALIFA third public data release DR3, the stellar population group studied the *spatially resolved* Star Formation (SF) along the Hubble sequence. The main results were: (a) the intensity of the SF rate (SFR) shows declining profiles with only small differences between spirals, with values at R = 1 half light radius (HLR) within a factor two of surface density of SFR (ΣSFR) $\sim$20 $M_{\odot}Gyr^{-1}$ pc^{-2}. The dispersion in ΣSFR(R) profiles is much smaller in late type spirals (Sbc, Sc, Sd). This confirms that the main sequence of star forming galaxies (MSSF) is a sequence of galaxies with nearly constant ΣSFR. (b) specific SFR (sSFR) scales with Hubble type and increases radially outward with a steeper slope in the inner 1 HLR. This suggests that SF in galaxies is quenched inside-out, faster in the bulge-dominated center than in the disks. (c) As a whole and at all radii, E and S0 are off the MSSF with SFR smaller than spirals of the same mass. (d) Applying the volume corrections for the CALIFA sample, we obtain a density of star formation (ρSFR) in the local Universe of ρSFR = (0.0105 ± 0.0008) $M_{\odot}yr^{-1}$ Mpc^{-3}, in agreement with independent estimates. Most of the SF occurs in the disks of spirals. (e) The volume-averaged birthrate parameter, which measures the current SFR with respect to its lifetime average, b' = 0.39 ± 0.03, implies that the present day Universe is forming stars at about one-third of its past average rate. E, S0, and the bulge of early spirals (Sa, Sb) contribute little to the recent SFR of the Universe, which is dominated by the disks of Sbc, Sc, and Sd spirals. (f) There is a tight relation between ΣSFR and μ⋆ (stellar surface brightness), defining a local MSSF relation with a logarithmic slope of 0.8, similar to the global MSSF relation between SFR and M⋆, suggesting that local processes are important in determining the SF in disks. The scatter in the local MSSF is driven by morphology-related offsets, with ΣSFR/μ⋆(the local sSFR) increasing from early to late type galaxies, indicating that the shut down of the SF is more related to global processes, such



Galaxy density map in the cluster LCDCS 0829 (z = 0.4510). The large black circle shows 1 Mpc around the cluster center. The (C,D) circles correspond to galaxy clusters in NED



Hubble Space Telescope images of 10 starburst galaxies 1 billion years after the Big Bang. Their spectroscopic study from the instrument VIMOS in the VLT reveals that their properties are very similar to those of the primaeval galaxies



Colour composite HST image of IZw18 in BGR=Hα-V-I

as the formation of a spheroidal component (109, 157, 252).

- AMIGA was focused on preparatory studies for the SKA, by comparing two extreme environments: isolated galaxies and compact groups. Studying the gas in groups requires to separate the gas (with HI-VLA data) in disks and tails, while studying its kinematics. Further progress can be made through a) studies at complementary wavelengths, b) advanced visualization techniques (as the X3D pathway), and c) preparatory work through pathfinders. The X3D Pathway is our new approach to visualise, share and publish multidimensional datasets using 3D diagrams (288). The power of this tool is well-illustrated when applied to HCG 91 HI-VLA data, which presents different projections of the HI cube via an interactive version accessible online as an interactive document. Complementarily, AMIGA got involved in two SKA design consortia: Infrastructure and Science Data Processor. Additionally, due its expertise in e-Science, AMIGA started in 2016 an active involvement in the design of SKA Regional Centres (SRC) which will allow scientists to access SKA science data, as well as the tools and processing power necessary to fully exploit their science potential. AMIGA's IP was invited as external advisor of the SRC Coordination Group.

- We confirmed the existence of the most luminous LINERs with the highest SFR at z=0.04–0.11 and found differences in extinction from other lower-z LINERs, but general similarities to star-forming galaxies. Their median stellar mass was 6-7 10^{10} $M_{\odot}$ which corresponds to the peak of relative growth rate of stellar populations and the highest star forming rates. We found that the fraction of local LINERs on the MSSF galaxies is related to the luminosity of their AGN (225).

- Within our collaboration with the NUGA-South project, the analysis of ALMA data for NGC 1068 allowed to spatially resolve the circumnuclear disk and, for the first time, imaged the dust emission, the molecular gas distribution, and the kinematics from a 7-10pc diameter disk that represents the submillimeter counterpart of the putative torus in NGC 1068. The molecular gas showed strong non-circular motions and enhanced turbulence on a surprisingly slow rotation pattern of the disk. The lopsided morphology and complex kinematics of the torus were interpreted as the signature of an instability long predicted to drive the dynamical evolution of AGN tori (90).

- We developed a simple method to detect **extensions and filaments** around 30 clusters of the DAFT/FADA survey using deep wide field photometry. In the redshift range 0.4 <z< 0.9 of our sample, clusters seem to be well formed but still accreting material along filaments. For each cluster, we selected galaxies in the cluster red sequence, and built density maps, finding elongations up to 7.6 Mpc in 12 clusters (71).

- The Estallidos-GR group is involved in several high-z surveys with VIMOS@VLT to explore the evolution of fundamental relations from early epochs of the Universe. We contributed to the analysis of the **chemical composition and stellar ionizing population in analogs of very young starbursts** (59).

Using the PMAS@CAHA we published the **first IFS data of IZw18**, a very metal-poor high-ionization starburst in the local Universe; a local benchmark to understand distant starbursts. The data sampled the entire IZw18 main body and ionized gas (cf. FoV in figure). We measured for the first time Te[OIII] > 22000 K and confirmed that it is due to photoionization from hot massive stars. The NW shows the largest Te[OIII], gas excitation, and ionization parameter. More than 70% of the spaxels with Te[OIII] > 22,000 K are HeII-emitting. These facts imply a harder ionizing radiation field at the NW SF knot (140).

MEMBERS

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LINES OF RESEARCH

Violent star formation

Star formation in galaxies

Stellar population synthesis

The interplay between massive star formation and chemical evolution in galaxies

The influence of the environment on the evolution of galaxies

Active Galactic Nuclei

Physics of Quasars

Cosmic evolution of galaxies

Astronomical instrumentation

HETH

Overview

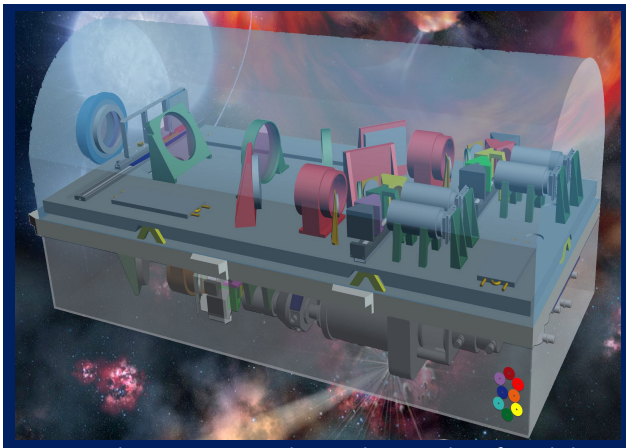
HETH (High-Energy Transients and their Hosts) is interested in any kind of explosive transients as well as their immediate and larger environment. Our research spans from novae and X-ray transients to supernovae (SNe) to gamma-ray bursts (GRBs). We study these phenomena with data from different wavelengths and since transients require fast reaction times, we have several target-of-opportunity programs at ORM, OSN, CAHA and VLT, ALMA and NOEMA. Apart from the actual transient event, we also study their aftermaths (such as nova remnants) and environments/hosts at high angular resolution to infer properties of the progenitors of those transients. Finally, very luminous transients such as GRBs are used to study galaxies and their chemical evolution up to very high redshifts. Last but not least, HETH is also involved in astronomical instrumentation projects. HETH, a young, international research group, grew from 3 to 7 members in 2016.

Highlights in 2016

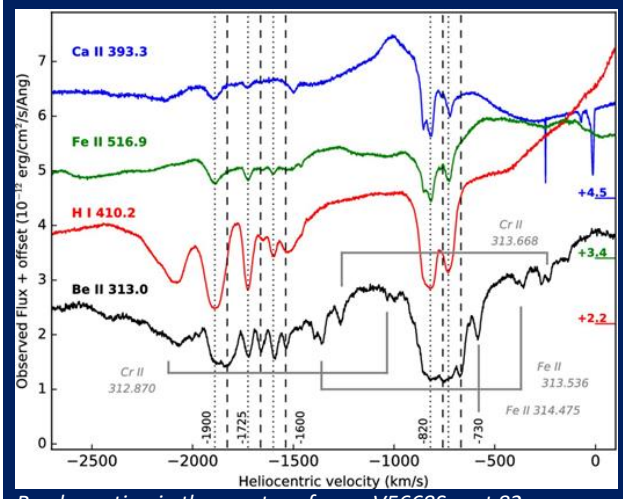
- **OCTOCAM** was selected in 2015 for a feasibility study as Gemini's new workhorse instrument. In August 2016, OCTOCAM answered the request for proposal and was selected for construction in Nov. 2016. OCTOCAM is an 8-channel simultaneous imager and spectrograph with high time-resolution capabilities, fully funded by AURA with 15MUSD to be installed at Gemini-South in early 2022. One of its main purposes is the follow-up of LSST-discovered transients, but its wide wavelength coverage and high sensitivity will serve a wide range of science goals. HETH is leading the project with partners from FRACTAL S.L.N.E in Madrid, SwRI in San Antonio, Texas and GWU in Washington D.C.

- **Discovery of ^{7}Be in novae and the implication for the origin of Li.** 25% of the Li abundance in the Universe was produced in the Big Bang, but the origin of the remaining 75% has long been a mystery. In 2015, Izzo et al. detected for the first time Li in the early phases of novae for the first time. ^{7}Li in novae is a product of the decay of ^{7}Be (half-life of 53.2 days) which again is produced by ^{3}He+^{4}He in the thermonuclear runaway. Indeed, in the "slow" nova V5668Sgr, Molaro et al. found large amounts of Be, which would translate to an overabundance of 4.7-4.9 dex of Li compared to solar value. This implying that only two such novae in the Galaxy would explain the missing Li thus making novae one of the important Li farms in the Galaxy (186)

- GRBspec. GRBspec (http://grbspec.iaa.es) is the world's largest public database of GRB spectroscopy, developed by HETH. In 2016 we were awarded a BBVA grant for researchers and cultural creators to continue with the development of the project. It also allowed us to incorporate spectra from GTC and VLT.



View into the OCTOCAM enclosure showing the infrared channel on top, the VIS channel is at the bottom



Be absorption in the spectra of nova V5668Sgr at 82

MEMBERS

K. Bensch, Z. Cano, L. Izzo, R. Sánchez-Ramírez, C.C. Thöne, A. de Ugarte Postigo

INVITED RESEARCHERS

D. A. Kann (Thüringer Landessternwarte Tautenburg), D. Perley and L. Christensen (Dark Cosmology Centre), M. Blažek (Technical University of Prague)

LINES OF RESEARCH

Gamma-ray bursts
Supernovae (Type IIn, broad-line Ic, SLSNe, GRB-SNe)
GRB and SN host galaxies and GRB/SN environments
Dwarf galaxies in 3D
X-ray binaries and magnetars
Novae and nova remnants
Cosmology
Astronomical instrumentation

LOW-MASS STARS AND EXOPLANETS

Overview

The full name of our group is "Physics of low-mass stars, exoplanets and associated instrumentation". It studies the physics of planetary systems and their low-mass stars. In the last years, the community has focused on these stars because of the great interest they present for the discovery of temperate rocky planets that could sustain liquid water. Therefore, we work in all possible aspects of the problem, from the general statistics and physics of the formation and evolution of exoplanets and their atmospheres to the internal structure and magnetic activity of their stars. The group includes personnel with experience in theory of stellar structure and evolution, magnetic activity, asteroseismology, observations with space and ground-based instruments, technical development of new instrumentation, project management and system engineering.

Highlights in 2016

- CARMENES, a world-wide unique instrument, started its scientific operation at CAHA observatory in January 1st. In the following years, the instrument will collect high-resolution spectra simultaneously in the optical and the near infrared for a radial velocity (RV) survey of around 300 M-dwarf stars to search and characterize temperate rocky exoplanets. During its first year (2016) of operation, the survey already collected at least one of such spectra of its 300+ target sample.

- HIRES is a second-generation instrument for the Extremely Large Telescope (ELT). It is an instrument conceptually similar to CARMENES. During 2016, our group, the IAA, being a member of the HIRES consortium and Project Office, participated in the preparation of the Phase A of the project. HIRES Phase A started in March 2016 and will last for two years.

- On Aug. 24th, 2016, the Pale Red Dot (PRD) team, represented by Guillem Anglada-Escudè (QMUL, UK), Pedro J. Amado (IAA, Spain)) and Ansgar Reiners (IAG, Germany), announced, at a press conference at ESO Headquarters, the discovery of a temperate rocky **planet orbiting our nearest star, Proxima Centauri (11)**. More details about the planets, named Proxima b, and its star can be found in the section about Press releases in this report and at the ESO and PRD.

PRD logo and phase-folded RV curve (top left). Pictures of the press conference at ESO (top right and middle top). Covers of three journals showing the discovery (middle bottom) and worldwide press impact (bottom).

MEMBERS

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INVITED RESEARCHERS

Andreas Quirrenbach (LSW-Heidelberg, Germany), Jean-Louis Lizon (ESO-Garching, Germany), Jürguen H. M. M. Schmitt (HS-Hamburg, Germany), Artie P. Hatzes (TLS-Tauntenburg, Germany), Michael A.C. Perryman (UCD-Dublin, Ireland)

LINES OF RESEARCH

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

PHYSICS OF THE INTERSTELLAR MEDIUM

Overview

This group studies the formation, evolution and death of stars at different mass and spatial scales across distinct environments.

The early stages of star and planet formation are studied through radio interferometric observations and modelling of the observed emission. Infalling molecular envelopes, dusty circumstellar discs and ionised radio jets in young stellar objects are studied. High angular resolution observations are used for analysing the multiplicity of massive stars.

The final stages of a star's life are studied by the multi-wavelength characterization of evolved stars and the wind-blown bubbles around them, to understand the processes that shape planetary nebulae (PNe) and the circumstellar medium around massive stars.

Radio interferometric monitoring of supernova (SN) explosions and their distribution in Ultra Luminous Infrared Galaxies (ULIRGs) is also carried out to determine the SN and star formation rates. We also disentangle the mechanisms for gas and dust heating. High-energy phenomena are studied at different scales.

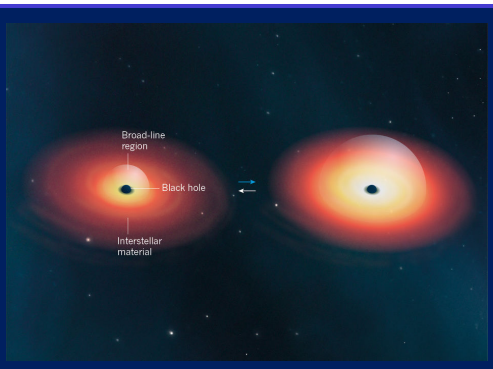
Highlights in 2016

- We observed the dramatic change of the activity of the black hole at the center of **Mrk1018**, which over the course of 10 yr changed from being a bright Sy 1 galaxy to a faint Sy 2 galaxy due to a tenfold decrease in its accretion rate (177 and 131).

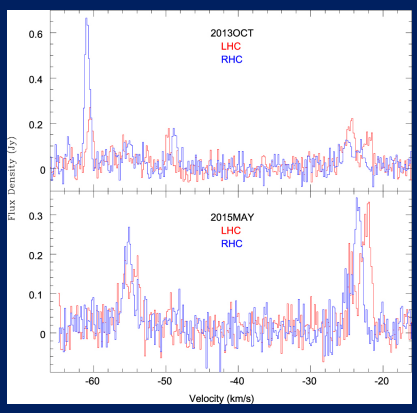
- We detected the shock-excited maser line of OH at 1720 GHz in the planetary nebula (PN) **IRAS 16333-4807** (230). This line is usually seen in in supernova remnants, but ours was the second ever detection in a PN. The detected spectra show the best example of Zeeman splitting in this type of objects, allowing a direct detection of magnetic field strength (2-10 mG).

- Within our proyect of studying planetary nebulae around subdwarf O-type stars, we used GTC observations to show that **RWT152**, one of these objects, is located in the Galactic halo and presents a very poor content in metals with an unusual lack of nitrogen. RWT152 seems to be the descendent of a star with an initial mass similar to that of our Sun (6).

- We discovered a dwarf protoplanetary disk around the M-type star **XZ Tau B** (205) using the highest angular resolution of ALMA (0.03”). The disk has a radius of only 3.4 au, while typical disks have radii 10-50 times larger.



Starving black hole returns brilliant galaxy to the shadows (Mrk1018)



Spectra of circular polarization of the OH emission at 1720 MHz from the PN IRAS 16333-4807, showing Zeeman splitting in the line (shift between the two circular polarizations)

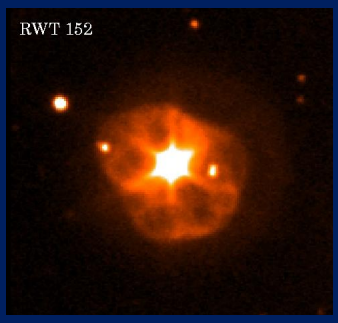


Image in the light of Halpha of the planetary nebula around the subdwarf O-type star RWT152 obtained with the instrument OSIRIS at the GTC

Such a tiny disk is expected to evolve 50 to 500 times faster than its bigger counterparts and could reveal the complete planet formation process in very short time-scales. A population of dwarf disks similar to that of XZ Tau B could be the progenitors of compact planetary systems, like those identified by the Kepler Mission or around the nearby stars Proxima Cen and Trappist-1.

- The last stages of the protoplanetary disc evolution should be characterized by the dispersal of the disc gas.

Photoevaporation by high energy radiation is considered the dominant mechanism for gas removal. We obtained direct evidence for this mechanism in the disc of **GM Aur** by spatially separating and imaging with the VLA the dust emission of the disc, the ionised jet, and the ionised photoevaporating disk (164).

- Important steps were given in 2016 in our understanding of the physical structure of hot bubbles. High-spatial resolution HST STIS spectroscopic observations of the Cat's Eye Nebula have allowed us to determine for the first time the spatial location of the interface layer between the hot bubble and optical nebular shell in a PN (75). Meanwhile, deep XMM-Newton EPIC-pn observations of the Wolf-Rayet (WR) bubble NGC 6888 have revealed for the first time temperature and nitrogen abundance inhomogeneities in the hot gas inside a WR nebula (275).

- We obtained the deepest and highest angular resolution (0.3") image at 150 MHz of **Arp220**, the closest ULIRG, using the LOFAR international telescope. The observations unveiled kpc-scale star-forming discs surrounding both nuclei, and shocked outflows (283).

MEMBERS

A. Alberdi, G. Anglada G., A.K. Díaz-Rodríguez, J.F. Gómez, M.A. Guerrero, E. Macías, G. Manjarrez, J.M. Mayen-Gijón, L.F. Miranda, R. Ortiz, M. Osorio, M.A. Pérez-Torres, N. Ramírez

INVITED RESEARCHERS

I.Martí-Vidal, (Chalmers, Sweden), C. Romero-Cañizales (UDP, Chile), J.I. Añez (ICE-CSIC, Spain), S. Lizano (UNAM, Mexico), R. Galván Madrid (UNAM, Mexico), C. Tapia (UNAM, Mexico), L. Hartmann (Univ. of Michigan, USA), E. Roth (University of Valencia)

LINES OF RESEARCH

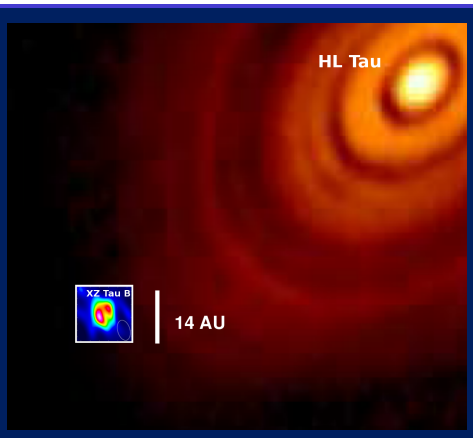
Massive stars and their surroundings

Star and planet formation modeling and observation

Multi-wavelength study of PNe and their precursors

Stellar endproducts, accretion phenomena and the ISM in LIRGs and ULIRGs

Prospective Science work for SKA



A comparison (same scale) of the size of the well-known protoplanetary disc around HL Tau and the dwarf disc around XZ Tau

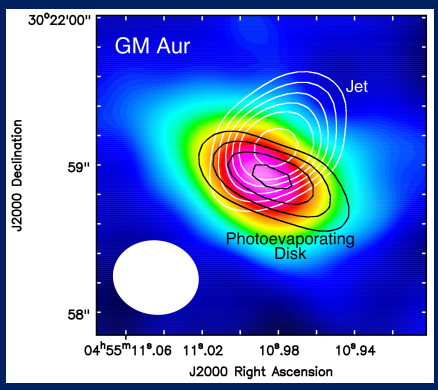
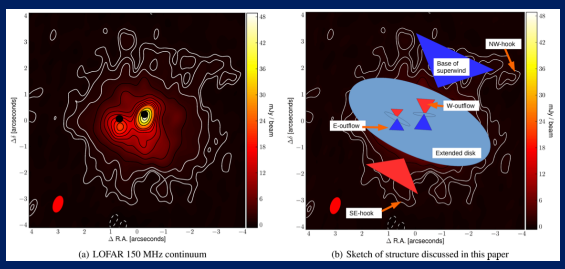


Image of the dust and ionised components in the young star GM Aur. The disc of dust is shown in colour scale, the ionised jet in white contours, and the ionised photoevaporative wind arising from the disc in black contours



The LOw Frequency ARray (LOFAR) unveils kpc-extended disks surrounding the nuclei of the closest ULIRG, ***Arp220***

SOLAR PHYSICS

Overview

The IAA's Solar Physics Group (SPG) main scientific interests root in solar spectropolarimetry and magnetic fields 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, in order to work out the sensitivities of the Stokes spectrum on the various physical quantities of the solar photosphere,
- the inversion of the RTE for its use on the interpretation of spectropolarimetric measurements in terms of the thermodynamic, magnetic, and dynamic parameters of the Sun,
- the structure and physical nature of photospheric magnetic structures like plage and network flux tubes, the umbra, the penumbra, and the moat of sunspots, and the internetwork magnetic fields,
- the design, development, and construction of solar instrumentation.

Highlights in 2016

Science

- Most accurate appearance and disappearance rate of internetwork magnetic fields. Both are well balanced.

- Supersonic downflows are found in compact patches moving outward, which are located in the mid- and outer penumbra. They may undergo fragmentations and mergings during their lifetime and are associated to magnetic fields of different polarity.

- An invited review to the important journal *Living Reviews in Solar Physics* has been published on "Inversion of the radiative transfer equation for polarized light".

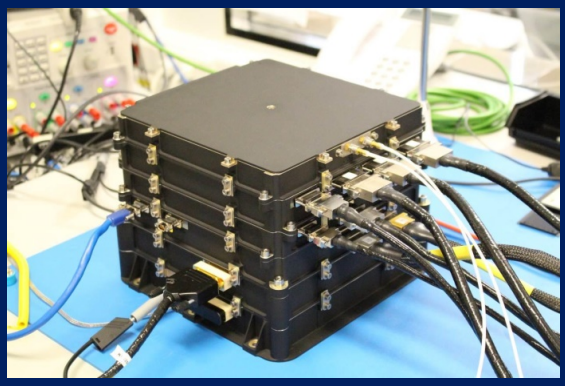
- We contributed to the first results obtained with the German telescope GREGOR.

- The path to the transition region of magnetic bubbles that had emerged with granular size was studied.

Instrumentation

- Milestones in the development of the **SO/PHI** magnetograph for the ESA's Solar Orbiter mission:
  · E-Unit qualification model (QM) integration and tests
  · E-Unit QM delvery
  · First integration and tests of the flight model

- Agreement for a third edition of the *Sunrise* stratospheric balloon mission, including a renovated IMaX+ magnetograph led by SPG.



Qualification model for the SO/PHI electronics unit

MEMBERS

D. Álvarez García, B. Aparicio del Moral, F.J. Bailén Martínez, M. Balaguer Jiménez, L.R. Bellot Rubio, J.P. Cobos Carrascosa, J.C. Del Toro Iniesta, J. España Navarro, F. Girela Rejón, M. Herranz de la Revilla, P. Labrousse, A.C. López Jiménez, J.L. Ramos Más, A. Ortiz Carbonell

INVITED RESEARCHERS

D. Utz (University of Graz, Austria), M. Murabito (University of Catania, Italy), A. FerrizMas (Universidad de Vigo)

LINES OF RESEARCH

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

PLANETS AND MINOR BODIES

Overview

Three are the research areas comprising the group "Planets and minor bodies of the SolarSystem": Planets, minor bodies of the Solar System and Cosmic Dust Laboratory.

Broadly speaking, this group aims to provide us with an integrated view of the Solar Systemmaking use of observational data obtained from ground and space. Moreover, several members of the group are focused on the development of models of planetary and cometary atmospheres in the Solar System.

Regarding the data obtained from space, it has to be noted that we are involved in 5 planetary missions from the scientific point of view as well as from the technical point of view. All technological challenges that we face are mostly devoted to electronics engineering, being developed until now by members of the UDIT.

The main objectives are:

Minor bodies: formation and evolution.

Ground and space observations in multi-spectral ranges.

Theoretical modeling regarding both thermophysical and coagulation processes, and physical properties of dust in comets and Main-Belt Comets by Monte Carlo dust tail models.

Because TNOs are believed to be the least evolved objects within our solar system, they carry very important information on the initial phases of the Solar System, with also implications to other solar systems. Therefore, their study is important in order to understand the early phases of solar system formation.

Planetary atmospheres and surfaces:

- Origin and evolution of the water content and its derivates in the atmospheres of the Giant Planets and Titan. Determination of the turbulent tranport and chemical schemes controlling the measured vertical profiles by the HIFI instrument on board the Herschel Space Telescope (ESA).

- We are developing applications for the scientific exploitation of the data provided by the laser altimeter (BeLA) on board the Bepi Colombo mission. These data are related to Mercury geology, geodesy, interior and surface characteristics.

- We are directed involved (CoPI level) from a theoretical and technological point of view in the NOMAD (Nadir and Occultation for Mars Discovery) instrument on board of the ESA ExoMars TGO Orbiter.

- IAA Cosmic Dust Laboratory (CODULAB): Experimental study of the angle dependence of the scattering matrices of dust samples of interest for the Solar System research, i.e. mineral dust particles that are potential candidates for being present in the planetary and cometary atmospheres of the Solar System (e.g. olivines, pyroxenes, basalt, palagonite, calcite, carbon, etc). The **CODULAB** provide experimental data in support of the research lines described above.

Left: Exomars-TGI launched from Baikonur, 14th Mars 2016. In its way to Mar.

Right: Discovery of a terrestrial planet around Proxima Centauri

Highlights in 2016

- Launching of **NOMAD** on board Exomars

- Discovery of a terrestrial planet in orbit of **Proxima Centauri** (11)

- End of the Rosetta Mission

MEMBERS

A.D. Benítez Yáñez, J.M. Castro Marín, R.D. Duffard, J. Escobar, E. Fernández, M. González García, P.J. Gutiérrez, J. Jiménez Ortega, M. Lampón, L.M. Lara, J.J. López Moreno, I. Martínez Navajas, A. Molina, N.F. Morales Palomino, F. Moreno, O. Muñoz, J.L. Ortiz, J. Rodrigo Campos, P. Santos

INVITED RESEARCHERS

E. Zubko (Universidad de Helsinki), A. Campo Bagatín (Universidad de Alicante), P. Maier (MPE), S. Pérez Hoyos (Universidad del País Vasco), Á. Álvarez Candal (Observatorio Nacional de Rio de Janeiro)

LINES OF RESEARCH

Planets and minor bodies of the Solar System
Dust in the Solar System

STELLAR SYSTEMS

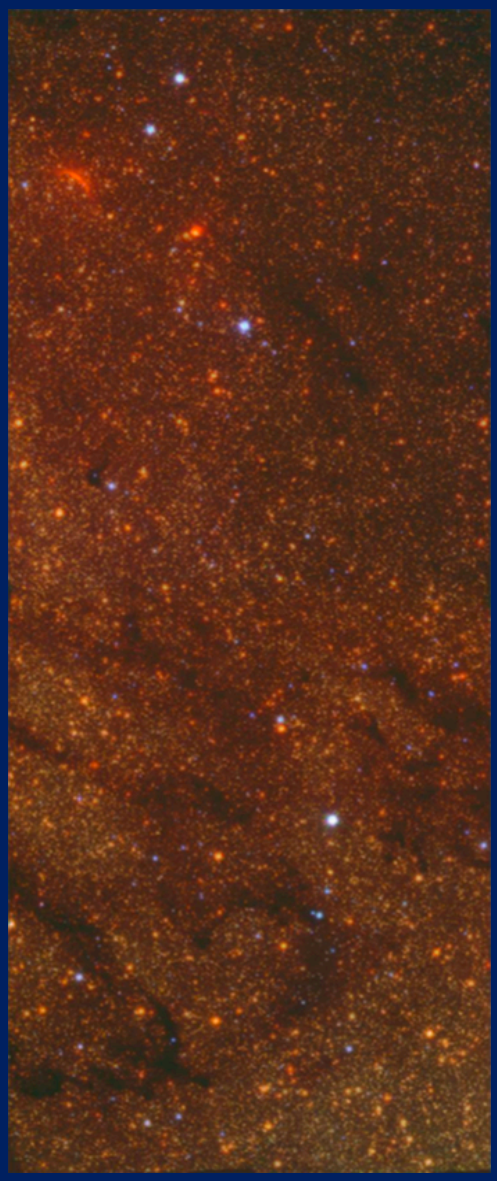
Overview

The Stellar Systems Group (SSG) was created in 1988. Since then, our research interests have diversified, even though the group has grown at a lower pace. The group's development departed from two fundamental concepts: (1) Internationalization, understood as the establishment of collaborations with leading international astronomical research centres and researchers and the incorporation of international researchers. (2) Specialization, understood as the hiring and promotion of leading researchers. As a result, we incorporated four Ramón y Cajal Fellows since the creation of the scientific team, which has increased the productivity and impact of it. We are leading the study of 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 (http://ssg.iaa.es), is carrying out an unprecedented study of the Galactic Centre region (http://gc.iaa.es) and performing the most complete catalogue of Galactic massive stars.

An ERC Consolidator Grant, awarded to Rainer Schödel, is still in operation, and we are leading or actively involved in four main surveys connected with stellar clusters, Galactic Centre, Galactic structure and massive stars (Gaia-ESO Survey, GALACTICNUCLEUS Survey, GALANTE, and GOSSS).

Highlights in 2016

- The third volume of GOSSS catalogue (168)
-The improved determination of Sgr A* mass and distance from a multi-star orbital analysis (33)
- New tool for searching for clustering in the phase space of stellar systems (5)



RGB image of a field in the Galactic Centre based on JHK data taken with HAWK-I/VLT as part of the GALACTICNUCLEUS survey. The field of view is about 8 arcmin by 3 arcmin with an angular resolution of 0.2

MEMBERS

E.J. Alfaro, M.T. Costado, A.J. Delgado, H. Dong, A.T. Gallego, E. Gallego, E., M. González, A. Lorenzo, F. Nogueras, L.M. Sampedro, N. Sánchez, R. Schödel, A. Sota

INVITED RESEARCHERS

M.C. Sánchez-Gil, M. C. (University of Cádiz, Spain), K. Mužic (Universidad de Diego Portales, Chile), F. Yusef-Zadeh (Northwestern University, USA)

LINES OF RESEARCH

Galactic Centre
Massive Stars
Formation and Destruction of Stellar Clusters

TERRESTIAL PLANET'S ATMOSPHERES

Overview

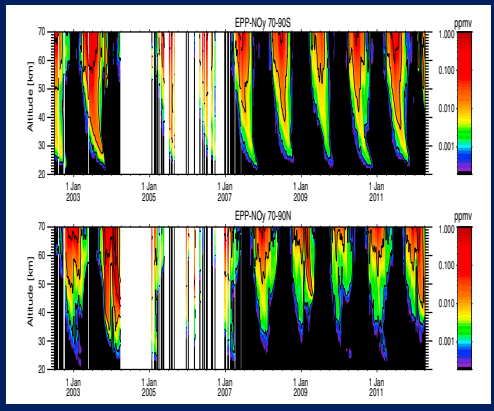
Research in our Group is being carried out about the Earth's atmosphere, on retrieving, processing and analysing the data of the MIPAS and SABER space-based instruments and ground-based SATI. Special focus is on the study of the effects of solar particles and solar radiation on atmospheric composition, and trends in temperature and species abundances. We also study atmospheric electricity in planetary atmospheres and are preparing for the analysis of the future ASIM and TARANIS missions. In 2016 the *eLightning* project was funded by the European Research Council with the aim of building multi-scale, coupled numerical models to investigate the physics of lightning. We coordinated the EC H2020 project *UPWARDS*, devoted to the exploitation of Mars Express data and to the development of new tools in preparation for Exomars. We also continued the analysis of VIRTIS/Venus Express data and the study of the variability of the Martian upper atmosphere using global climate models and ground-based observations. The Group has recently initiated studies on exo-atmospheres.

Highlights in 2016

- For the first time, a climatology of temperature tides was derived from 20 to 150 km from a single instrument (MIPAS) on a global scale (91).
- A semi-empirical model for **stratospheric and mesospheric reactive nitrogen** produced by energetic particle precipitation was developed from the 10 years' record of MIPAS (84).
- The development of **GRASSP**, a spectrograph for the study of transient luminous events (211).
- Estimation of the intensity of lightning on Venus required for observable effects on its upper atmosphere (218).
- Launch and successful insertion on Martian orbit of the **ExoMars TGO orbiter, including NOMAD**, in which our group has a strong involvement (159).

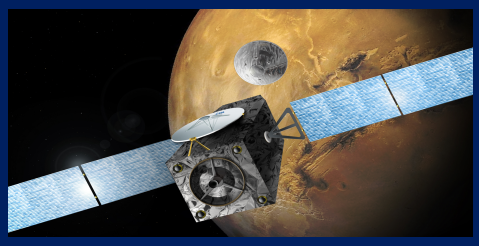
MEMBERS

A. Cala, B. Funke, M. García Comas, A. Gardini, F. González Galindo, M. González, F.J. Gordillo Vázquez, S. Jiménez Monferrer, A. Luque Estepa, M.J. López González, M. López Puertas, M.Á. López Valverde, M. Passas Varo, F.J. Pérez Invernón, A. Sánchez López, J. Sánchez del Río



Temporal evolution of the EPP-NOy concentration at (top) 70-90º S and (bottom) 70-90º N during the Envisat Mission lifetime (July 2002 – March 2012)

The GRASSP instrument



ExoMars mission inserted in Mars' orbit

INVITED RESEARCHERS

N. Lehtinen (University of Bergen, Norway), T. Hoder (Masaryk University, Czech Republic)

LINES OF RESEARCH

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 and exo-atmospheres

Remote sensing of planetary atmospheres in the IR and UV

THEORETICAL GRAVITATION AND COSMOLOGY

Overview

20th-century physics totally changed the way we understood the world by giving birth to two revolutionary theories, General Relativity and Quantum Mechanics. Instead of having a single theoretical framework with which to understand nature, we have two, and two which are mutually inconsistent, at least as far as we can see. There are at least two situations that ask for General Relativity and Quantum Mechanics at the same time: The formation and evolution of black holes and the origin and evolution of the Universe as a whole, the subject of Cosmology.

The main activity of our group is to investigate these two situations and to search for ways of combining the gravitational and the quantum realms. For that we use a wide range of techniques: From geometrical techniques in General Relativity to group-theoretical and condensed matter techniques. The specific subtopics are briefly described below:

1. Gravitational collapse in theories of gravity beyond Einstein's Generel Relativity: We are interested in making a comparison between the collapse process in standard General Relativity and that in other gravitational theories that incorporate modifications to General Relativity. In particular, we analyze the effect that a specific regularization of the classical singularity would have in the process of collapse itself and in the final forms of equilibrium one could attain.

2. Group-theoretical quantization: We further develope the group-theoretical quantization scheme to attack the problem of quantization of General Relativity or at least, of subsectors of it reduced by symmetry considerations. To apply these techniques, we first develope a gauge theoretical version of General Relativity mixed other interactions such that the internal and spacetime symmetries appear on an equal footing.

3. Analogue Gravity: Condensed matter systems with emergent geometrical properties have already proved very important in understanding which type of quantum corrections one could expect to see when probing gravity at high energies. For instance, they have provided a way of studying the high-energy properties of Hawking radiation. We are analyzing whether the dynamics of General Relativity can also be obtained as an emergent phenomenon.

4. The origin of the mass of the particles: One of the biggest problems in physics is to understand what it is the origin of the mass of elementary particles. In the standard model of particle physics the mass emerge owing to the interaction of the Higgs particle with initially massless fermions. In our group we investigate an alternative mechanism that does not need the existence of the standard Higgs. It relies on the possibility of mixing gravity with other interactions and on the group-theoretical quantization of non-Abelian Yang-Mills theories.

Highlights in 2016

Withing the different proposals for the regularization of a black hole through a bounce, we proved that those involving the transition to a white hole have to be very rapid or they become unstable (22).

We succeeded in producing a **quantum model** for a particle moving in three-dimensional sphere. Special attention was taken to undertand the role of the basic cummutators which differ from the canonical ones (4).

We made a strong case for changing the way the Unruh and Hawking effects were understood. We argued that a consistent interpretation required to take the Unruh effect as something occurring when a detector is accelerating with respect to infinity and not with respect the local free-fall reference (20).

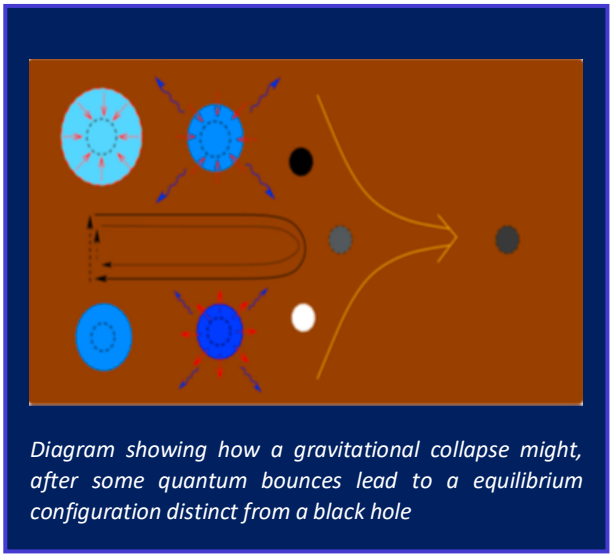


Diagram showing how a gravitational collapse might, after some quantum bounces lead to a equilibrium configuration distinct from a black hole

MEMBERS

V. Aldaya, L.C. Barbado, C. Barceló, R. Carballo-Rubio, G. Jannes

INVITED RESEARCHERS

D. Oriti (AEI, Germany), L.J. Garay (UCM), G.A. Mena-Marugán (IEM-CSIC)

LINES OF RESEARCH

Gravitational collapse and semiclassical gravity
Group theoretical quantization
Analogue and emergent gravity
Origin of masses of elementary particles

CALAR ALTO OBSERVATORY

The IAA is also the reference institute for the Calar Alto Hispano-Alemán observatory (CAHA). The German-Spanish Astronomical Center at Calar Alto is located on the mountain range of Los Filabres, in Almería, at a height of 2167m. CAHA is operated jointly by the Max-Planck-Institut für Astronomie (MPIA, Heidelberg, Germany) and the IAA. Calar Alto provides three telescopes with apertures of 1.23m, 2.2m and 3.5m to the general community. A 1.5m-telescope, also located on the mountain, is operated under the control of the Observatory of Madrid. The ideal atmospheric conditions for astronomical observations and aperture size of the telescopes at CAHA make of it the most important astronomical observatory in the continental Europe.

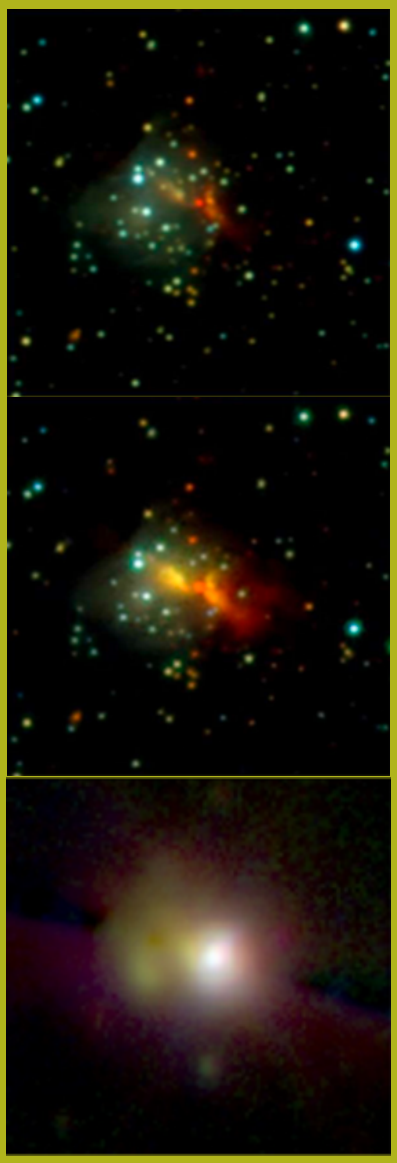
The CAHA telescopes are equipped with state-of-the-art astronomical instrumentation including direct imaging optical and near-infrared cameras, and intermediate- and high-dispersion spectrographs. The observatory itself has its own technical installations: clean rooms, electronic, mechanic and computing facilities, and all-sky cameras and sensors to monitor the quality of the night sky.

The observatory offers aluminizing services as it has the largest aluminizing chamber in Europe, which can host mirrors with diameters up to 4m.

Workshop on "New Instrumentation and legacy projects for Calar Alto

The workshop “New instrumentation and legacy projects for Calar Alto” was held at the Instituto de Astrofísica de Andalucía (IAA-CSIC) headquarters (Granada) on October 13th-14th 2016. A total of 70 people from 8 countries in 3 continents registered to attend the workshop. A total of 23 talks –3 of them via teleconference from Beijing, Boston and Paris– and 4 posters were presented. The workshop was live-streamed; all the oral contributions of the different sessions of the workshop were made available on the IAA-CSIC Youtube channel.
https://www.youtube.com/user/iaaudc/videos

Calar Alto observatory is looking for competitive long-term science cases and associated instruments concepts. The proposals presented in this workshop could be used as a guide-line. The final investment must be predominantly externally funded.



The accretion burst produced a light-echo, which showed how the sparkle shifts from its origin towards to the star’s jets. Images of PANIC observations during November-15, Febreruary-16 from CAHA

Scientific results in 2016

A STELLAR BURST REVEALED THE FORMATION MECHANISM OF MASSIVE STARS

An outburst from a massive star in formation produced due to the sudden inflow of material coming from its accretion disk, was detected for the very first time. This discovery is the most solid evidence so far that high mass stars are formed through a similar process to that which gives rise to the low mass ones. The study of an outburst detected on the massive star in formation NIRS 3, and published in Nature Physics, has provided the most solid evidence that, in effect, all stars are formed in a similar way.

STELLAR FORMATION SHOOTS OBSERVED IN A TYPE OF GALAXY WHERE, IN THEORY, STARS ARE NO LONGER BORN

CALIFA project allowed to detect, in three early-type galaxies, a very tenuous arm where stars are being formed. The data obtained with Calar Alto Observatory 3.5m telescope, contradict the widespread belief that in old galaxies stars are no longer born.

SN2015BH: END OF STAR OR SUPERNOVA "IMPOSTOR"?

Astronomers spotted an intense explosion of a massive star, which, according to records, experienced frequent eruptions for at least 20 years. The analysis of the outburst did not allow to discern between a real supernova - an explosive event marks the end of a star - or a giant eruption implying a massive change in the star's evolutionary course.

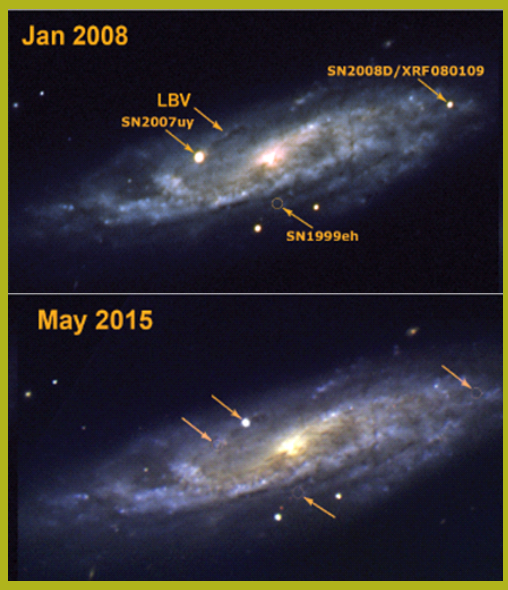
REWINDING STELLAR EVOLUTION: THE LAST 400,000 YEARS OF MASS LOSS FROM A STAR

The study of K4-37, a planetary nebula never studied in detail before, allowed us to trace back the mass loss history of its last stages as a star.

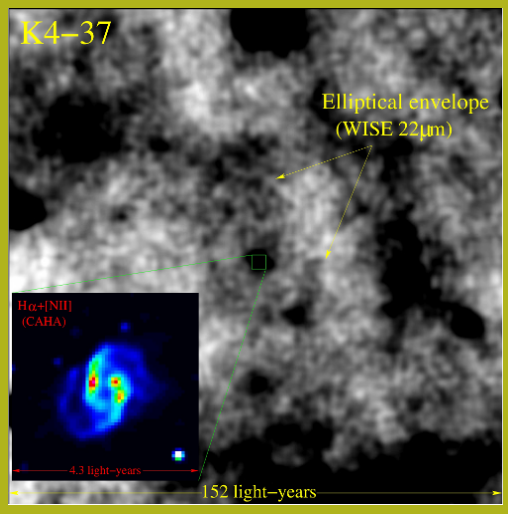
The study made use of data from Calar Alto and San Pedro Martir (Mexico) observatories. The new images taken at Calar Alto show that, besides its typical bipolar appearance with an equatorial torus and two bipolar lobes, K4-37 also exhibits distortions in the lobes. Moreover, the 3-dimensional reconstruction of the nebula reveals that the central torus and lobes are not perpendicular to each other, but they appear as such only due to their projection onto the sky.

THE PECULIARITIES OF THE BIG EQUATORIAL JET STREAM OF SATURN'S ATMOSPHERE REVEALED

A study showed how are the structure and the temporal variations of the biggest jet stream of the Solar System.



Galaxy NGC2770. LBV marks the position where the explosion was detected



Left: Fasle color image of K4-37 obtained with CAFOs at the 2.2m Calar Alto telescope, in the light of hydrogen and single-ionized nitrogen emission lines. Dark blue represents the faintest nebular regions, yellow and red the brightest ones. (Right) Infrared images of 22microns from the WISE archive (black represents brighter regions).

The research, carried out by the Group of Planetary Sciences of the University of País Vasco, used the PlanetCam camera installed at the Calar Alto Observatory 2.2m Telescope. This job produced a publication in Nature.

COLLABORATIONS IN 2016

THE EUROPEAN SPACE AGENCY (ESA) RENEWED THE COLLABORATION WITH CAHA

On January 16, the ESA collaboration with CAHA started. ESA and Calar Alto signed a collaboration agreement for the exclusive remote use of the 80 cm. Schmidt Telescope. The agreement, which included a first stage until March 2017, yielded the use of the 80 cm. Schmidt Telescope to ESA. It is a telescope that had fallen into disuse in 2001, and Observatory technicians recovered it for remote observation with a minimal investment.

The progresses achieved after one year of operation were shown in the ESA SSA-NEO observers meeting in ESRIN from 31th March 2017 in Frascati, near Rome, Italy. As a consequence, the agreement was renewed for one more year up to March 2018. Indeed, there is an increasing interest by ESA to develop a self-funding wide field camera for this facility.

COLLABORATION CAHA- UNIVERSITY OF BEIJING

Reverberation mapping is a powerful tool for the detection of the dynamics and the structure of broad line regions (BLR) and hence the measurement of super-massive black hole masses in AGNs. As a special population of AGNs, super-Eddington accreting massive black holes (SEAMBHs) play a key role in several fundamental issues: (1) physics of high accretion rates onto BHs is poorly understood, as well as kinematics of BLR in AGNs and quasars; (2) BH masses; (3) co-evolution of fast-growing BHs and their hosts; (4) potential applications to cosmology for dynamics of the high-z Universe. The key step forward is to measure the BH masses of SEAMBHs in the time domain through a large RM campaign.

In summary, the SEAMBH team plans to do reverberation mapping of a homogeneous and big sample of quasars to answer the fundamental issues listed above. The proposed campaign provides opportunities to reinforce the current results and greatly enhance understanding of the fundamental issues. To do so, CAHA and the University of Beijing closed a collaboration for 3 years starting in 2016, for the use of the 2.2m telescope and CAFOS instrument.

TECHNOLOGICAL RESULTS IN 2016

The technical work on CARMENES since its provisional acceptance at the end of 2015 concentrated on making the instrument operations automated and reliable, on improving the stability of both spectrographs (including many small changes to hardware and operating procedures), and on establishing the instrument performance.

CARMENES NIR channel at CAHA

The main results of the technical efforts can be summarized as follows:

• Both channels meet the requirements in terms of throughput (i.e., sensitivity).

• Both channels show an internal precision of about 1 m/s, substantially exceeding the requirements and being close to the goals.

• The VIS channel demonstrated 2 m/s long-term stability in repeated observations of stars.

• Analogous on-sky tests for the NIR channel were executed, and the analysis of the results demonstrate a performance close to the requirements and, at the same time, a convincing evidence about the prospects to reach the 5 m/s requirement with stellar light in a very close future.

• The instrument control system is working. CARMENES can be operated by CAHA staff on a daily and nightly basis. The data reduction pipeline provides feedback on the health of the system and the success of the observations.

• Regular maintenance procedures were established and are executed by CAHA personnel.

SIERRA NEVADA OBSERVATORY

AN OBSERVATORY AT 3000M

The Sierra Nevada Observatory (OSN) is a high mountain observatory located at Loma de Dílar (2896m altitude) within the Sierra Nevada National Park (Granada, Spain). The observatory is operated and supplied by the IAA. It consists of a main building which hosts two Nasmyth optical telescopes of 90-cm and 1.50-m diameter each (hereafter T90 and T150). The astronomical instruments attached to those telescopes are two similar 2048x2048 CCD cameras, a Strömgren-Crawford simultaneous six-channel photometer and Albireo, a low- and intermediate-resolution optical spectrograph. The technical maintenance of the telescopes and instruments is supported by the UDIT (Instrumental and Technological Development Unit) staff belong to IAA. Its southernmost high-altitude location in continental Europe together with the dry climatic conditions of Sierra Nevada makes the observatory an excelent place for carrying out other experiments and studies. For this, in addition to the main building, there are secondary facilities which complete the infrastructure available.

Due to the size of their telescopes, the OSN is especially suited for projects requiring a prompt response (Target of Opportunity, ToO) and/or monitoring observations during long periods of time. The astronomical observations carried out at OSN respond to proposals submitted by IAA research groups, although the number of observing requests by external collaborators is growing with time. In addition to the typical visitor and service observing modes, the OSN offers the possibility to carry out observations in remote mode. Five ToO programs have been awarded in both semesters. As in previous years, during 2016 the observatory has performed observations related to educational activities: observing practices of the Master in Astronomy and Astrophysics organized by the Valencia International University and observing sessions for the PIIISA project to introduce Andalucian Secondary students to the research.

Besides the main telescopes, there are two smaller ones: the 60-cm Infrared Semi-authomated Telescope (T60) for early follow-up of gamma-ray busts (GRB), and the 35-cm telescope (T35) for the observation of variable stars. Also, secondary astronomical facilities are carrying out observations for specific projects. The Spectral Airglow Temperature Imager (SATI), a Fabry-Perot spectrometer dedicated to the study of the high layers of the Earth's atmosphere. Moreover, two seeing-monitors take continuously dome and open-sky measurements in order to characterize the quality of the

Aerial view of the Sierra Nevada Observatory

Sierra Nevada sky. In addition to the instrumentation belonging exclusively to IAA, the OSN hosts astronomical devices in collaboration with other institutions, such as universities and research centres. The OSN fireball detection station is part of the SMART project led by Huelva University to monitor the sky in order to analyse the matter interplanetary matter impacting our planet. In the geoscientific field, a GPS station belonging to the Topo-Iberia project is installed near the telescopes in order to perform integred studies on topography and 4-D evolution.

OSN observations are to be used frequently by the IAA PhD students to support their work. The most relevant scientific results of the observations are published in international journals. During 2016, observations obtained at OSN have been used in 21 publications (15 ISI and 6 non-ISI journals).

The OSN does not only contribute to the scientific production of the IAA and to the formation of its students, but it also participates in multiple outreach activities, such as the summer scientific campus organizated by the Granada University. It must be particularly emphasized the guided visits, public observations, and talks organized at OSN every summer since 2006 (http://www.iaa.es/noticias/este-verano-visita-dos-observatorios)

MEMBERS

OSN Director: S. Martín Ruiz

OSN Technical Support Head: L. Costillo Iciarra

Members: F.J. Aceituno Castro, V. M. Casanova Escurín, J.L. de la Rosa Álvarez, F.A. López Comzzi, J.A. Mirasol Junco, M.P. Misquero Castro, T. Pérez Silvente, J.A. Ruiz Bueno, A. Sota Ballano

UDIT INSTRUMENTAL AND TECHNOLOGICAL DEVELOPMENT UNIT

THE **UDIT** PRIME OBJECTIVES ARE THE TECHNOLOGICAL DEVELOPMENT OF SCIENTIFIC INSTRUMENTATION AND TECHNICAL SUPPORT TO THE IAA SCIENTISTS AND OBSERVATORIES.

The Instrumental and Technological Development Unit (Unidad de Desarrollo Instrumental y Tecnológico – UDIT) is in operation at the IAA since its foundation in 1975. State-of-the-art instruments designed and built at the UDIT for balloon and terrestrial rocket payloads in early times and for space missions and ground-based observatories nowadays have put the IAA on the map as a reference center for technological-challenging research projects. The technical production at the UDIT can be split into two major lines:

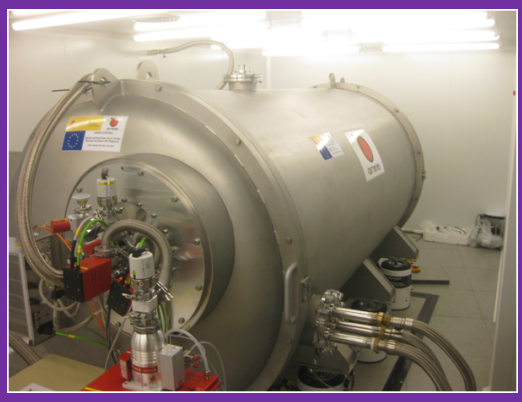
- Analysis, design, integration, and verification of astronomical instruments for ground-based telescopes, especially for the telescopes at CAHA and OSN.
- Analysis, design, integration, and verification of astronomical instruments for interplanetary scientific missions.

Here we report on a selection of instrumentation projects and their associated technical development.

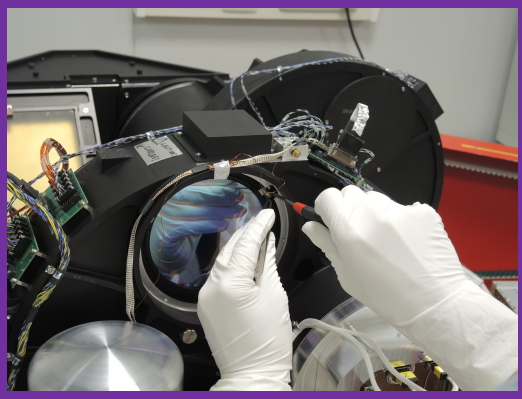
GROUND BASED INSTRUMENTS

CARMENES. On Jan. 1st 2016, the official CARMENES survery (CAHA) started and the technical commission of the NIR channel was continued. A cross-talk issue was found affecting the stability, producing short and long-term motions of spectra on the detector. During the technical commissioning held during 2016, we tested that the Cooling System performance is according to technical requirements as the extremely stable Optical Bench temperature profiles state. After several interventions, the issue was mitigated and controlled, achieving an internal precision below 1m/s, with long term stability of better than a few rm/s. Performance tests on the sky were also initiated.

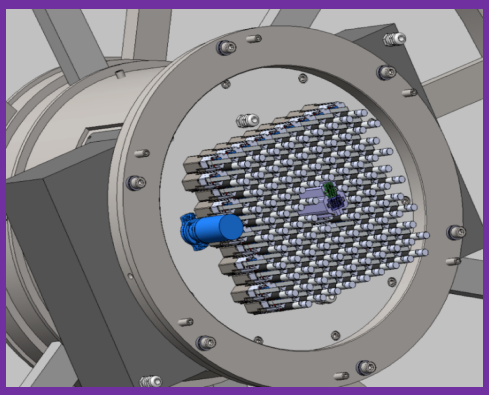
PANIC (CAHA) was operated on February in order to add a Br-gamma filter. In total, during 2016 PANIC worked successfully for 46 observing nights at 2.2m telescope. At the end of 2016, first results obtained with PANIC camera were published (Caratti o Garatti et al.



CARMENES NIR chanel at CAHA clean room



Installing new Br-gamma filter in PANIC



Layout of the focal plane of MEGARA with the 92 robotic positioners

"Disk-mediated accretion burst in a high-mass young stellar object", Nature Physics), being and excellent example of the possibilities of the instrument.

MEGARA. The IAA contribution is led by the scientific project **"Estallidos"**, the main result in 2016 was the completion of the software suite MEGARA-FMPT (Fiber-MOS Positioning Tool) for the bidimensional

spectrograph MEGARA, to be installed at GTC in March 2017. This software suite computes the trajectories of the 92 robotic positioners of the MEGARA Multi-object spectrograph so that they reach the desired targets with maximum efficiency.

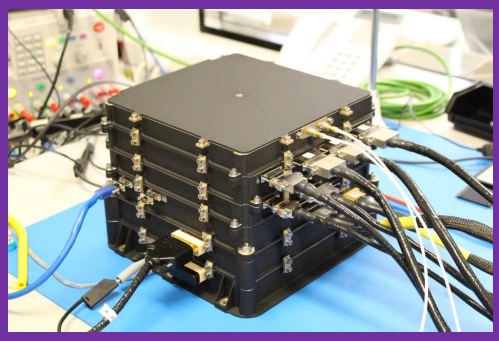
SPACE PROJECTS

PHI (Polarimetric and Helioseismic Imager for the ESA Solar Orbiter mission). The IAA is the PHI co-PI institution and its Solar Physics group coordinates the Spanish team. The IAA is also responsible for the electronics unit and the harness work packages. During 2016 we made multiple tests (electrical, bake-out, vacuum, vibration and shock) for the QM model. Also, we made the mechanical integration of the whole E-Unit (FM) and its corresponding electrical tests.

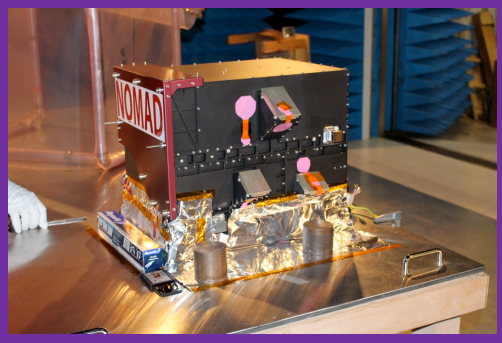
NOMAD (Nadir and Occultation for Mars Discovery for the ESA ExoMars-TGO mission). The IAA, co-PI institution of the international consortium, is responsible for SINBAD (Spacecraft INterface BoArD) consisting in Com_Board (CPU and communications with the spacecraft), Pow_Board (power distribution filtering and distribution), DC/DCs_module (module with the DC/DC converters) and SFS (NOMAD onboard SW). The Orbiter and Schiaparelli were launched together on 14 March 2016 on a Proton rocket, with the pair arriving at Mars in October. First NOMAD tests to monitor the status of the instrument, demonstrated that it is working properly. The orbiter (TGO) was then inserted into an elliptical orbit around Mars, expecting first science operation in March 2018.

GALA (GAnymede Laser Altimeter) and **JANUS** (Jovis, Amorum ac Natorum Undique Scrutator) for the ESA mission JUICE. The IAA is responsible for the power supply modules of both instruments, and the filter wheel and mechanism controller module of the JANUS camera. During 2016, JUICE continued Phase B2, and GALA passed the PDR. The IAA activities were focused in the finalization of the integration model of the filter wheel and the manufacturing of the pre-engineering models of the Power Supply-Motion Control boards (PSM-MCM) for both JANUS and GALA. For the power supply modules, the new elegant breadboard models were finished and ready to be manufactured by an industrial contract.

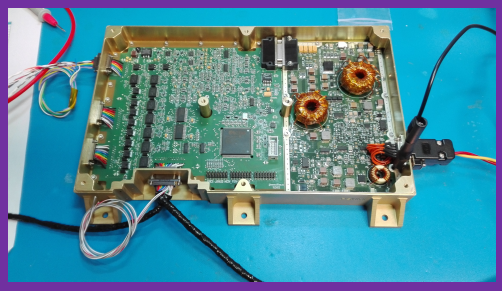
PLATO (PLAnetary Transits and Oscillation of stars, ESA). IAA is responsible for the Main Electronic Units for the control and acquisition of the "normal" cameras. During 2016, the System Requirement Review phase was passed, and B2 phase started. The design of the prototype of N-DPU and SpW router continued, and the first test boards were ready to be manufac-tured. The preliminary mechanical design and themal simulations of mechanical structure box that will house the electronics boards were accomplished.



Qualification model for the SO/PHI electronics unit



NOMAD just before installed in the Orbiter



JANUS PSM-MCM pre-engineering board

More exciting news @: https://udit.iaa.csic.es/

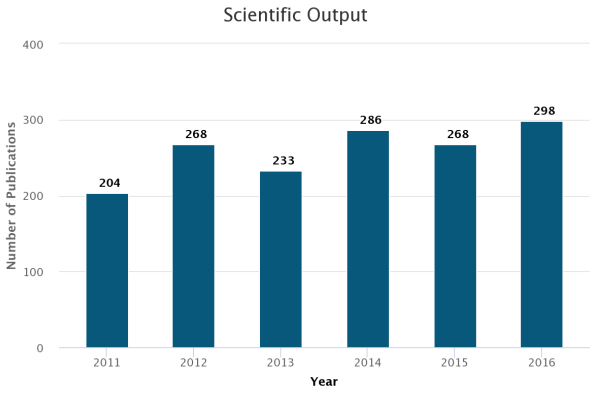
UDIT Members

Electronics: M. Abril, D. Álvarez, B. Aparicio, J.P. Cobos, L.P. Costillo, J.J. España, F.J. Girela, M. Herranz, J.M. Jerónimo, J. Jiménez, P. Labrousse, H. Magán, I. Martínez, J.L. Ramos, N. Robles, J. Rodrigo, J. Sánchez, M. R., Sanz, A. Tobaruela. Mechanics: F. Alvarez, S. Becerril, I. Bustamante, R. Calvo, E. Mirabet, M.A. Sánchez. Optics: F.J. Bailén, C. Cárdenas, I. Ferro, M.P. Hernández, D. Pérez. Project Management: M. Balaguer, J.M. Castro, A. López, J.F. Rodriguez. Software: A. García, J.M. Gómez, J.M. Ibáñez, I. Morales, R. Morales, C. Pastor

SCI PUBLICATIONS

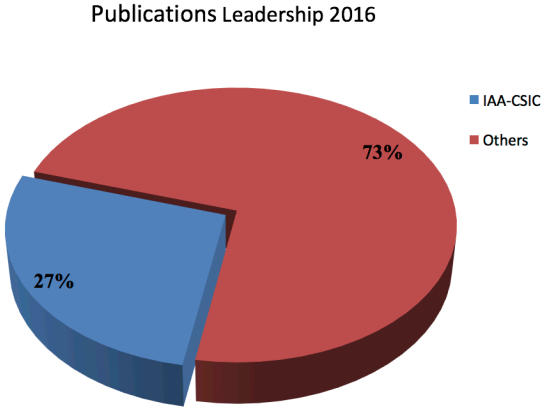
The research activity carried out at the IAA-CSIC during 2016 can be measured by the number of publications in scientific journals included in the Science Citation Index (SCI), i.e., international journals recognized by their quality and impact. This year, this activity has resulted in 298 papers published in journals of the SCI.

The complete list of the IAA-CSIC publications in 2016 is given in the Annex at the end of this report. The evolution of the number of SCI publications since 2011 is shown below. The number of publications shows a steady increasing trend with time. The IAA-CSIC publications in 2016 exceeds the average of the previous 5 years by 18%.

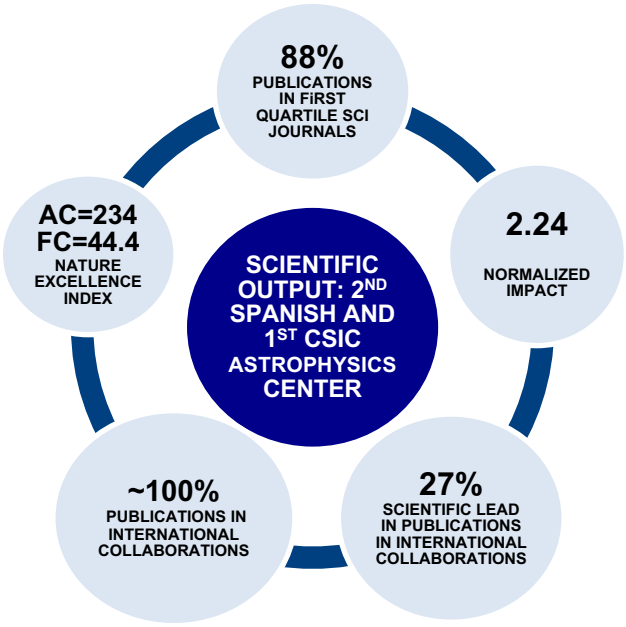


The publications of the IAA-CSIC are mostly distributed in high impact journals (see the figure in the following page). About 88% of our publications are made in journals of the first quartile (top 25% journals). Among these publications, 7% are made in the first decile (top 10% journals). Most of the IAA-CSIC scientific results are published in Astronomy & Astrophysics and Monthly Notices of the Royal Astronomical Society, the main European and British astronomical journals, respectively. A significant fraction of these results are published in Astrophysical Journal, the most important American astronomical journal.

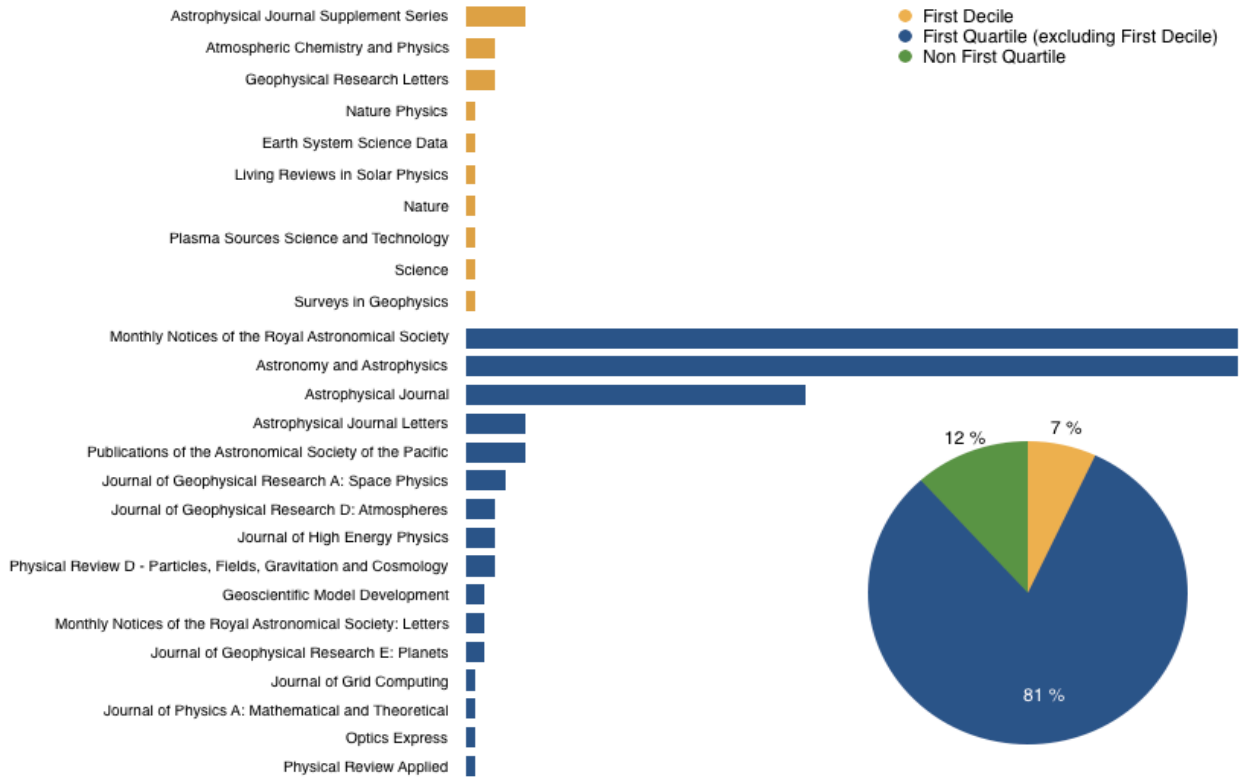
Other aspects of the scientific research of the IAA and its quantitative results are the leadership and inter-nationalization of these publications. More than a quarter (27%) of the IAA SCI 2015 publications are led by IAA scientists, i.e. their first author belongs to the IAA. This is consistent with the leadership of the IAA in the last 5 years.



Furthermore, almost 100% of the IAA publications include authors from international institutions, probing the extraordinary level of internationalization of the IAA research.



In the tracking of scientific papers made by Nature, they provide the Article Count (**AC**), which accounts for the total number of papers for a given institution, and the Fractional Count (**FC**), that takes into account both the percentage of authors from that institution and the number of affiliated institutions. According to these **Nature indices** the scientific output of the IAA in 2016 ranks, among the Spanish centers devoted to research in astrophysics, the second position in Spain and the first one among the centers of CSIC.


First Decile
First Quartile (excluding First Decile)
Non First Quartile
Astrophysical Journal Supplement Series
Atmospheric Chemistry and Physics
Geophysical Research Letters
Nature Physics
Earth System Science Data
Living Reviews in Solar Physics
Nature
Plasma Sources Science and Technology
Science
Surveys in Geophysics
Monthly Notices of the Royal Astronomical Society
Astronomy and Astrophysics
Astrophysical Journal
Astrophysical Journal Letters
Publications of the Astronomical Society of the Pacific
Journal of Geophysical Research A: Space Physics
Journal of Geophysical Research D: Atmospheres
Journal of High Energy Physics
Physical Review D - Particles, Fields, Gravitation and Cosmology
Geoscientific Model Development
Monthly Notices of the Royal Astronomical Society: Letters
Journal of Geophysical Research E: Planets
Journal of Grid Computing
Journal of Physics A: Mathematical and Theoretical
Optics Express
Physical Review Applied
12 %
7 %
81 %

EDUCATION

PHD THESES

"Portabilidad de aplicaciones en astronomía a la infraestructura de computación Grid"

Author: José Ramón Rodón Ortiz

Supervisors: Dr. Juan Carlos Suárez Yanes and Dr. Julio Ortega Lopera

Universidad de Granada Jan 15, 2016

"Kinematic study of the molecular environment in the early phases of massive star formation: ammonia observations and modeling"

Author: Juan Manuel Mayén Gijón

Supervisors: Dr. Guillem Anglada Pons

Universidad de Granada Jan 15, 2016

"High-Performance scientific computing on FPGA aboard the SOLAR ORBITER PHI instrument "

Author: Juan Pedro Cobos Carrascosa

Supervisors: Dr. D. Antonio C. López Jiménez (IAA) y Dr. D. Christian A. Morillas Gutiérrez (UGR)

Universidad de Granada Feb 05, 2016

"Gravity as an emergent phenomenon: fundamentals and applications"

Author: Raúl Carballo Rubio

Supervisors: Carlos Barceló Serón

Universidad de Granada Mar 03, 2016

"Multi-wavelength polarimetric studies of relativistic jets in active galactic nuclei"

Author: Carolina Casadio

Supervisors: José Luis Gómez Fernández and Juan Iván Agudo Rodríguez

Universidad de Granada Apr 14, 2016

"Star-forming galaxies as tools for cosmology in new-generation spectroscopic surveys"

Author: Ginevra Favole

Supervisors: Francisco Prada Martínez

Universidad Autónoma de Madrid May 20, 2016

"Caracterización de Sistemas Estelares en Espacios de N-Dimensiones: Simulaciones y Aplicación al Catálogo Astrométrico UCAC4"

Author: Laura María Sampedro Hernández

Supervisors: Emilio Javier Alfaro Navarro

Universidad de Granada Jun 10, 2016

"Cosmic Lighthouses at High Redshift: Intervening material in sight-lines towards GRBs and QSOs"

Author: Rubén Sánchez Ramírez

Supervisors: Antonio de Ugarte Postigo, Alberto Castro Tirado and Javier Gorosabel Urkia

Universidad de Granada Jun 10, 2016

"From circumstellar disks to planetary systems: Observation and modeling of protoplanetary disks"

Author: Enrique Macías Quevedo

Supervisors: Guillem Anglada Escudé and Mayra Carolina Osorio Gutiérrez

Universidad de Granada Oct 28, 2016

"Radial velocity fiber-fed spectrographs towards the discovery of compact planets and pulsations on M stars"

Author: Zaira Modroño Berdiñas

Supervisors: Pedro José Amado González

Universidad de Granada Nov 25, 2016

TEACHING

Master and PhD Programs

Title: ***Astrobiología y Planetas Extrasolares III***
Authors: **Miguel Angel López Valverde y Manuel López Puertas**
Program: Máster en Física: Radiaciones, Nanotecnología, Partículas y Astrofísica
University: Universidad de Granada (UGR)
Hours: 14
Date: November, 2016

Title: ***Astrofísica de Altas Energías***
Authors: **Alberto Javier Castro Tirado, Martín Antonio Guerrero Roncel, Binbin Zhang**
Program: Física y Matemáticas – FISYMAT
University: Universidad de Granada (UGR)
Hours: 60
Date: February, 2016

Title: ***Cosmología y galaxias***
Authors: **Emilio Alfaro Navarro**
Program: Máster en Física: Radiaciones, Nanotecnología, Partículas y Astrofísica
University: Universidad de Granada (UGR)
Hours: 30
Date: April, 2016

Title: ***Detectores de radiación***
Authors: **Jorge Iglesias Páramo**
Program: Máster en Física: Radiaciones, Nanotecnología, Partículas y Astrofísica
University: Universidad de Granada (UGR)
Hours: 15
Date: October, 2016

Title: ***Radioastronomía e Interferometría***
Authors: **José Francisco Gómez Rivero, Antonio Maria Alberdi Odriozola, Guillem Josep Anglada Pons**
Program: Física y Matemáticas – FISYMAT
University: Universidad de Granada
Hours: 60
Date: October 2016

Title: **Taller de Python para principiantes e iniciados, 2ª edición**
Authors: **Salvador Manuel Duarte Puertas y Simon Verley**
Organizer: Asociación de Estudiantes de Física y Electrónica de la UGR
Hours: 18
Date: November 2016

Title: ***Introducción al Sol y el Sistema Solar***
Authors: **José Carlos del Toro Iniesta**
Program: Del Big Bang a la vida
Organizer: Universidad de Granada
Hours: 4
Date: April 2016

Title: ***Orbitar el Sol fuera de la eclíptica***
Authors: **José Carlos del Toro Iniesta**
Program: Grandes hitos de la Astronomía
Organizer: Universidad Politécnica de Cartagena
Hours: 4
Date: July 2016

Title: ***Cúmulos estelares y evolución estelar***
Authors: **Maria Teresa Costado Dios**
Program: Prácticas de orientación profesional de corta duración
Organizer: Colegio Alemán Juan Hoffman
Hours: 50
Date: June 2016

Other Programs

Title: ***Física I***
Authors: **Francisco Nogueras Lara**
Program: Cursos de grado en Química
Organizer: Universidad de Granada
Hours: 60
Date: November 2016

Title: ***Iniciación a DRUPAL***
Authors: **César Husillos Rodríguez, Aurelia Teresa Gallego Calvente**
Program: Cursos del Gabiente de Formación del CSIC
Organizer: Consejo Superior de Investigaciones Científicas
Hours: 27
Date: April 2016

INTERNATIONAL

SEMINARS

★ **Dr. Belén Arroyo-Torres** (Universitat de València)
Title: "Spectro-interferometry study of red supergiants"
Date: Jan 28, 2016

José Luis Ortiz Moreno (IAA - CSIC)
Title: "ORISON un proyecto de instrumentación astronómica estratosférica"
Date: Feb 04, 2016

★ **Dr. Yosuke Mizuno** (Institute for Theoretical Physics, Japan)
Title: "The role of magnetic field for stability in relativistic jets"
Date: Feb 11, 2016

★ **Dr. Juan Carlos Gómez Martín** (University of Leeds, UK)
Title: "Experimental simulation of the atmospheric ablation of cosmic dust particles: implications for HPLA radar and lidar observations"
Date: Feb 18, 2016

★ **Drs. Tracy Cheetham & Antony Schinckel** (SouthAfrica - ASKAP Team, CSIRO Astronomy and Space Science, Sydney, Australia)
Title: "Progress on the construction of the South African SKA Pathfinder (MeerKAT) and the African VLBI Network &The Australian Square Kilometre Array Pathfinder (ASKAP)"
Date: Feb 25, 2016

★ **Florence Durret** (Institut d'Astrophysique de Paris, France)
Title: "Massive galaxy clusters: from relaxed to highly substructured"
Date: Mar 01, 2016

★ **Dr. Francisco Najarro** (Centro de Astrobiología - CSIC)
Title: "Multiwavelength studies of massive stars"
Date: Mar 04, 2016

★ **Dr. Silvia Mateos** (Instituto de Física de Cantabria (IFCA))
Title: "Shaking the grounds of unification: are type 1 and type 2 AGN intrinsically different?"
Date: Mar 10, 2016

Antonio de Ugarte Postigo (IAA - CSIC)
Title: "OCTOCAM: A fast multi-channel imager and spectrograph proposed for the Gemini Observatory"
Date: Mar 17, 2016

Prof. Rafael Garrido / Dr. Javier Pascual (IAA - CSIC)
Title: "Are LIGO data connected? "
Date: Mar 31, 2016

Pedro José Amado González (IAA - CSIC)
Title: "CARMENES as a precursor for HIRES@E-ELT: First results at the telescope"
Date: Apr 07, 2016

★ **Lda. Koraljka Muzic** (Universidad Diego Portales, Chile)
Title: "Young brown dwarfs: exploring the bottom of the Initial Mass Function"
Date: Apr 13, 2016

★ **Prof. Lee Hartmann** (University of Michigan, USA)
Title: "Issues in star and cluster formation"
Date: Apr 18, 2016

Drs. Alejandro Luque & Rainer Schoedel (IAA - CSIC)
Title: "Colloquium on ERC's proposals"
Date: Apr 21, 2016

Carlos Barceló Serón (IAA - CSIC)
Title: "The lifetime dilemma of evaporating black holes "
Date: Apr 28, 2016

Emilio Javier Alfaro Navarro (IAA - CSIC)
Title: "Formación Estelar: ¿podemos acotar el problema?"
Date: May 05, 2016

★ **Dr. Daniel Wang** (University of Massachusetts, USA)
Title: "Sgr A* and its environment: insights from X-ray observations"
Date: May 12, 2016

David Orozco Suárez (IAA - CSIC)
Title: "The magnetic field vector in solar chromospheric structures: the diagnostic potential of the near infrared He I 1083nm triplet"
Date: May 19, 2016

★ **Francisco Ángel Espartero Briceño** (ECS. Espartero Construcción y Servicios)
Title: "ECS: Diseño y construcción de Observatorios Astronómicos"
Date: May 25, 2016

Mirjana Povic (IAA - CSIC)
Title: "Star formation and AGN activity in the most luminous LINERs in the local universe"
Date: Jun 02, 2016

★ **Prof. Nicholas Macdonald** (Boston University, USA)
Title: "Blazars: Order and Disorder"
Date: Jun 09, 2016

★ **Yuri Kovalev** (Lebedev Physical Institute, Russia)
Title: "Space VLB interferometer RadioAstron: status and results"
Date: Jun 16, 2016

★ **Manuel Moreno Raya** (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT))
Title: "Using the local gas-phase oxygen abundances to

explore a metallicity-dependence in SNe~Ia luminosities"
Date: Jun 23, 2016

Pedro José Amado González (IAA - CSIC)
Title: "Proxima b: What could I say you already do not know about it?"
Date: Sep 15, 2016

Enrique Pérez Montero (IAA - CSIC)
Title: "Delving into the gas-phase of CALIFA galaxies to trace O and N gradients"
Date: Sep 22, 2016

Christina Thöne (IAA - CSIC)
Title: "Presentation of the HETH group (High Energy Transients and their Hosts)"
Date: Sep 29, 2016

★ **Prof. Olivier Lefevre** (Laboratoire d'Astrophysique de Marseille, France)
Title: "The VIMOS Ultra Deep Survey: galaxy formation and evolution, 13Gyr back in cosmic time"
Date: Oct 04, 2016

★ **Prof. Deborah Dultzin Kessler** (Universidad Nacional Autónoma de México)
Title: "The Unfied Model for AGN 30 years after, and recent support for an Evolutionary Model of AGN"
Date: Oct 20, 2016

★ **Laura Vega** (Max Planck Institute for Radioastronomy, Germany)
Title: "RadioAstron observations in the jet in 0836+710"
Date: Oct 24, 2016

Sara Cazzoli (IAA - CSIC)
Title: "A search for neutral gas outflows in nearby (U)LIRGs"
Date: Nov 03, 2016

★ **Prof. Farhad Yusef-Zadeh** (Northwestern University, USA)
Title: "Star Formation Close to and Accretion onto the Supermassive Black Hole Sgr A*"
Date: Nov 09, 2016

★ **Dr. Josefa Becerra** (University of Maryland, USA)
Title: "Very High Energy gamma rays from AGNs: key for AGN structure and cosmological studies"
Date: Nov 10, 2016

Mary Loli Martínez Aldama (IAA - CSIC)
Title: "The CaII triplet in Quasars: from the accretion disk to the star formation"
Date: Nov 17, 2016

★ **Dr. Rocco Lico** (Università di Bologna, Italy)
Title: "Exploring the radio and gamma-ray connection in AGNs detected above 10 GeV"
Date: Nov 23, 2016

Rafael Morales Muñoz (IAA - CSIC)
Title: "Big Data at the IAA: main ideas and how to run a real application at the IAA computation cluster"
Date: Nov 24, 2016

★ **Dr. Antonio Ferriz** (Universidad de Vigo)
Title: "History of solar activity recorded in polar ice"
Date: Dec 01, 2016

★ **Dr. Lorena Hernández García** (INAF, Italy)
Title: "Multiwavelength analysis of PBC J2333.9-2343"
Date: Dec 02, 2016

★ **Gabriella Hodosán** (University of Saint Andrews, UK)
Title: "Lightning on exoplanets and brown dwarfs"
Date: Dec 20, 2016

VISITING SCIENTISTS

Jose Ignacio Añez López
Institut de Ciències de l'Espai - CSIC
02/11/2016 - 04/11/2016
Universidad de Granada
18/02/2016 - 19/02/2016

Josefa Becerra
NASA Goddard Space Flight Center, USA
01/11/2016 - 23/12/2016

Gabriele Bruni
Max Planck Institute for Radioastronomy, Germany
18/04/2016 - 22/04/2016

Joyce Byun
University of Sussex, UK
20/11/2016 - 25/11/2016

Estefanía Cañavate
Junta de Andalucía
27/07/2016 - 27/07/2016

Carolina Casadio
Max Planck Institute for Radioastronomy, Germany
21/11/2016 - 25/11/2016

Roberto Cid Fernandes
Universidade Federal de Santa Catarina, Brazil
14/01/2016 - 11/02/2016

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10/10/2016 - 14/10/2016

Francesco di Filippo
Università di Salerno, Italy
02/04/2016 - 31/08/2016

Laurent Drissen
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11/10/2016 - 14/10/2016

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29/02/2016 - 05/03/2016

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05/01/2016 - 08/01/2016

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18/04/2016 - 18/04/2016

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18/07/2016 - 30/07/2016

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23/10/2016 - 25/10/2016

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24/10/2016 - 04/11/2016

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11/05/2016 - 17/05/2016

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Finnish Geospatial Research Institute, Finland
07/07/2016 - 22/07/2016

WORKSHOPS AND MEETINGS

New Instrumentation and Legacy Projects for Calar Alto
Granada, Spain Oct 13 – 14, 2016
IAA members of the Scientific Organizing Commitee:
J. Iglesias (co-chair), O. Muñoz, J.M. Vílchez
IAA members of the Local Organizing Commitee:
C. Kehrig (co-chair), S. Duarte, E. Pérez-Montero, J. Iglesias
http://caha2016

II Jornadas de divulgación inclusiva de la ciencia
Granada, Spain Nov 28 –29, 2016
IAA members of the Organizing Commitee:
E. Pérez Montero (chair), E. García, A. Tamayo, **A.T. Gallego,** A. Pelegrina
http://cienciainclusiva.iaa.es/

Blazars through Sharp Multi-Wavelength Eyes
Málaga, Spain May 30 – June 3, 2016
IAA members of the Scientific Organizing Commitee:
J.L. Gómez (co-chair)
IAA members of the Local Organizing Commitee:
J.L. Gómez (chair), I. Agudo, C. Casadio, A. Fuentes, C. Husillos, S.N. Molina
http://jets2016.iaa.es/

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del Toro Iniesta, José Carlos
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Oates, Samantha Rachel
Zhang, Binbin

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ENGINEERS AND TECHNICIANS

Mechanics

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Abril Martí, Miguel
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Optics

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Observatory Maintenance /Support

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López Comazzi, Francisco Alejandro
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Pérez Silvente, Tomás
Ruiz Bueno, José Antonio
Sota Ballano, Alfredo

Software

Benítez Yáñez, Alicia Desirée
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Garrido Sánchez, Julian
Gómez López, Juan Manuel
Husillos Rodríguez, César
Ibáñez Mengual, José Miguel
Morales Durán, Isaac
Morales Muñoz, Rafael
Passas Varo, María
Pastor Morales, María del Carmen
Rodón Ortiz, José Ramón
Ruiz del Mazo, José Enrique
Sánchez Expósito, Susana

Computer Center

Guijarro Jiménez, Juan José
Parra Garófano, Rafael

General Services

Molero Delgado, José Francisco
Molina Rodrigo, Antonio
Navarro Ayala, Francisco
Quiles Gutiérrez, Antonio Manuel
Rendón Martos, Francisco

Library

Arco Sarmiento, María Ángeles

Outreach and Communication Unit

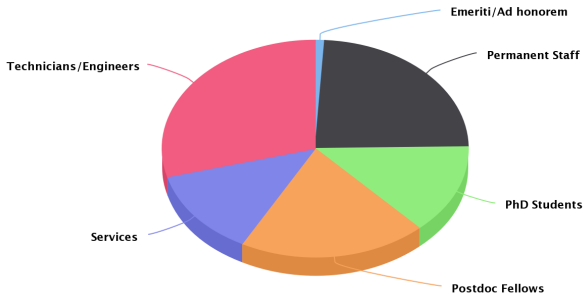
García Gómez-Caro, Emilio José
López de la Calle, Silbia

SERVICES AND ADMINISTRATION

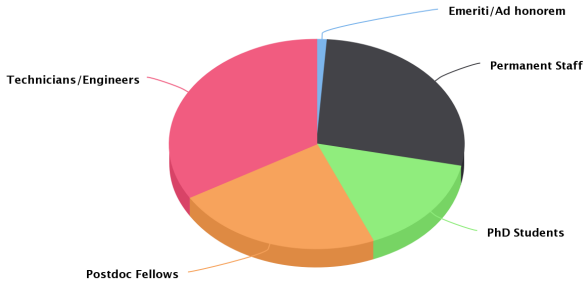
Administration Services

Bordons Mesonero, Fernando
Cortés Guerrero, María Ángeles
de Castro Díaz, Rosa Irene
Gómez Finnett, Susana Alicia
Heredia Maldonado, María José
Herrera Jiménez, Eva María
Madrid Gómez, Carmen Elisa
Molina Guerrero, Josefina
Nieto Serrano, Concepción
Rodríguez Hernández, Adrián
Tapia Ruiz, Francisco José
Torrededia Rodrigo, Cristina

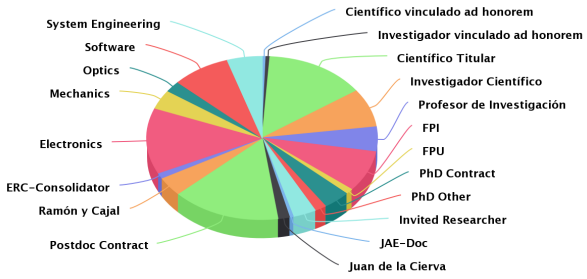
The 2016 IAA staff was distributed among the following general groups. The staff was mainly composed by scientists, with a non negligible fraction of technicians and engineers.



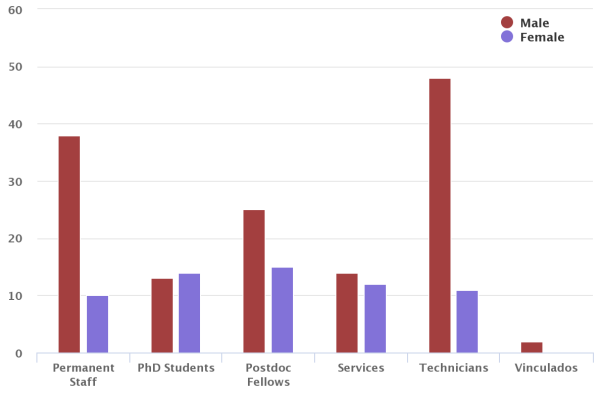
The scientific and technical personnel can be arranged among these overall categories.



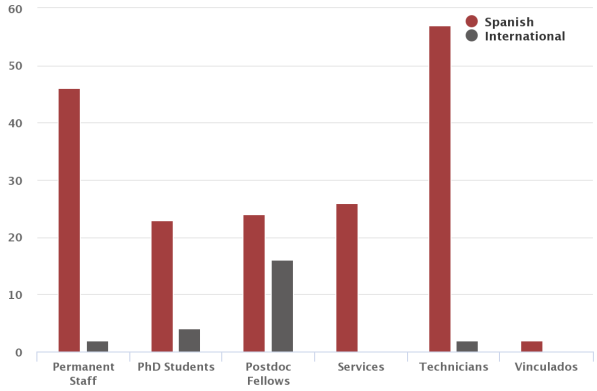
These can be disgregated into the different technician, engineer, and scientific groups.



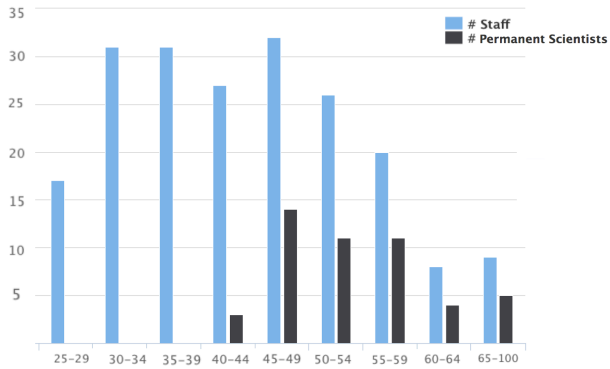
The gender and nationality distribution of the different groups are shown next. The fraction of women is closer to parity among the PhD students and post-doctoral fellows.



The fracyion of international staff was larger among PhD students and post-doctoral fellows.



Finally, the distribution of all the IAA staff and those of scientists with permanent positions by age reveals the aging of the last group.



PUBLIC OUTREACH

PROJECTS HELD DURING 2016

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 (http://revista.iaa.es). Issues in 2016: 48, 49, 50, with a special issue for the Granada Book Fair.

- *El Radioscopio*, a weekly popular science radio program in collaboration with Canal Sur Radio and broadcasted by Radio Andalucía Información. http://radioscopio.iaa.es

- *Lucas Lara* popular talks. These conferences began in 1995. We celebrate nine talks every year. http://www.iaa.es/lucas_lara

- *¿Eres de óptico o de radio?* Summer weekend astronomical and tourist event that includes a visit to the IAA-CSIC Observatory of Sierra Nevada (OSN) and to the IRAM 30-meter radioantenna (Granada).

- *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 23 "moving" its research to the center of the city.

- PIIISA Project. A multidisciplinary project designed to allow high school students work with scientists. The IAA-CSIC is the founder of the project. http://www.piiisa.es

- Science Radio Fictions with Canal Sur Radio and Escuela Remiendo Teatro. 30 episodes were recorded. A scientific podcast course for students with the "Zaidin Vergeles" Secondary School.

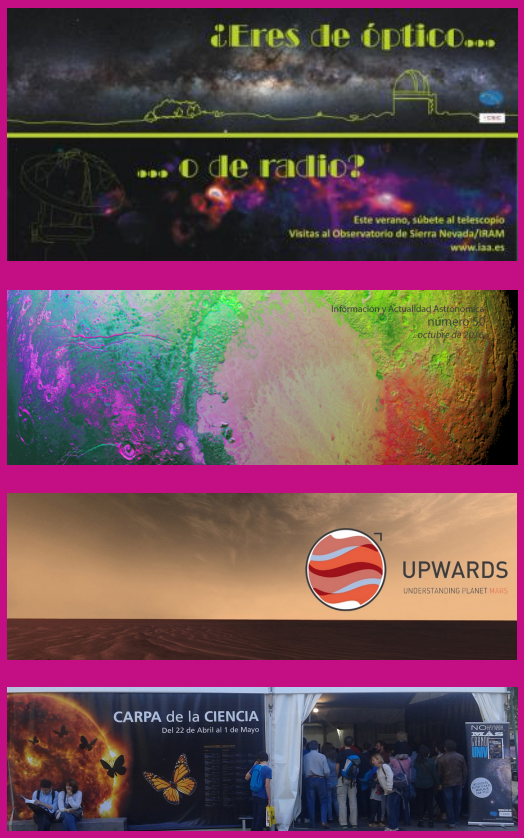
- Granada Book Fair, *Carpa de la ciencia*. A house for science surrounded by book stands, with outrecah activities for children and general public during ten days.

- "Cuando los astros se animan". An astronomy outreach project with cartoons. http://animaciones.iaa.es

- *El astrónomo indignado.* Videoblog about controversial issues in astronomy and science communication.

- "UPWARDS: Understanding planet Mars" Project Communication (http://upwards.iaa.es) and outreach: TV broadcast of the documentary "UPWARDS" / Launch of the mobile app "Lets go to mars" / "The Martian Postcards" promotional material / EXOMARS launch live event.

ACTIVITIES OF THE COMMUNICATION, EDUCATION AND PUBLIC OUTREACH UNIT



- Participation in Retroback (classic cinema festival) and FEX (music and dance festival).

- Calar Alto Observatory Communication. The **IAA-CSIC Communication, Education and Public Outreach Uni**t is in charge of the communication of the Observatory.

- Astronomía Accesible. This project aims to emphasize the popularization of astronomy among blind and low-vision people. http://astroaccesible.iaa.es/

- Educational activities. The IAA-CSIC attends two student groups every month.

- Social Networks. Twitter, facebook and youtube profiles managing.

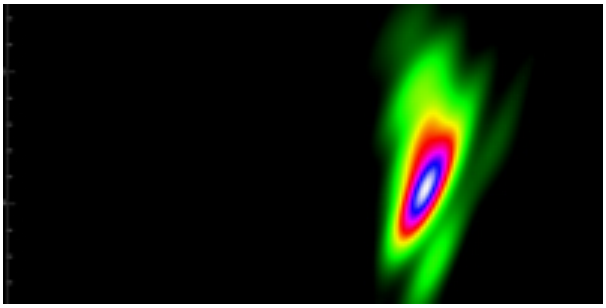
https://twitter.com/iaaucc
https://www.facebook.com/iaa.comunicacion
https://www.youtube.com/user/iaaudc

PRESS RELEASES

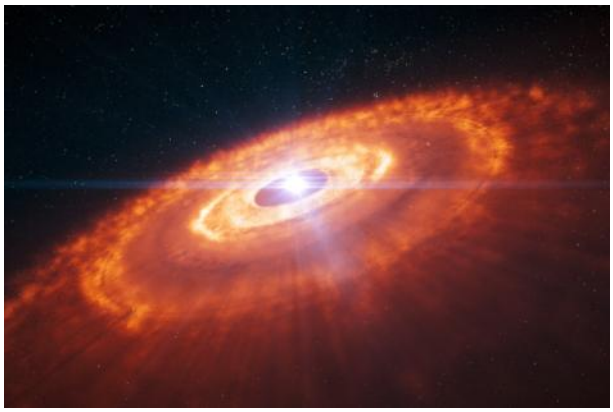
The IAA 2016 scientific achievements attracted the media interest producing the media news listed below. They can be also found online in the following link: http://www.iaa.es/en/news

FOLLOW A PLANET HUNT!
15/01/2016
A unique outreach campaign was launched that will allow the general public to follow scientists from around the globe as they search for an Earth-like exoplanet around the closest star to us, Proxima Centauri. The observing campaign ran from January to April 2016 and was accompanied by blog posts and social media updates.

THE HIGHEST ANGULAR RESOLUTION IMAGE IN ASTRONOMY REVEALS THE INSIDES OF A GALACTIC NUCLEUS
26/01/2016
The space mission RadioAstron (Russian Space Agency) observed, along with fifteen other radio telescopes distributed around the globe, the environment of the black hole at the core of the active galaxy BL Lacertae



PLANET EMBRYO ORBITING AROUND STAR HL TAU SHOWS HOW PLANETARY FORMATION CAN BE ACCELERATED
17/03/2016
In 2014, the ALMA array of antennae produced an iconic image: it showed star HL Tau Surrounded by a disk of dust, displaying numerous grooves which could possibly point to the existence of planets in the process of formation, and which would have swept up material sitting on the trajectory of their orbits. However, new and more detailed observations seem to suggest the existence of a planetary embryo, in a different location, formed through a heretofore unknown process.



PLANNING STARTS FOR MOS AND HIRES INSTRUMENTS ON THE E-ELT
23/03/2016
Scientists and engineers began mapping out the detailed specifications of two new instruments that will be part of the instrument suite on ESO's forthcoming European Extremely Large Telescope (E-ELT). MOS (the Multi-Object Spectrograph) and HIRES (the High Resolution Spectrograph) will be world-leading workhorse instruments on what will be the world's largest telescope.

LAUNCH OF THE UFFO TRACKING SPACE TELESCOPE, DESIGNED TO CAPTURE THE EARLY MOMENT OF GAMMA-RAY BURSTS
18/04/2016
The UFFO international collaboration developed a tracking space telescope that will detect X-rays and track UV/optical lights emitting from very early moment of Gamma-ray Bursts (GRBs), the most extreme explosions in the universe since the Big Bang. The space-telescope was installed in the Lomonosov spacecraft and was launched the very first time ever at Vostochny Cosmodrome newly built in the far eastern Russia. The UFFO/Lomonosov is expected to observe the early rise phase in GRBs, opening a new horizon in studying and understanding of the early and extreme universe.

PROJECT ORISON TO STUDY THE COSMOS FROM STRATOSPHERIC BALLOONS LAUNCHED

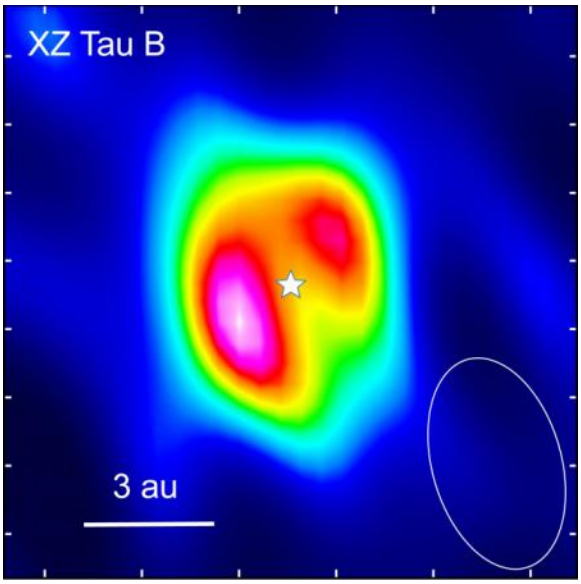
03/05/2016

The atmosphere provides us with vital support and equally protects us from harmful radiation, impacts of small asteroids, and other harmful elements. At the same time, however, it constitutes an obstacle for most astronomical observations. For this reason, astronomers try to locate observatories either in the high altitude of mountains or on satellites. Since most of the limiting effects, however, occur only in the first 20 to 30 km of the atmosphere above ground, the use of stratospheric balloons is an effective option, potentially much cheaper than satellite launches. Project ORISON will study the feasibility of creating an observation infrastructure in the stratosphere based on instruments carried by balloons.

DISCOVERY OF MINIATURE PLANETARY FORMATION DISK WILL ENABLE OBSERVATION OF PLANETARY GESTATION IN REAL TIME

30/06/2016

In the course of the last few decades, the discovery of thousands of planets around other stars has unveiled a wide variety of planetary systems whose architecture defies our understanding of planet formation. The search for disks of gas and dust around young stars, from which planetary systems stem, is fundamental to explain newly observed worlds, and this finding confirmed that miniature systems can exist.



UNIVERSITY OF ALMERÍA, CALAR ALTO OBSERVATORY AND IAA WILL ENHANCE ASTRONOMICAL KNOWLEDGE

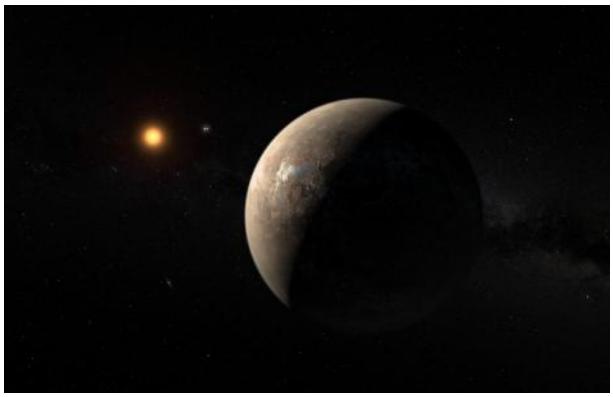
12/07/2016

Among the collaboration projects that were launched, stand out the creation of an astronomical lecture room at the UAL, the incorporation of trainees at the Observatory and the creation of a summer course that approach its work to the whole society.

EARTHLIKE PLANET DISCOVERED ORBITING AROUND NEAREST STAR TO SUN

24/08/2016

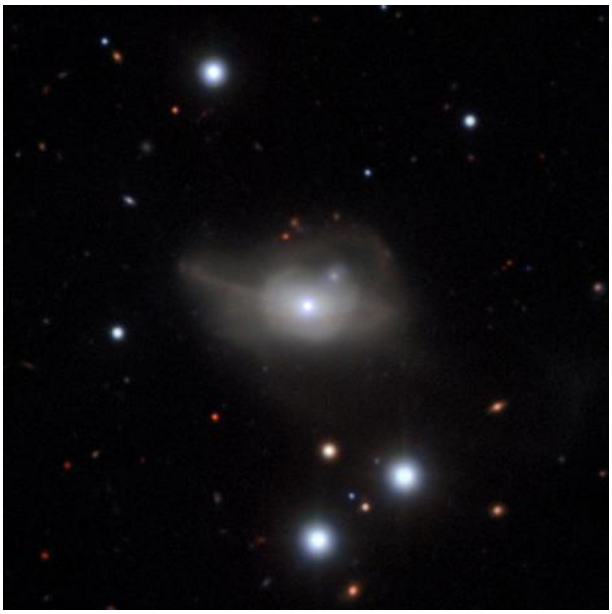
The IAA-CSIC collaborated with an international group of astronomers in a study that discovered a planet in the vicinity of Proxima Centauri, the star nearest to the Sun. Named Proxima B, it is located in the habitable zone, i.e., the region around a star where conditions would allow for liquid water, and its mass is estimated to be only somewhat greater than that of the Earth. The discovery, made in the context of the Pale Red Dot observation campaign, was published in Nature.



MRK1018: THE BLACK HOLE THAT RETURNS TO THE SHADOWS

15/09/2016

Active galactic nuclei are one of the most energetic objects in the universe, and can emit continuously over a hundred times the energy of all the stars in the Milky Way. They are the manifestation of the existence of a supermassive black hole in the center of the host galaxies and, depending on the type of light emitted, they are classified into different types. A group of researchers solved the case of Mrk1018, an active nucleus whose classification had changed for the second time and, after thirty years glowing, had returned to the shade.



NEW BREAKTHROUGH IN METHODOLOGY TO ESTIMATE LIFE SPAN OF STARS

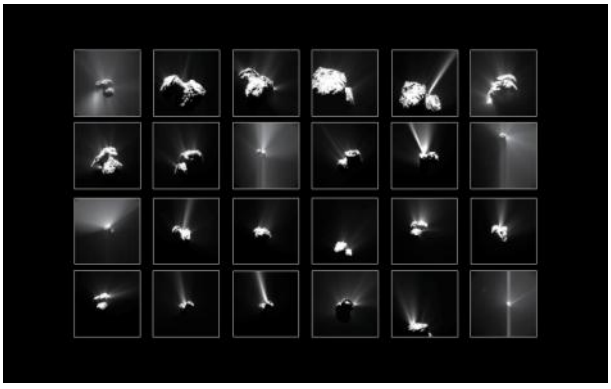
22/09/2016

Stars draw their energy from nuclear fusion occurring inside their nuclei, where densities and temperatures reach extreme levels. In the nuclei of massive stars, a phenomenon known as core overshooting can occur, which drastically impacts the evolution of the star, especially its life span. A study lead by IAA-CSIC measured the magnitude of this phenomenon and was able to establish an unequivocal dependency between it and the mass of the star.

SUMMER FIREWORKS ON ROSETTA'S COMET

26/09/2016

Brief but powerful outbursts seen from Comet 67P/Churyumov–Gerasimenko during its most active periodwere traced back to their origins on the surface.



ROSETTA'S GRAND FINALE

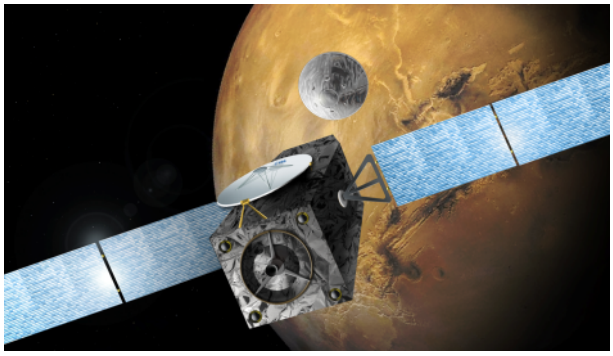
29/09/2016

Rosetta mission (ESA) received the commands to execute the collision maneuver that would make it collide into the nucleus of comet 67P Churyumov-Gerasimenko. The spacecraft descended to a region in the smaller lobe of the comet known as Ma'at, which shows cavities similar to natural wells. The OSIRIS camera, in which the IAA-CSIC participated, had a leading role, as took images of the comet from a unique perspective and sent the last picture of the mission.

EXOMARS MISSION, IN ORBIT AROUND MARS

20/10/2016

The ExoMars mission was put in orbit around Mars. The orbital insertion of the Trace Gas Orbiter satellite occurred between 13:05 and 15:24 GMT on October 19, and ESA teams continued to monitor the status of the orbiter.



STUDY CONFIRMS THAT NOVAE, A TYPE OF EXPLOSIVE PHENOMENON IN STARS, ARE MAIN SOURCE OF LITHIUM IN THE UNIVERSE

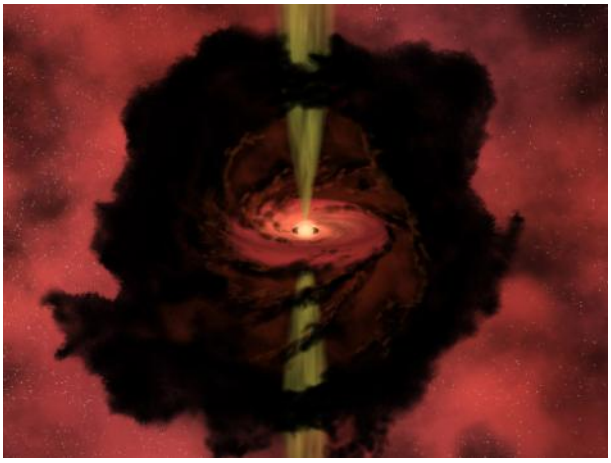
02/11/2016

Lithium, the lightest solid element in existence, plays an important role in our lives, both at the biological and the technological level. Like the majority of chemical elements, its origins stem back to astrophysical phenomena, but its point of genesis was so far unclear. A group of researchers detected enormous quantities of beryllium-7 –an unstable element which decays into lithium in 53.2 days– inside nova Sagittarii 2015 N.2, suggesting that novae are the main source of lithium in the galaxy.

A STARTBURST REVEALS THE FORMATION MECHANISM OF MASSIVE STARS

14/11/2016

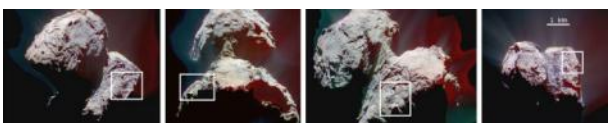
Low mass stars, like the Sun, are formed from big fragments of clouds of gas and dust, which condense until a central object, or protostar, is formed, growing up by absorbing gas from a surrounding disk and expelling the surplus material through a couple of jets located on both poles. However, it was unclear if the most massive stars, with tens of solar masses, are formed through the same mechanism. The study of an outburst detected in the forming massive star NIRS 3, and published in Nature, provided the most solid evidence that, indeed, all stars are formed the same way.



BRIGHTNESS VARIATIONS ON THE SURFACE OF '67P / CHURYUMOV' SHOW THE COMPLEXITY OF COMETARY ACTIVITY

18/11/2016

An international team, with the participation of the IAA-CSIC, observed with the OSIRIS camera onboard the Rosetta mission changes in light reflected on the surface of comet 67P / Churyumov with different time scales, from minutes to several days. These changes in brightness are mainly due to the amount of ice present in the observation area. This finding, published in the journal Science, helps to construct models to simulate cometary activity and, therefore, to advance in the understanding of the formation of the Solar System.



FIRST DATA CONFIRM THAT NOMAD WILL BE ABLE TO PUT AN END TO THE METHANE MYSTERY ON MARS

30/11/2016

The ExoMars (ESA) mission was in orbit around Mars since 19 October. Over the following two weeks, the first test observations of the instruments were made. NOMAD, a spectrograph co-designed by IAA-CSIC to solve the so-called methane problem on Mars has sent its first data confirming the excellent performance of the instrument.

THE INSTITUTE OF ASTROPHYSICS OF ANDALUSIA LAUNCHES THE APP "LET´S GO TO MARS!"

29/12/2016

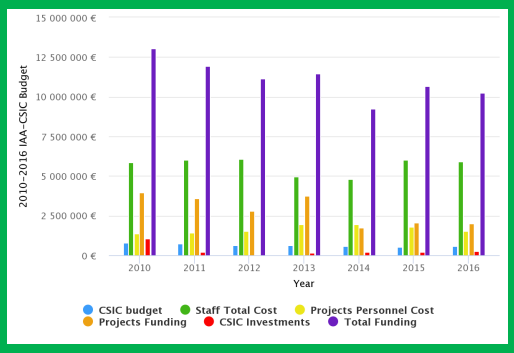
"Let's go to Mars" is an application for mobile, tablets and PC developed by the IAA-CSIC, Wildsphere & Laniakea Management & Communication in the context of the H2020 project "UPWARDS: Understanding Mars planet". It was funded by the Spanish Foundation for Science and Technology - Ministry of Economy and Competitiveness (MINECO) and the H2020 european program.

Throughout 2016, the IAA has posted more than 300 appearances in media.

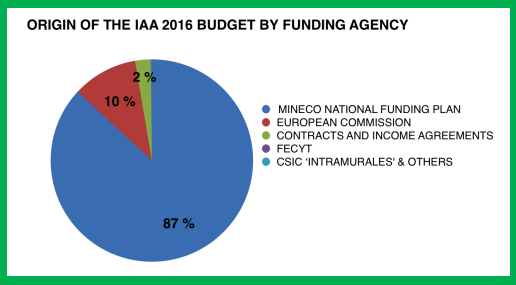
FUNDING

The IAA obtains most of its funding through competitive Andalucian, Spanish, and European calls. Here we provide a list of all competitive funding awarded to IAA staff in 2016.

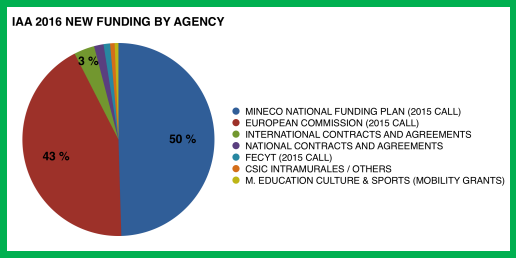
The time evolution of the IAA budget in the last years is shown in the top-right figure. The fraction of the IAA budget (the money used along 2016) and new funding (the money awarded in 2016) by funding agency are shown next.



Time evolution of the IAA budget since 2010



Origin of the IAA 2016 budget by funding agency



IAA 2016 new funding by agenc

EUROPEAN RESEARCH COMISSION FP7

Lightning propagation and high-energy emissions within coupled multi-model simulations
Reference: 681257 (ERC-2015-COG)
PI: **Alejandro Luque Estepa**
Duration: Jan 01, 2016 – Jan 01, 2021
Amount: 1 960 820 €

Small Bodies: Near and Far (SBNAF)
Reference: H2020-LEITSPACE/ 0140 687378
PI: **René Damián Duffard**
Duration: Jan 01, 2016 – Jan 01, 2019
Amount: 355 000 €

Innovative infrastructure for astronomical research based on stratospheric balloons (ORISON)
Reference: H2020- INFRA/0126 690013
PI: **José Luis Ortiz Moreno**
Duration: Jan 01, 2016 – Jan 01, 2017
Amount: 226 133 €

MINECO

Sounding and study of the Martian atmosphere. Scientific exploitation of the instrument NOMAD on board TGO/ExoMars
Reference: ESP2015-65064-C2-1-P
PI: **Miguel Angel López Valverde**
Duration: Jan 01, 2016 - Dec 31, 2018
Amount: 35 574 €

AMIGA6: gas in and around galaxies. Preparation for SKA science and contribution to the design of the SKA data flow
Reference: AYA2015-65973-C3-1-R
PI: **Lourdes Verdes-Montenegro Atalaya**
Duration: Jan 01, 2016 - Dec 31, 2018
Amount: 490 050 €

Dust in the Solar System: Experiments, computations, and application to the study of 67P Churuymov-Gerasimenko, target of the Rosetta mission
Reference: AYA2015-67152-R
PI: **Olga Muñoz Gómez**
Duration: Jan 01, 2016 - Dec 31, 2018
Amount: 108 900 €

The BOOTES Global Network for astro-physical research and space debris detection and participation in the SVOM mission
Reference: AYA2015-71718-R
PI: **Alberto Castro Tirado**
Duration: Jan 01, 2016 - Dec 31, 2018
Amount: 147 620 €

Galactic and Extragalactic Astronomy at the highest resolution and sensitivity
Reference: AYA2015-63939-C2-1-P
PI: **Antonio María Alberdi Odriozola, Miguel Angel Pérez Torres**
Duration: Jan 01, 2016 - Dec 31, 2018
Amount: 94 864 €

Contribution of IAA-CSIC to the PLATO2.0 space mission. Phases B & C. Operation of NOMAD-ExoMars
Reference: ESP2015-65712-C5-3-R
PI: **Rafael Garrido Haba, Julio Federico Rodríguez Gómez**
Duration: Jan 01, 2016 - Dec 31, 2018
Amount: 1 718 200 €

The IAA contribution to ASIM scientific return
Reference: ESP2015-69909-C5-2-R
PI: **Francisco José Gordillo Vázquez, Alejandro Luque Estepa**
Duration: Jan 01, 2016 - Dec 31, 2017
Amount: 314 600 €

FECYT

Let's Explore Mars
Reference: FCT-15-10384y
PI: **Miguel Angel López Valverde**
Amount: 13 000 €

Territorio gravedad
Reference: FCT-15-9917
PI: **Carlos Barceló Serón**
Amount: 45 000 €

EL RADIOSCOPIO. HAY MUCHA MÁS CIENCIA DE LA QUE CREES
Reference: FCT-15-10195
PI: **Antonio María Alberdi Odriozola**
Amount: 7 000 €

ANNEX

SCI PUBLICATIONS LIST

1. Abbott B.P. et al. (includes **Castro-Tirado A.J.**, **Cunniffe R.**, **Tello J.C.**, **Oates S.R.**, **Hu Y.-D.**, **Rendón F.**, **Jeong S.**, **Claret A.**, **Sánchez-Ramírez R.**, **Zhang B.-B.**, **De Postigo A.U.**, **Thoene C.C.**)
"SUPPLEMENT: 'lOCALIZATION and BROADBAND FOLLOW-UP of the GRAVITATIONAL-WAVE TRANSIENT GW150914' (2016, ApJL, 826, L13)", Astrophysical Journal Supplement Series, Vol. 225, Number 8
DOI: 10.3847/0067-0049/225/1/8

2. Abbott B.P. et al. (includes **Castro-Tirado A.J.**, **Cunniffe R.**, **Tello J.C.**, **Oates S.R.**, **Hu Y.-D.**, **Rendón F.**, **Jeong S.**, **Claret A.**, **Sánchez-Ramírez R.**, **Zhang B.-B.**, **De Ugarte Postigo A.**, **Thoene C.C.**)
"Localization and broadband follow-up of the gravitational-wave transient GW150914", Astrophysical Journal Letters, Vol. 826, Number L13
DOI: 10.3847/2041-8205/826/1/L13

3. Agarwal, Jessica; A'Hearn, M. F.; Vincent, J. -B.; Güttler, C.; Höfner, S.; Sierks, H.; Tubiana, C.; Barbieri, C.; Lamy, P. L.; Rodrigo, R.; Koschny, D.; Rickman, H.; Barucci, M. A.; Bertaux, J. -L.; Bertini, I.; Boudreault, S.; Cremonese, G.; Da Deppo, V.; Davidsson, B.; Debei, S.; De Cecco, M.; Deller, J.; Fornasier, S.; Fulle, M.; Gicquel, A.; Groussin, O.; **Gutiérrez, P. J.**; Hofmann, M.; Hviid, S. F.; Ip, W. -H.; Jorda, L.; Keller, H. U.; Knollenberg, J.; Kramm, J. -R.; Kührt, E.; Küppers, M.; **Lara, L. M.**; Lazzarin, M.; **Lopez Moreno, J. J.**; Marzari, F.; Naletto, G.; Oklay, N.; Shi, X.; Thomas, N.
"Acceleration of Individual, Decimetre-sized Aggregates in the Lower Coma of Comet 67P/Churyumov-Gerasimenko", Monthly Notices of the Royal Astronomical Society, p. S78-S88
DOI: 10.1093/mnras/stw2179

4. **Aldaya V.**, **Guerrero J.**, López-Ruiz F.F., **Cossío F.**
"SU(2) particle sigma model: The role of contact symmetries in global quantization", Journal of Physics A: Mathematical and Theoretical, Vol. 49, Number 505201
DOI: 10.1088/1751-8113/49/50/505201

5. **Alfaro, Emilio J.**; **Gonzalez, Marta**
"Looking for phase-space structures in star-forming regions: an MST-based methodology", Monthly Notices of the Royal Astronomical Society, Vol. 456, p. 2900-2906
DOI: 10.1093/mnras/stv2822

6. Aller, A.; **Miranda, L. F.**; Olguín, L.; Solano, E.; Ulla, A.
"Observations of the planetary nebula RWT 152 with OSIRIS/GTC", Monthly Notices of the Royal Astronomical Society, p. 3945-3954
DOI: 10.1093/mnras/stw1916

7. Alvarez-Candal A., Pinilla-Alonso N., **Ortiz J.L.**, **Duffard R.**, **Morales N.**, **Santos-Sanz P.**, Thirouin A., Silva J.S.
"Absolute magnitudes and phase coefficients of trans-Neptunian objects", Astronomy and Astrophysics, Vol. 586, Number A155
DOI: 10.1051/0004-6361/201527161

8. Amaro-Seoane, P.; Casanellas, J.; **Schödel, R.**; Davidson, E.; Cuadra, J.
"Probing dark matter crests with white dwarfs and IMBHs", Monthly Notices of the Royal Astronomical Society, p. 695-700
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9. Andreon, S.; **Dong, Hui**; Raichoor, A.
"Size growth of red-sequence early-type galaxies in clusters in the last 10 Gyr", Astronomy and Astrophysics, Vol. 593, p. A2
DOI: 10.1051/0004-6361/201628442

10. Anglada-Escudé G., Tuomi M., Arriagada P., Zechmeister M., Jenkins J.S., Ofir A., Dreizler S., Gerlach E., Marvin C.J., Reiners A., Jeffers S.V., Butler R.P., act S.S., **Amado P.J.**, **Rodríguez-López C.**, **Berdiñas Z.M.**, Morin J., Crane J.D., Shectman S.A., Díaz M.R., Sarmiento L.F., Jones H.R.A.
"NO EVIDENCE for ACTIVITY CORRELATIONS in the RADIAL VELOCITIES of KAPTEYN'S STAR", Astrophysical Journal, Vol. 830, Number 74
DOI: 10.3847/0004-637X/830/2/74

11. Anglada-Escudé, Guillem; **Amado, Pedro J.**; Barnes, John; **Berdiñas, Zaira M.**; Butler, R. Paul; Coleman, Gavin A. L.; de La Cueva, Ignacio; Dreizler, Stefan; Endl, Michael; Giesers, Benjamin; Jeffers, Sandra V.; Jenkins, James S.; Jones, Hugh R. A.; Kiraga, Marcin; Kürster, Martin; **López-González, María J.**; Marvin, Christopher J.; **Morales, Nicolás**; Morin, Julien; Nelson, Richard P.; **Ortiz, José L.**; Ofir, Aviv; Paardekooper, Sijme-Jan; Reiners, Ansgar; **Rodríguez, Eloy**; **Rodríguez-López, Cristina**; Sarmiento, Luis F.; Strachan, John P.; Tsapras, Yiannis; Tuomi, Mikko; Zechmeister, Mathias
"A terrestrial planet candidate in a temperate orbit around Proxima Centauri", Nature, Vol. 536, p. 437-440
DOI: 10.1038/nature19106

12. Argo, Megan; Beswick, Rob; **Perez-Torres, Miguel**; Westcott, Jonathon
"The nearby universe", Astronomy and Geophysics, Vol. 57, p. 3.36-3.39
DOI: 10.1093/astrogeo/atw103

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"The effect of local and large-scale environments on nuclear activity and star formation", Astronomy and Astrophysics, Vol. 592, p. A30
DOI: 10.1051/0004-6361/201628232

14. Arias, Julia I.; Walborn, Nolan R.; Simón Díaz, Sergio; Barbá, Rodolfo H.; Maíz Apellániz, Jesús; Sabín-Sanjulián, Carolina; Gamen, Roberto C.; Morrell, Nidia I.; **Sota, Alfredo**; Marco, Amparo; Negueruela, Ignacio; Leão, João R. S.; Herrero, Artemio; **Alfaro, Emilio J.**
"Spectral Classification and Properties of the OVz Stars in the Galactic O Star Spectroscopic Survey (GOSSS)", Astronomical Journal, Vol. 152, p. 31
DOI: 10.3847/0004-6256/152/2/31

15. Arsenovic P., Rozanov E., Stenke A., **Funke B.**, Wissing J.M., Mursula K., Tummon F., Peter T.
"The influence of Middle Range Energy Electrons on atmospheric chemistry and regional climate", Journal of Atmospheric and Solar-Terrestrial Physics
DOI: 10.1016/j.jastp.2016.04.008

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"An accurate cluster selection function for the J-PAS narrow-band wide-field survey", Monthly Notices of the Royal Astronomical Society, Vol. 456, p. 4291-4304
DOI: 10.1093/mnras/stv2988

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"Searching for New Yellow Symbiotic Stars: Positive Identification of StHα63", Astronomical Journal, Vol. 151, p. 100
DOI: 10.3847/0004-6256/151/4/100

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"Spectropolarimetric observations of an arch filament system with the GREGOR solar telescope", Astronomische Nachrichten, Vol. 337, p. 1050-1056
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"A tensorial description of particle perception in black-hole physics", Physical Review D - Particles, Fields, Gravitation and Cosmology, Vol. 94, p. 064004
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"Hawking versus Unruh effects, or the difficulty of slowly crossing a black hole horizon", Journal of High Energy Physics, Vol. 2016, p. 1-14
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"Black holes turn white fast, otherwise stay black: no half measures", Journal of High Energy Physics, Vol. 2016, Number 157, p. 1-21
DOI: 10.1007/JHEP01157

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"Where Does the Physics of Extreme Gravitational Collapse Reside?", Universe, Vol. 2, Number 7
DOI: 10.3390/universe2020007

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"Detection of exposed H2O ice on the nucleus of comet 67P/Churyumov-Gerasimenko. as observed by Rosetta OSIRIS and VIRTIS instruments", Astronomy and Astrophysics, Vol. 595, p. A102
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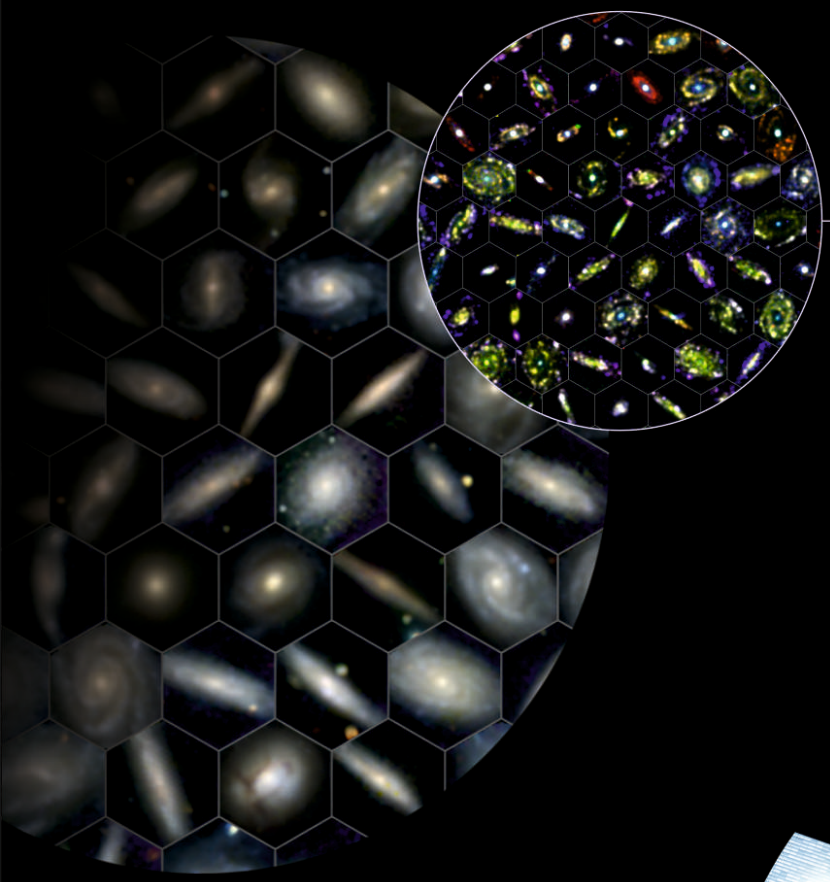
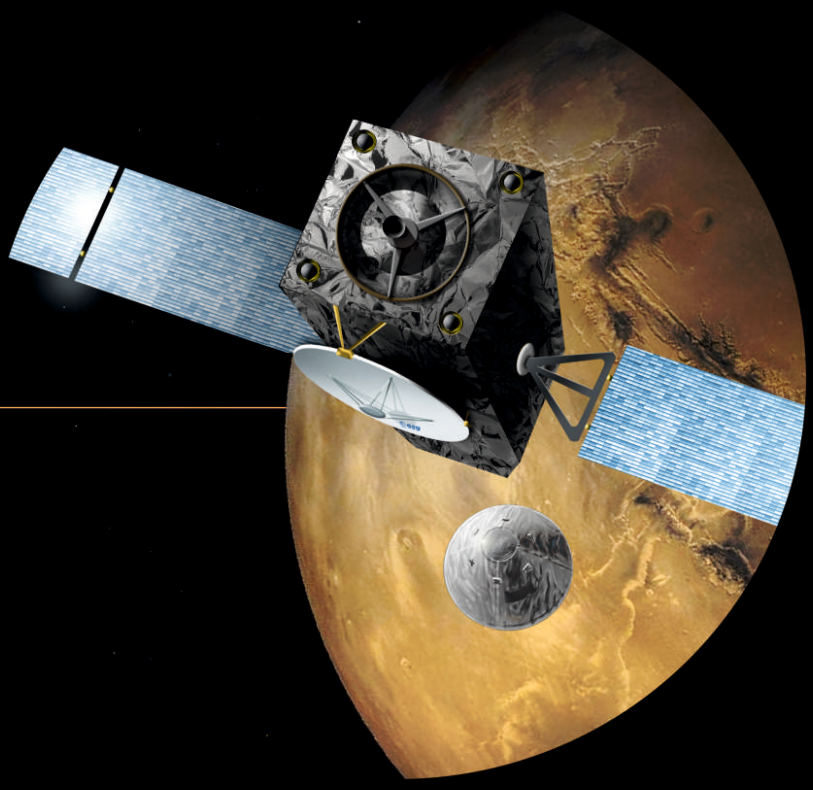
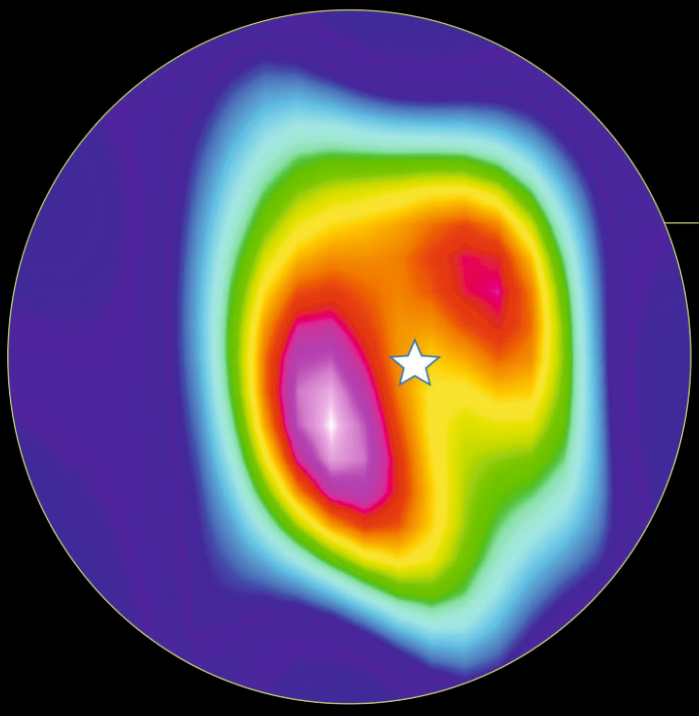


CALIFA PROJECT, last data release
The 11th of April 2016 we liberated 1576 fully reduced and quality controlled datacubes, corresponding to 667 galaxies.



EXOMARS MISSION, in orbit around Mars
NOMAD, a spectrograph co-designed by IAA-CSIC to solve the so-called methane problem on Mars sent its first data confirming the excellent performance of the instrument



Discovery of miniature planetary formation disk will enable observation of planetary gestation in real time
Young star XZ Tau B displays a dwarf protoplanetary disk which may evolve up to five hundred times faster than bigger disks and display observable changes in just a few months

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