INSTITUTE OF COSMOS SCIENCES
UNIVERSITY OF BARCELONA

2019 ANNUAL REPORT

Institute of Cosmos Sciences of the University of Barcelona.
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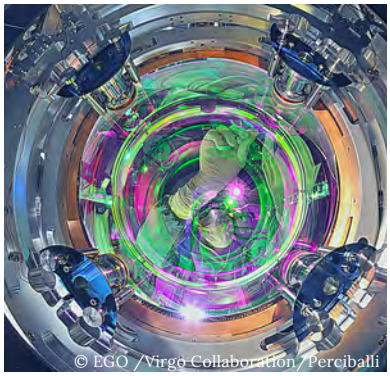
This report has been written and designed by the Scientific Office.
Cover photography by Eduard Masana

CONTENTS

FOREWORD

2019 has been for the ICCUB a year marked by the Maria de Maetzu awards. Our first one finished on June, and we reapplied for a renewal without success, although we obtained a very high score that has encouraged us to define an ambitious strategic program for the next four years and to apply again. The four years of our first award have allowed us to consolidate the structure of our institute and this year has been very rich in results.

In July 2019 we have officially become members of the Virgo consortium, thus strengthening our Gravitational Waves strategic line. We are contributing to Virgo both in instrument development through our Technological Unit, and science through an initial PhD position and the involvement of several of our senior researchers.



Let me here remark the significant consolidation of our Technological Unit during this year after the opening of its new labs and offices in the Parc Científic. This unit is quickly becoming a key asset of the institute, taking an active part in new research projects, and we encourage all our members to establish working links with it. Also, our Scientific Office and our Administrative

Office have become a key feature of the institute, providing a much necessary support to our activities. Among other things, these offices have allowed us a significant expansion of our outreach activities, with an increased presence in the social media channels and with the creation of the new outreach website ServiAstro, which complements the already existing ServiParticules. Another important milestone of the institute has been the implementation of the Diversity, Equity and Inclusion commission. Created in 2018, during this year it has started its work in force, as detailed on the report contained in this memory.

In 2019 we have also strengthened our participation in the Institut d'Estudis Espacials de Catalunya (IEEC). An updated memorandum of understanding has been signed, new members have been added and new joint projects have started.

To close this foreword, we want to welcome the two Ramón y Cajal and the new ICREA researchers that have joined the institute in 2019, and to congratulate Licia Verde for her Premi Nacional de Recerca. We also want to sadly farewell to our colleague and friend Jordi Torra, who left us in February this year; we will miss you. His work was acknowledged by the Generalitat de Catalunya with the 2019 Narcís Monturiol medal to the scientific merit.

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Xavier Luri

DIRECTOR OF THE ICCUB

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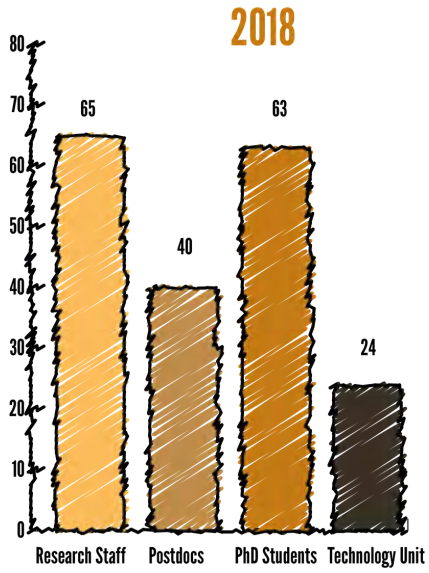
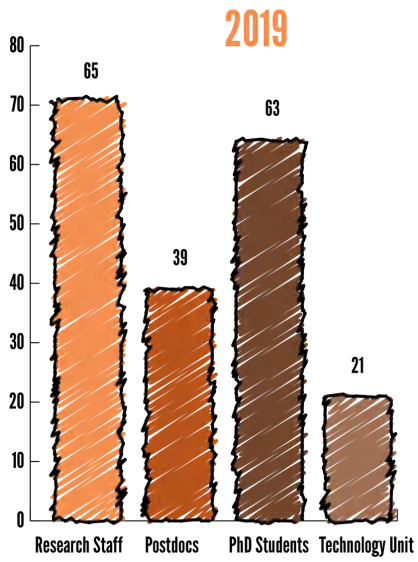
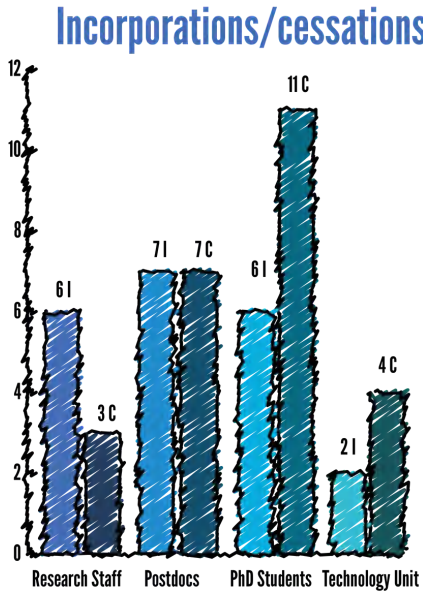
ICCUB IN FIGURES

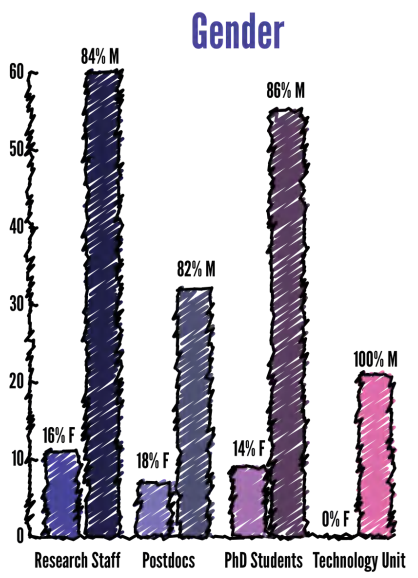
STAFF

Number of ICCUB members

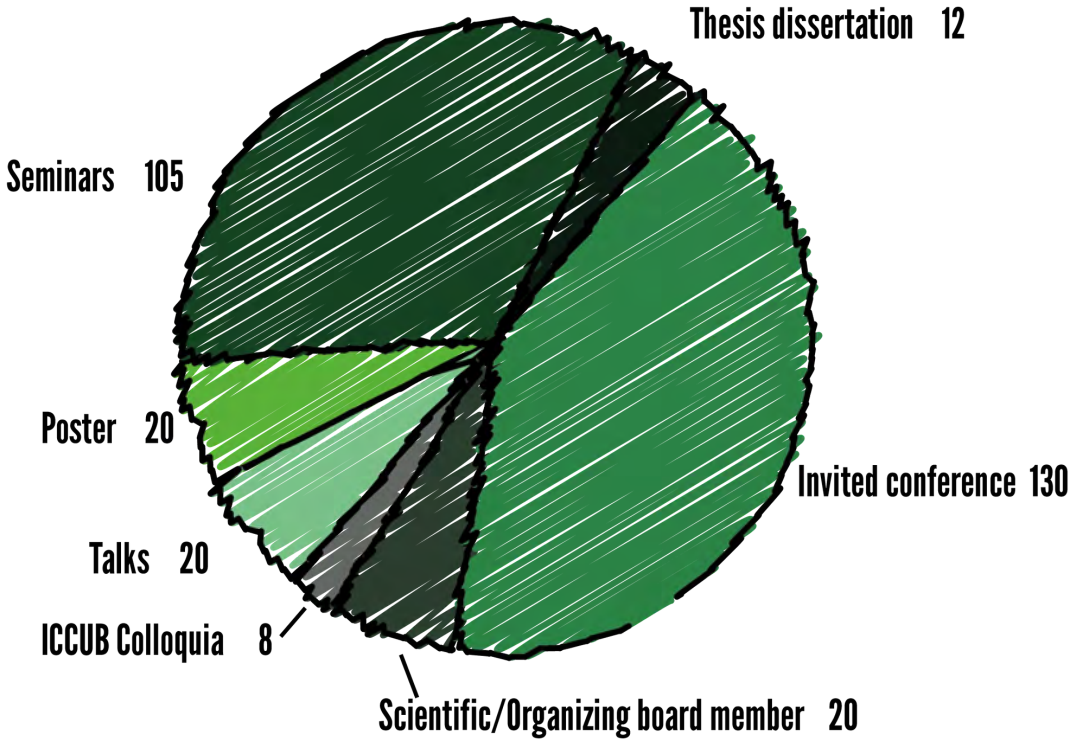




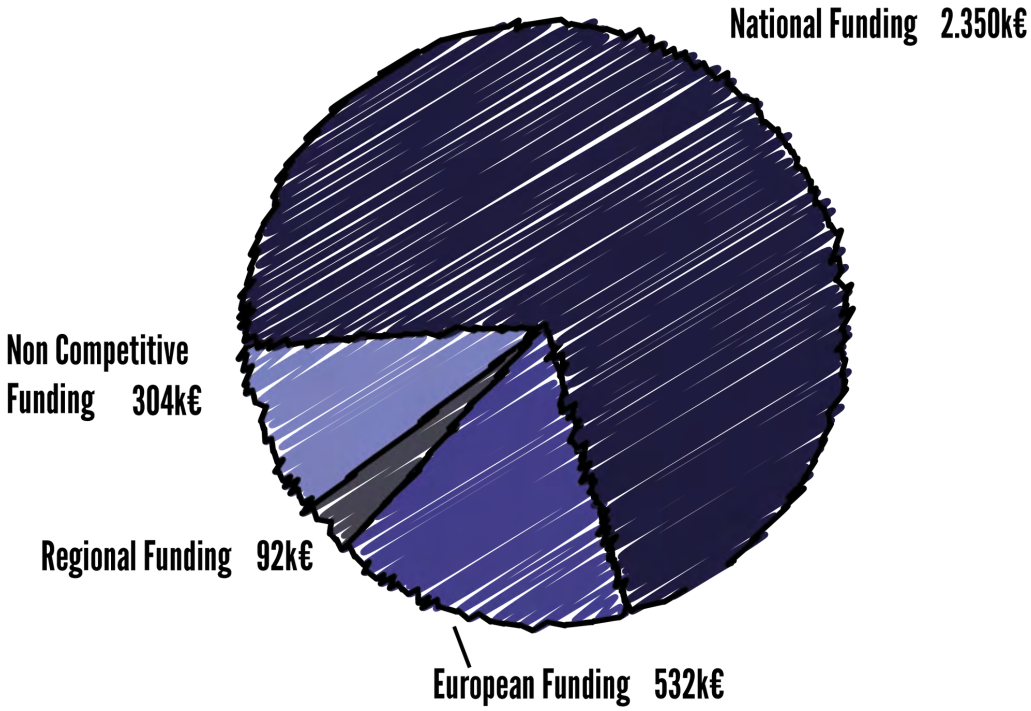




ACTIVITIES



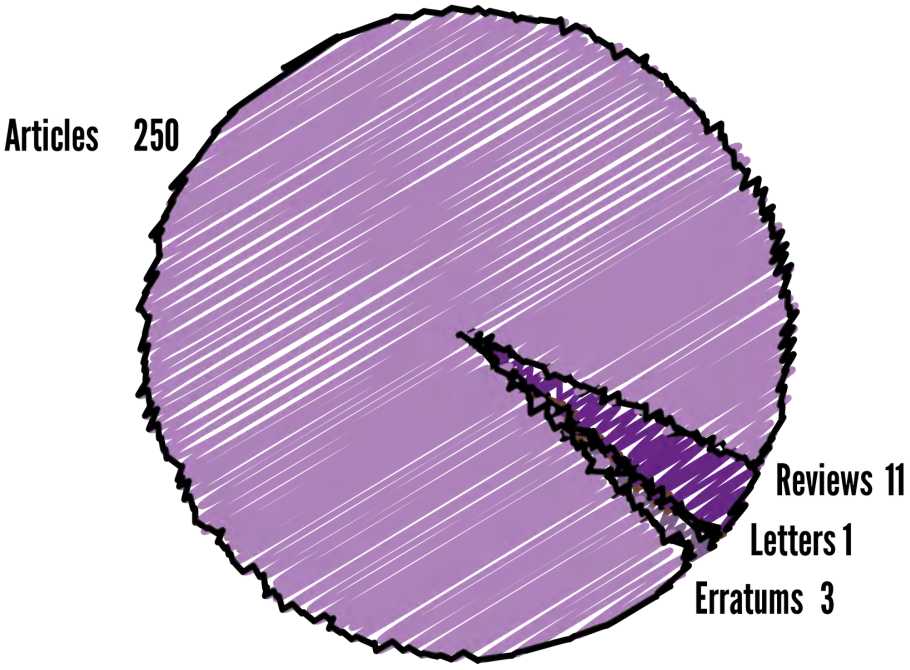
FUNDING SOURCES



RESEARCH HIGHLIGHTS

PUBLICATIONS

262 publications



COSMOLOGY AND LARGE SCALE STRUCTURE

The group has continued to work on timely topics in physical cosmology such as developing approaches to study the nature of dark energy via future 21 cm observations, developing analysis tools for analyzing forthcoming and future galaxy redshift surveys, and gearing up for the DESI survey (which had first light recently).

Main scientific results:

We have proposed a way to test the homogeneity of the Universe (something which is usually taken as an assumption in cosmology) and continued explore the implications of the Hubble tension between model-dependent early-universe based determination and the late-time, cosmology-independent measurements.

Significant amount of work went into the analysis of the e-BOSS SDSSIV survey, scientific results from data release 14 were published. The final data release and papers with cosmological interpretation of the data are expected in summer 2020.

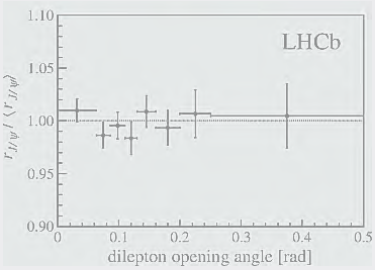
The potential of highly magnified stars in lensing clusters to explore the presence of axion structures and subhalos in the dark matter was analysed. Other research has involved possible radio stimulated emission signatures of axion dark matter, and the search for Lyman alpha emission around quasars in the JPLUS photometric survey.

An overdensity of Lyman-alpha emitters (LAEs) has been analyzed at a redshift of 6.5. It has been shown to correspond to a Coma-like protocluster, with a relaxed core, which is the most distant protocluster so far detected. In addition, we have demonstrated that this protocluster lies in a ionized super-bubble. It is the first time that such bubbles are directly observed near the epoch of reionization.

EXPERIMENTAL PARTICLE PHYSICS

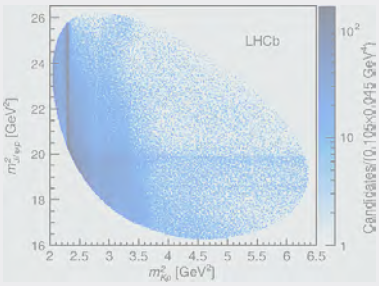
The ICCUB participation in the LHCb experiment has resulted in several scientific results in 2019. Those with highest impact are related to new decay observations, with new discovered states and in the search of new physics beyond the Standard Model (SM) of particles and fields in rare b-quark decays. Namely, a) the first observation of the radiative decay Λ_b--> Λ0 gamma (which was the main topic of the PhD thesis of an ICCUB student), b) measurement of CP-violating and Mixing Induced observables in Bs--> Phi gamma decays, c) the search for lepton-universality violation in rare B meson decays and , d) the observation of new Pentaquark states (made up of five quarks uudc anti-c) decaying into a J/psi and proton.

Main scientific results:



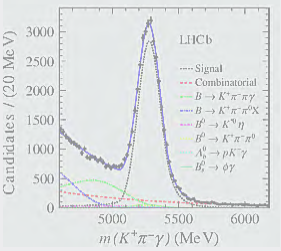
Search for Lepton-Universality Violation in B+→K+ℓ+ℓ− Decays

R. Aaij et al. (LHCb Collaboration)Phys. Rev. Lett. 122, 191801 – Published 13 May 2019



Observation of a Narrow Pentaquark State, Pc(4312)+, and of the Two-Peak Structure of the Pc(4450)+

R. Aaij et al. (LHCb Collaboration)Phys. Rev. Lett. 122, 222001 – Published 5 June 2019



First Observation of the Radiative Decay Λ0b→Λγ

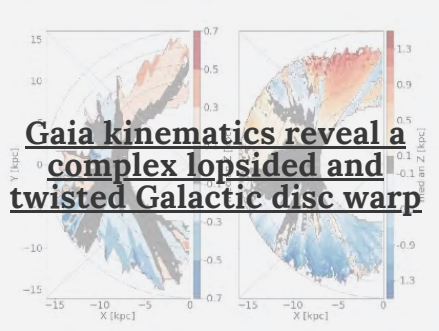
R. Aaij et al. (LHCb Collaboration)Phys. Rev. Lett. 123, 031801 – Published 15 July 2019

GALAXY STRUCTURE AND EVOLUTION

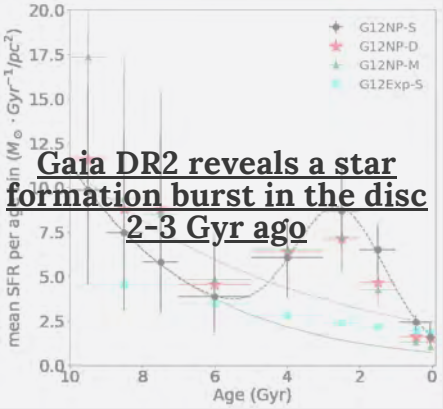
The Gaia group has been working in two main lines of research. The first one includes our participation in the Data Processing and Analysis Consortium and has been focused on the production of the Third Data Release DR3 (cross-matching of the observations of sources, image parameter and photometric calibration models, validation of data, development of the archive for early and full DR3) and on the development and implementation of the algorithms for the processing of the DR4 which will include the full 5 years of the nominal operations.

The second line concerns the scientific exploitation of the DR2, which started right after its publication in 2018. The results have been published in 15 peer refereed papers in 2019. They include, among others, the first clear manifestation of the Galactic bar in the stellar density distributions, the characterization of the warp of the disc confirming its age dependency; the derivation of the Star Formation History of the solar neighbourhood revealing a formation burst 2-3 Gyr ago, the study of open clusters population using artificial intelligence methods revealing that many known clusters are asterisms and discovering ~700 new ones, and the study of star forming regions revealing extremely complex substructures in space, kinematics and age.

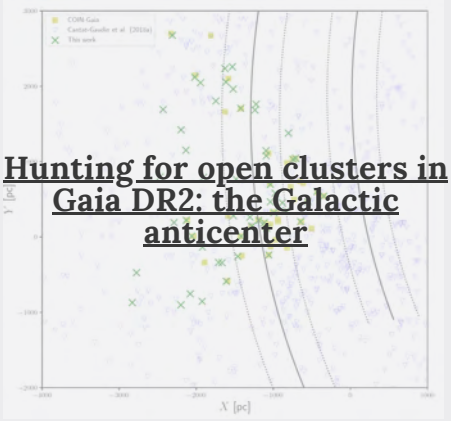
Main scientific results:



Gaia kinematics reveal a complex lopsided and twisted Galactic disc warp



Gaia DR2 reveals a star formation burst in the disc 2-3 Gyr ago



Hunting for open clusters in Gaia DR2: the Galactic anticenter

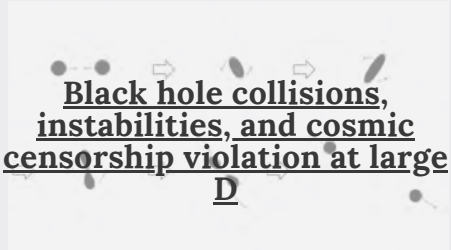
GRAVITATION AND COSMOLOGY

Black holes have been the main focus of our research on a wide variety of phenomena, divided into main two strands:

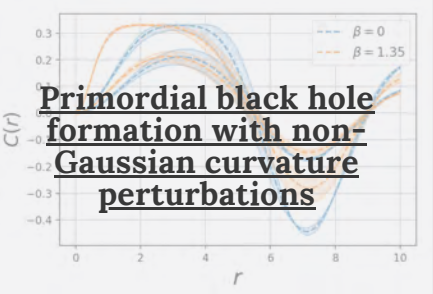
Fundamental studies of black holes and singularities
We have studied a novel violation of cosmic censorship in the collision of two black holes in high dimension D. We have proposed that the loss of predictability in this and similar violations is small independently of D. Using a 1/D expansion, we have investigated the topology-changing transition between black strings and black holes, and reduced the problem to a Ricci flow equation.

Primordial black holes (PBH) in cosmology
The formation of PBH has been studied from several perspectives. We have investigated the effect of non-Gaussianities on the threshold for PBH formation, also founded a bound on non-gaussianity above which false vacuum regions dominate the production of PBHs. We have derived a universal threshold for PBH formation and an analytic formula for the threshold amplitude of the compaction at its maximum. We have probed the fraction of dark matter in the form of PBH by studying the merger rate of PBH binaries (constrained by LIGO/Virgo). Furthermore, we have developed the non-linear statistics of PBH generated by a gaussian spectrum of primordial curvature perturbations.

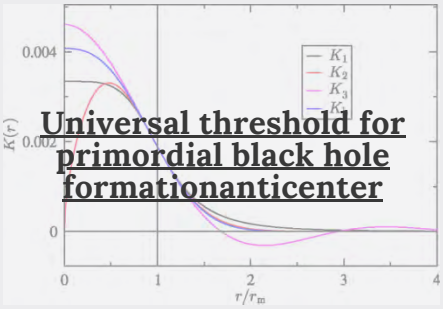
Main scientific results:



Black hole collisions, instabilities, and cosmic censorship violation at large D



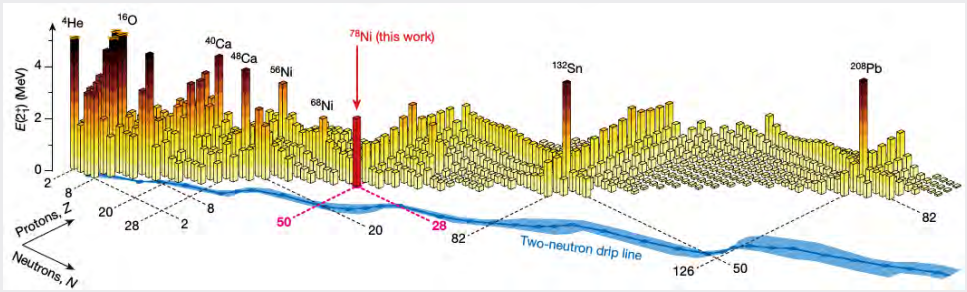
Primordial black hole formation with non-Gaussian curvature perturbations



Universal threshold for primordial black hole formationanticenter

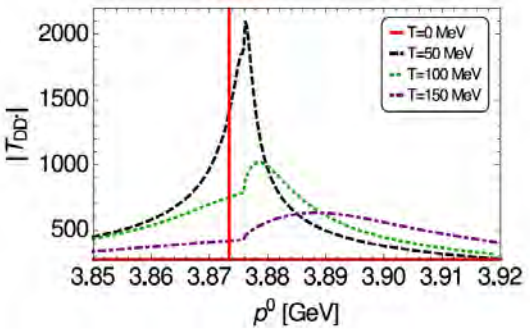
HADRONIC, NUCLEAR AND ATOMIC PHYSICS

Doubly magic nickel-78



So-called *magic* atomic nuclei are cornerstones for the understanding of these strongly-interacting many-body systems. Very selected nuclei are *doubly-magic*: their ground-states need to be especially stable due to both protons and neutrons completely filling shells of orbitals, just like electrons in noble-gas atoms. In this research, we present first-principles nuclear structure calculations that predict neutron-rich nickel-78 to be doubly magic. The experiment, performed at the RIBF facility, confirms the theory predictions: in nickel-78 an excitation from the ground to an excited state requires much more energy, than in similar mass nuclei. The results encourage pursuing first-principles calculations in heavier, more neutron-rich nuclei, which often cannot be accessed in the laboratory in spite of being key, for instance, for the nucleosynthesis of heavy elements in stars.

The X(3872) in a hot pion bath



Establishing the nature of the X(3872) meson has been one of the main priorities in the field of quarkonium physics. Not qualifying as a conventional $c\bar{c}$ state, the multiquark structure of this exotic meson has received very different interpretations, ranging from a compact tetraquark configuration to an extended $D\bar{D}^*$ molecule. Relativistic heavy ion collisions may provide useful information as the production yields depend strongly on the nature of the particles. We have explored the effect that a hot pion bath may have in the properties of the X(3872), assuming this state to be a $D\bar{D}^*$ molecule resulting from a coupled channels unitarized amplitude that takes into account the properties of the charmed mesons at finite temperature. The X(3872) develops a substantial width, of the order of a few tens of MeV, at temperatures 100-150~MeV, and its nominal mass moves above the DD* threshold. These results should have important implications in the production yield of the X(3872) from relativistic heavy-ion collisions.

HIGH ENERGY ASTROPHYSICS

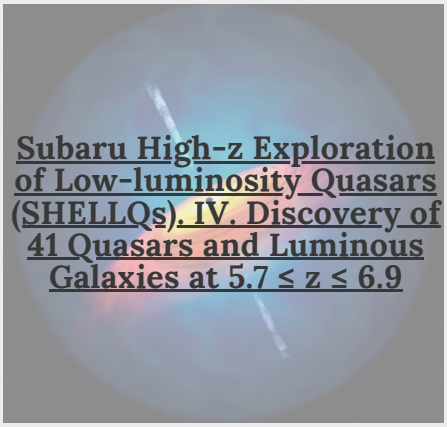
With the MAGIC Collaboration we reported the 1st TeV unambiguous detecion of a GRB, GRB 190114C, from about 1 m after the burst, revealing also afterglow photons. These results allow a deeper understanding of GRBs and relativistic shocks. In a 2nd paper was reported GRB 190114C multi-frequency observations, and a time evolution study of its emission from 5 × 10−6 to 1012 eV. Moreover, we contributed significantly to the discovery of TeV emission from around SNR G24.7+0.6, interpreted as p-p emission from the supernova interacting with a CO-rich medium, as well as a study on the new extreme blazar 2WHSP J073326.7+515354.

In the CTA framework we have taken shifts to the LST1 and participated in the study of non-transient gamma-ray binaries and prospects for CTA (A&A 2019).

Outside these Collaborations, we have developed leptohadronic single-zone models to explain the observed neutrino (IceCube-170922A) and multiwavelength electromagnetic emission of TXS 0506+056, and explored how the non-thermal emission of high-mass microquasar jets is affected by the stellar wind and orbital motion.

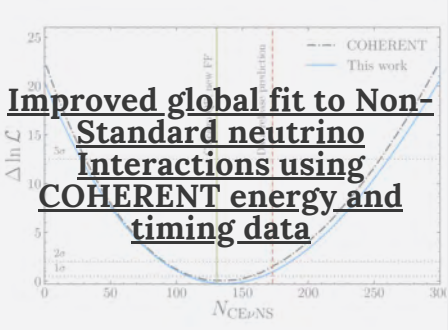
We have studied some fast-moving pulsars with asymmetric non-thermal features much larger than their pulsar wind nebulae. We have also determined the dynamics and emission of red giant winds bubbles penetrating blazar jets and studied the non-thermal leptonic radiation from SNR-AGN jet interactions. We have continued the search for quasars at highest redshift (z = 6-7), using the Subaru Hyper-Suprime Cam survey with the SHELLQs collaboration. In 2019 we have published 4 papers with SHELLQ, and with a receding torus model for the Iwasawa-Taniguchi effect for Compton-thick AGN.

Main scientific results:



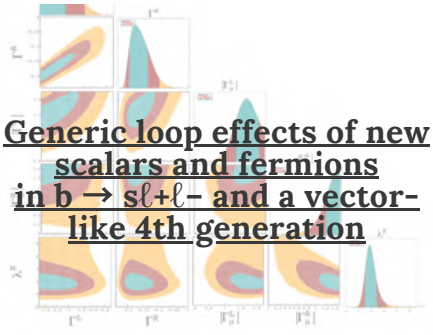
PARTICLE PHYSICS PHENOMENOLOGY

In JHEP 2002 (2020) 023, we perform a global fit to neutrino oscillation and coherent neutrino-nucleus scattering data. we quantify for the first time the less precisely known parameters θ23, δCP, and the neutrino mass.



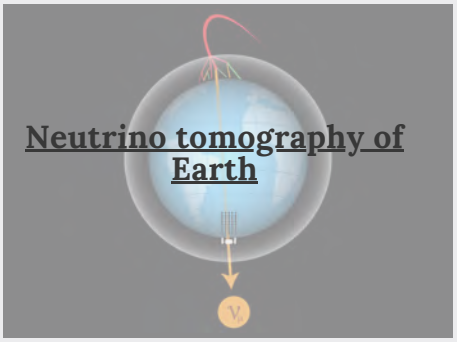
Improved global fit to Non-Standard neutrino Interactions using COHERENT energy and timing data

In JHEP 1906 (2019) 118 ICCUB researchers have been worked to clarify the b->s mu mu anomalies come out from the new results of LHCb. In several papers, we study the impact of a generic class of NP models featuring new heavy scalars and fermions that couple to the SM fermions via Yukawa-like interactions. These models can explain the anomalies and offer good candidate DM candidates.



Generic loop effects of new scalars and fermions in b → sℓ+ℓ− and a vector-like 4th generation

In Nature Physics volume 15, pages37–40(2019), we perform the first neutrino-based tomography of the Earth using one-year of through-going muon atmospheric neutrino data collected by the IceCube neutrino telescope. By using only weak interactions, we are able to determine the mass of the Earth and the core, its moment of inertia. See Figure Earth

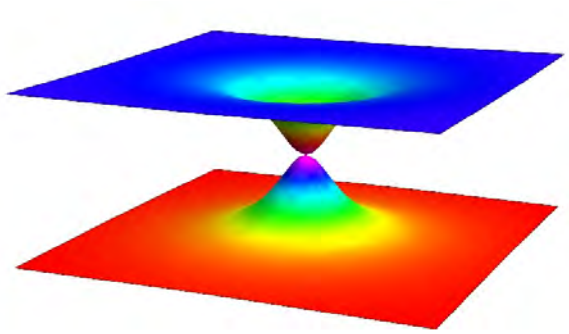


Neutrino tomography of Earth

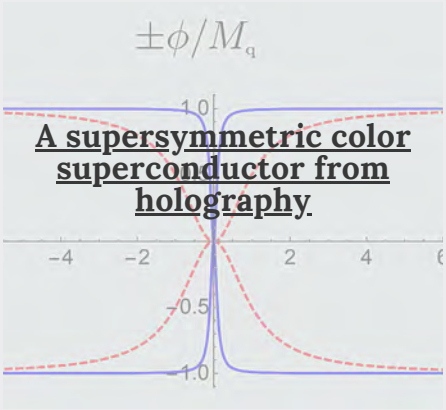
QUANTUM FIELD THEORY AND STRING THEORY

Color superconductors are a phase conjectured to exist in QCD at high density. We have discovered that, in their holographic description, their properties are encoded in the bending in the extra dimensions of higher-dimensional objects known as “D-branes” (see figure). This geometrization provides a completely new perspective on color superconductors. Hydrodynamic attractors generalize the gradient expansion beyond local thermal equilibrium. We have used holography to extended our understanding of attractors to intermediate values of the coupling.

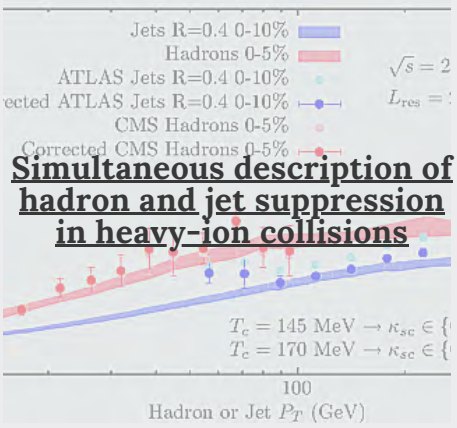
We have combined holography with the large-D expansion to study the dynamics of strongly coupled gauge theories undergoing boost-invariant expansion in a large number of space-time dimensions. We have used field-theoretical methods to derive new properties of supersymmetric Yang-Mills theories such as N=4, N=2*, and N=2 with massive matter. We have investigated different aspects of compactifications of higher-dimensional theories to de Sitter space, specially in the context of string and M-theory. We have also constructed several non-relativistic limits of string and M-theory. We have provided a simultaneous understanding of jet and hadron suppression at RHIC and LHC using the strong/weak hybrid model of jet quenching that we pioneered.



Main scientific results:



A supersymmetric color superconductor from holography



Simultaneous description of hadron and jet suppression in heavy-ion collisions

QUANTUM TECHNOLOGIES

We have covered aspects of quantum simulation, topological phases of matter, atomtronics and disorder in many-body systems.

Quantum Simulation
-QS1, we have devised new algorithms to study the out of equilibrium dynamics of quantum many-body systems and tested them in quenched fermionic hamiltonians. The key idea is to trade entanglement for mixture, thus using mixed states in the representation.
-QS2, Quamtum simulators are assumed to capture the quantum properties of the simulated systems. In our study we concentrate on checking this assumption for the entanglement entropy of spin chains and their corresponding quantum simulators with ultracold quantum gases.

Topological phases
We proposed a family of order parameters to detect the symmetry fractionalization class of anyons in 2D topological phases. A notable example of the latter is the fractional quantum Hall effect, where for the filling factor 1/3 the anyons carry a third of the electron charge.

Atomtronics
A minimal vortex transferring device composed of few-site Hubbard rings has been studied, paying special attention to the ability of the device to work properly in presence of interactions

Disorder in many-body quantum systems
The role played by contact boson-boson interactions in few-body 1D disordered systems has been studied. In the two and three body cases the interactions do not seem to favor delocalization.

Main scientific results:

Simulating the out-of-equilibrium dynamics of local observables by trading entanglement for mixture

Entanglement structure of the two-component Bose-Hubbard model as a quantum simulator of a Heisenberg chain

Local order parameters for symmetry fractionalization

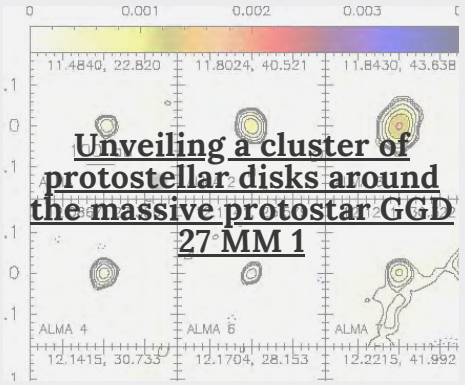
Nonlinear waves of Boson-Einstein condensates in rotating ring-lattice potentials

Few-boson localization in a continuum with speckle disorder

STAR FORMATION

Protostellar Disks with ALMA

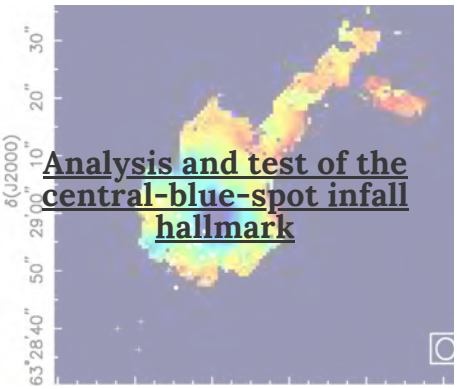
We used ALMA to observe the star-forming region GGD 27 at 1.14mm with an unprecedented angular reolution, 40 mas (56 au), and sensitivity (0.002 Msun). We detected a cluster of 25 continuum sources, most of which likely trace disks, with masses in the range 0.003-0.05 Msun, around Class 0/I protostars. We found a paucity of disks with radius above 100 au.



Unveiling a cluster of protostellar disks around the massive protostar GGD 27 MM 1

Searching for Infall onto Protostars

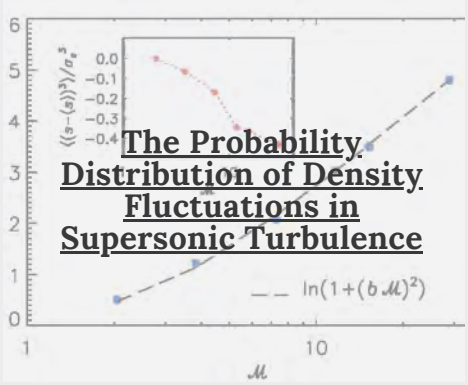
The infall of material onto a protostar, in the case of optically thick line emission, produces an asymmetry in the blue- and red- wing line emissions, which translates into a blue central spot in an intensity-weighted velocity. We have modeled this analytically and applied it as a method to detect infall and protostellar masses from existing data.



Analysis and test of the central-blue-spot infall hallmark

Fragmentation of Star-Forming Clouds in the Supercomputer

We have developed a theoretical formulation to investigate the physics of turbulent fragmentation in cold interstellar clouds. With the help of supercomputer simulations, we have shown that the increase in the probability of high-density gas with increasing Mach number in supersonic turbulence tends to saturate at very high Mach number. This result implies that the star-formation rate in some extreme regions may be lower than previously predicted.



The Probability Distribution of Density Fluctuations in Supersonic Turbulence

LIFE AT THE ICCUB

Welcome Dr. Javier Menendez

Javier Menéndez's research focuses on studying the structure of atomic nuclei from first-principles. Javier is specially interested in nuclear matrix elements for fundamental processes which can unveil the nature of neutrinos (neutrinoless double-beta decay) and dark matter (the scattering of dark matter particles off nuclei). His research combines powerful many-body techniques to simulate how nucleons---protons and neutrons---are arranged in atomic nuclei, with effective theories of the strong interaction (QCD) that govern the interactions of nucleons with neutrinos and dark matter particles. Javier joined the ICC from the University of Tokyo.

Roger Mor awarded second place at "Bona Gent" contest

Astronomer Roger Mor wins the second prize of the "La Bona Gent" contest, organized by El Diari de Tarragona.
The contest searched for the Tarragonian person of the year. The winner was Ruth Lau, a neurosurgeon who won the Young Neurosurgeon Award 2019. Mor ended in the second place, and was voted by 8.077 people.

PhD Student meetings

PhD students continued to meet with every colloquium speaker. The structure of the meetings was reformulated into four groups of students, based on their research lines, each one with a coordinator and their own series of activities. One of the activities consisted of organising courses between the members of each group, where a topic was chosen and each member had to "teach" some aspects of the topic to the other members of his/her group.

Furthermore, there were weekly general meetings, where each group had to present their research generally giving a three-slide presentation to the rest. These meetings serve as a tool for the teams to learn, in general terms, about the line of research of the other groups, and promote possible collaborations.

Licia Verde awarded 2019 Lodewijk Woltjer Lecture

Prof. Licia Verde was honored with The Lodewijk Woltjer Lecture which is awarded to astronomers of outstanding scientific distinction.

It has been awarded to Prof. Licia Verde for her outstanding work in cosmology, especially in the study of the cosmic microwave brackground and the large-scale structure of the Universe.

Prof. Licia Verde is a cosmologist who addresses questions such as origin, composition and evolution of the Universe, with special attention to statistical methodology.

Welcome Dr. Javier Virto

Javier Virto joined the ICCUB in September 2019 as a Ramon y Cajal fellow, after a Marie Curie fellowship at the Massachusetts Institute of Technology and the Technical University of Munich. His research is currently focused on the interpretation of LHCb measurements, where he has contributed significantly in the field of Rare B Decays. One example is his proposal for the measurement of the observable P5' and the subsequent discovery of the b-->s Anomalies. He is also working on analytical calculations of non-perturbative matrix elements relevant for B decays, and on the automation of calculations within the Standard Model Effective Field Theory. As a new member of the ICCUB, he plans to strengthen the flavor-physics wing of the particle physics group and tighten the links to the experimental LHCb group.

DIVERSITY, EQUITY AND INCLUSION COMMITTEE

At the end of 2018, the ICCUB Council approved the creation of the Diversity, equity and inclusion commission (DEIC), with the aim of promoting specific actions to provide a welcoming environment to our members and visitors, regardless of gender, gender identity, sexual orientation, ethnicity, beliefs or disability. During 2019, the members of the DEIC have participated in two training activities focused on drawing specific measures to increase diversity and reduce minority imbalance in our Institute. First, the meeting with Dr. Emma Nichols, Outreach Officer at the University of Manchester, which took place on January 22 at our Institute.

Second, we participated in the project LIBRA workshop “How to design, implement and follow-up a Gender Equality Plan”, which was held in Sitges, Spain, on February 14-15. The training provided us with specific policies and procedures to implement equity in different areas of the Institute's everyday life, especially focussing on gender. The material, collected in our web page, emphasizes on how to address situations related to different types of complaints, harassment, the bias in recommendation letters or job advertisements, or unconscious bias in decision panels.

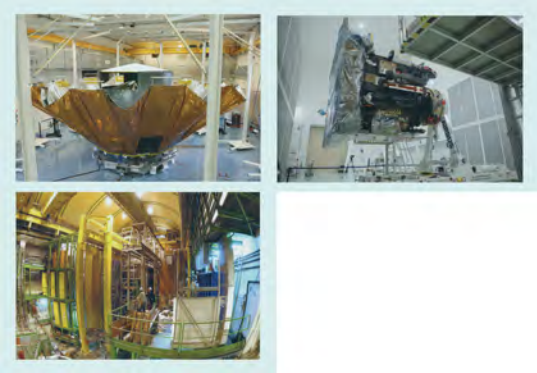
An important step forward for our visibility among the University's community has been our participation in the Equity Committee of the University of Barcelona. Currently, we do not have voting rights, since the regulatory statutes of the university do not allow representatives of the UB research institutes to formally take part of the Committee, but we have been actively participating in

discussions regarding the drafting of the upcoming III Equity Plan of the University of Barcelona, as well as in the design and implementation of the recently inaugurated conference series "Debates UB: Feminisms".

We also participated in the International Day of Women and Girls in Science (February 11), with the shooting of an audiovisual project to disseminate the work of female scientists and to attract the attention of girls to science (directed by COPILOTOS Social Content and sponsored by ACCIONA), and with the organization of an open discussion session on the topic “Women in Science” following the scientific colloquia given by Caterina Biscari, director of the ALBA Synchrotron, with the title “ALBA light at the service of society”.

Lastly, we have contributed to the design and contents of the exhibition "Women and Physics". Its opening took place at the Institute of Catalan Studies, on October 18, with a talk given by Prof. Àngels Ramos, one of the most prominent female researchers of the Institute, about the role of women in physics. The exhibition could also be seen from October 2 to 16, at the Physics building of the University of Barcelona.

TECHNOLOGICAL UNIT



Gaia: our team executed the instrumental calibration and image parameters determination system in Marenostrum. We also started defining the new algorithms that will be needed for the 4th Data Release.

Solar Orbiter: the main activity has been its assembly of the Flight Model in the platform and starting test procedures.

LHCb: the SPD was dismantled as the first step on the activities of the calorimeter upgrade. Moreover, it has been produced and designed Front End Boards, particularly in the analog circuit and ICECAL integration.

CTA: During 2019, the technological unit defined the modifications required for the ASIC ACTA in order to implement a "test pulse" functionality.

Virgo: The ICCUB became a full member of the Virgo Collaboration this 2019. On software and computing we participated developing a better software management, compilation, packaging and deployment approach.

IAXO: The ICCUB has proposed the read-out electronics design for the micromegas sensor.

OUTREACH

The ICCUB research groups are very active in the dissemination of their activity in schools and public centers, and since its establishment, the institute has provided economic and human support to the extent possible. Thanks to the Maria de Maeztu award, the institute has been able to significantly expand this support. The Institute main outreach activities are:

- Publication of outreach articles
- Astronomy sessions, courses and public talks
- "Taller de Física de Partícules" organization
- Fabrication and management of itinerant exhibitions.
- Astronomic events follow-up

MASTERCLASS ON PARTICLE PHYSICS 2019

The Masterclass on Particle Physics is an activity addressed to high school students in their final year, as part of the international activity Hands on Particle Physics. The workshop has taken place at the UB since 2005 and lasts one day, during which students attend talks about Physics and study real data from LHC. The students also visit the laboratories and attend a presentation about the courses offered at the Faculty of Physics.

In 2019 two sessions were held on the 8th and the 22nd of March at the Faculty of Physics.

179 STUDENTS — ATTENDANCE

139 — HIGH SCHOOLS

TRAVELLING EXHIBITIONS

The ICCUB owns eight travelling exhitibions. These exhibitions have different printed versions that are displayed annually in different external centers, like high schools, libraries or community centers. All the exhibitions also have online versions, some of them translated in several languages.

In 2019 a new exhibition has been created "Dones i Física" thanks to the parnership of the Societat Catalana de Física, the Faculty of Physics and the ICCUB.

exhibitions

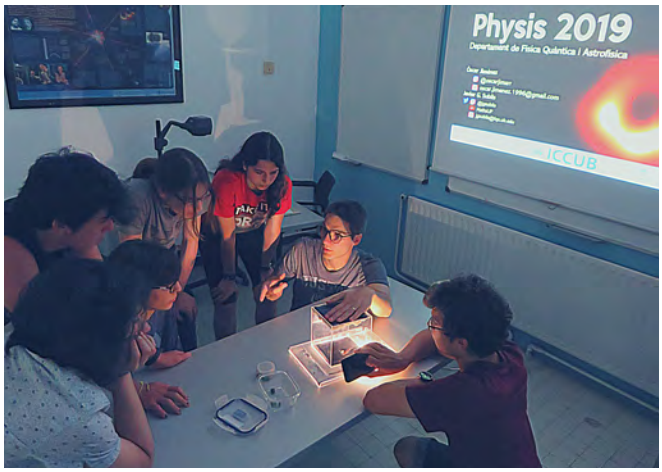
- **Dones i Física**
- **De la Terra a l'Univers**
- **Amb A d'AstrònomA**
- **Les distàncies còsmiques**
- **Mil milions d'ulls per a mil milions d'estrelles**
- **Viatge cap a l'univers fosc**
- **Telescopi Assumpció Català**
- **Investigadores en Física Nuclear**

24 DESTINATIONS

8 TRAVELLING EXHIBITIONS

OTHER OUTREACH ACTIVITIES

ICCUB members give outreach talks addressed both to students and general public; they also give courses and participate in workshops, science festivals or students fairs. They assist high school students on their final projects, organize astronomical observations, and give coverage to remarkable astronomical ephemeris.



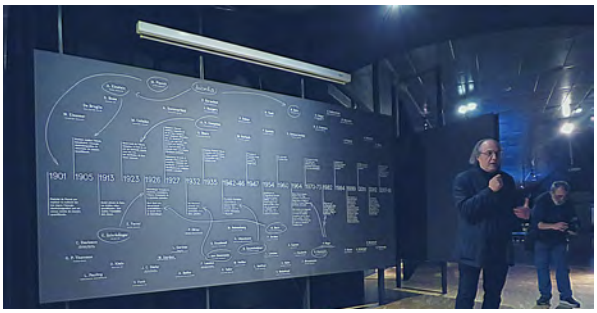
REMARKABLE OUTREACH ACTIVITIES

Mercury's transit

The Mercury's transit began at 12:35 UT on November 11, but in Catalonia, it was not possible to see it coming to an end because the sun had already risen.
To mark the occasion was planned an observation with a telescope open to the general public and, moreover, a theoretical session of the phenomena of planetary transits by astronomers of the ICCUB directed to students.

"Quantum" - CCCB exhibition

The ICCUB's member José Ignacio Latorre was, together with Mónica Bello and José Carlos Mariátegui, curator of the CCCB exhibition Quantum. An exhibition that brings closer the quantum theory to the general public through the joint creative work of scientists and artists. Two itineraries, the artistic with ten artistic projects and nine windows that introduce laboratory research work. Many members of the ICCUB collaborated lending instruments or giving talks.



"Women and Physics" exhibition

The Societat Catalana de Física, together with the Faculty of Physics and the Institute of Cosmos Sciences created a new exhibition dedicated to women in physics. This exhibition is made up of 13 posters and it was oppened to the public at the Institut d'Estudis Catalans on September 18th where ***Àngels Ramos*** will give a conference about "*The female physics. The female physicist.*"

Dark Matter Day

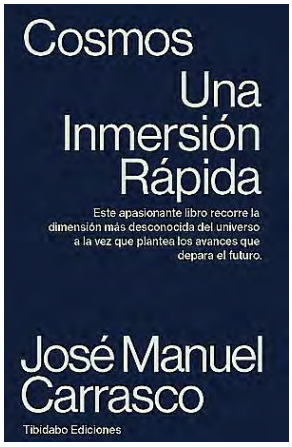
A successful rountable was held on the occasion of the celebration of the Dark Matter Day where different aspects of the research on this subject in our Institute was briefly presented by Prof. Licia Verde, Prof. Francesca Figueras, Prof. Mark Gieles and PhD Student Cristian Cogollos.

11F: Roundtable "Women in Science"

To celebrate the International Day of Women and Girls in Science, we organised a round table where several topics were discussed, such as how to reach total equality or what the Glass Ceiling or the Matilda Effect are. Afterwards, we engaged in a impassionated debate.

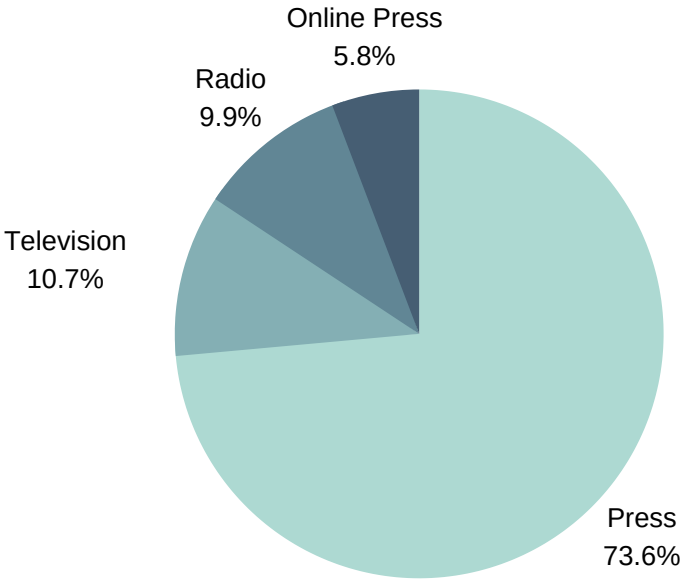
During 2019 the Institute's members have actively participated in the dissemination of science, through the publication of popular science books and articles in journals and magazines; giving interviews about their groups' scientific publications to press and television; commenting about discoveries or remarkable achievements as experts, and participating in roundtables and debates in radio shows.

The astronomer **Josep Manel Carrasco** published the book "*Cosmos; a quick immersion*", where he unveils certain aspects of the Universe. Theoretical physicist J**osé Ignacio Latorre** published "*Ethics for machines*", where he discusses about our relationship with artificial intelligence.



Media appearances

Our researchers gave written statements and comments about scientific articles and discoveries in their appearances in written press.



121 APPEARANCES

TELEVISION

Licia Verde interviewed about her 2018 Catalonian National Research Award, in the frame of the award ceremony.

PRESS

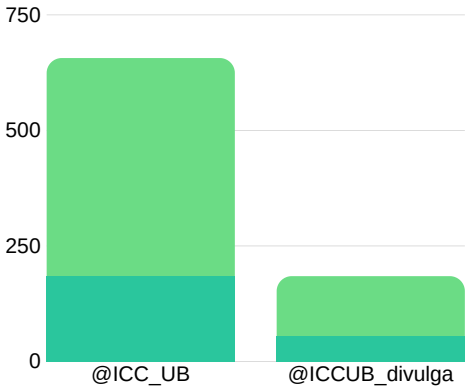
Anna Ferré-Mateu interview to La Vanguardia, explaining her career research and interests.

ONLINE MEDIA

Press article about Roger Mor's findings on the Milky Way, published in Astronomy & Astrophysics journal.

Social Media appearances

Our social media strategy has been to increase the Institute's visibility among the scientific community and to reach a more global audience through the outreach twitter account.



769
+357 IN 2019

FOLLOWERS
@ICC_UB

472
+149 IN 2019

FOLLOWERS
@ICCUB_DIVULGA