

**Annual Report 2016**  
**Instituto de Astrofísica**  
**Facultad de Física**  
**Pontificia Universidad Católica de Chile**

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## Abstract

The Institute of Astrophysics (IA) at PUC has 16 active faculty members, one Emeritus Professor, 46 post-doctoral researchers, and about 50 graduate students. The IA members published 228 refereed articles during 2016. In the academic year 2016, 12 students received their *Licenciatura* degree, 4 obtained an M.Sc., and 4 a Ph.D.

## 1 Introduction

The *Instituto de Astrofísica* (Institute of Astrophysics, IA) is one of the two academic divisions of the Faculty of Physics of *Pontificia Universidad Católica de Chile* (PUC). The Institute offers an undergraduate (*Licenciatura*) degree in Astronomy, and Ph.D. and Master's programmes in Astrophysics.

The IA is becoming an international centre of excellence for studies in the field of Astrophysics, covering a broad range of topics in observational and theoretical astrophysics, and is preparing the next generations of students that will benefit from the superb observational facilities available to Chilean astronomers and their collaborators. In addition, the IA together with the associated Center for Astro-Engineering (AIUC) are engaged in innovative telescope instrumentation projects and high-performance computing programs. In this report, we review the main activities at IA from January until December 2016.

## 2 Personnel

### 2.1 Changes in 2016

#### 2.1.1 New Faculty

Dr. Ezequiel Treister arrived from Universidad de Concepción, Chile, and hired as a new faculty member (Associate Professor).

#### 2.1.2 Postdocs Arrivals

- Dr. Loic Maurin, from Université Paris Diderot, France
- Dr. Claudio Ricci, from Université de Geneve, Italy
- Dr. Xian Chen, from Peking University, China

- Dr. Aiara Lobo, from Universität Heidelberg, Germany
- Dr. George Privon, from University of Virginia, USA
- Dr. Jorge González, from Heidelberg University, Germany
- Dr. Nicolás Cuello, from Université Claude Bernard, France
- Dr. Rafael Brahm, from Pontificia Universidad Católica de Chile, Chile
- Dr. Nicolás Tejos, from Universidad de Durham, UK
- Dr. Paul Eigenthaler, from University of Vienna, Austria
- Dr. Sam Kim, from University of California, USA
- Dr. Rodrigo Contreras, from Universidad de Bologna, Italy
- Dr. Alvaro Rojas, from Université de Nice, France
- Dr. Roberto Puddu, from Università di Siena, Italy
- Dr. Carlos López, from Universidad de la Laguna, Spain

#### 2.1.3 Postdoc Departures

- Dr. Iván Lacerna, takes a faculty position at Universidad Autónoma, Chile.
- Dr. Adal Mesa.
- Dr. Robert Nikutta left to take on a Postdoc position in Tucson, Arizona.
- Dr. Karla Peña left to take on a Faculty position at Universidad de Antofagasta, Chile.
- Dr. Steve Schulze left to take on a Postdoc position in Tel Aviv, Israel.
- Dr. Aldo Valcarce is now in Cruz das Almas, Bahia State, Brazil.

- Dr. Jincheng Yu left to take on a Postdoc position in Shanghai, China.
- Dr. Luca Sbordone left to take on a Postdoc position at ESO, Chile.
- Dr. Zheng Zhenya left to take on a faculty position in Shanghai, China.
- Dr. Xian Chen left to take on a Postdoc position in Beijing, China.
- Dr. Aiara Lobo relocated to Belgium.
- Dr. Mark Booth left to take on a Postdoc position in Germany.
- Dr. Jesús Corral left to take on a Postdoc position at ESO, Chile.
- Dr. Istvan Dékány left to take on a postdoctoral position at the Astronomisches Rechen-Institut (ARI) of Heidelberg University.
- Dr. Roberto González.
- Dr. Nicolas Laporte, take on a postdoctoral position at University College London.
- Dr. Cristina Romero left to take on a Postdoc position at Universidad Diego Portales, Chile.
- Dr. Sanzia Alves do Nascimento left to take on a faculty position at Univ. Federal do Recancavo da Bahia, in Cruz das Almas, Bahia State, Brazil.
- Dr. Julio Chanamé, Assistant Professor (Ph.D. The Ohio State University, USA, 2005) – *Stellar dynamics. The Milky Way and the Local Group. Stellar structure and evolution.*
- Dr. Alejandro Clocchiatti, Full Professor (Ph.D. University of Texas at Austin, USA, 1995) – *Supernovae, near and far. Radiative Transfer. Galaxy Clusters. Cosmology.*
- Dr. Jorge Cuadra, Associate Professor (Ph.D. Ludwig-Maximilians-Universität München, Germany, 2006) – *Gas dynamics around massive black hole binaries. Accretion onto Sgr A\*. Protoplanetary discs. Star formation and dynamics in galactic nuclei.*
- Dr. Rolando Dünner, Adjunct Assistant Professor, (Ph.D. PUC, 2009) – *Large scale structure and cosmology. Astronomical instrumentation.*
- Dr. Gaspar Galaz, Associate Professor and current IA Director (Ph.D. Université de Paris, France, 1998) – *Stellar populations in galaxies. Galaxy evolution. Low surface brightness galaxies. Statistical properties of the galaxy distribution.*
- Dr. Leopoldo Infante, Full Professor (Ph.D. University of Victoria, Canada, 1990) – *Galaxy and structure evolution. Pairs, groups and clusters of galaxies. LSB, dwarf and star forming galaxies in relation to environment. High-z QSOs. Correlation functions. The very high redshift universe.*

## 2.2 IA Faculty

List of faculty members at the IA as of late 2016.

- Dr. Felipe Barrientos, Associate Professor (Ph.D. University of Toronto, Canada, 1999) – *Galaxy evolution and morphology. Elliptical galaxies. Clusters of galaxies. Observational cosmology.*
- Dr. Franz E. Bauer, Associate Professor (Ph.D. University of Virginia, USA, 2001) – *AGN Demographics, Feeding, and Evolution. Coeval Growth of Galaxies and Super-Massive Black Holes. Deep Blank-field Surveys (Radio through X-ray). Nearby Supernovae and X-ray Binaries. Structure Formation and Galaxy Cluster Evolution.*
- Dr. Márcio Catelan, Full Professor (Ph.D. Universidade de São Paulo, Brazil, 1996) – *Stellar structure and evolution. Globular clusters. Variable stars. Stellar Populations. Galaxy formation and evolution.*
- Dr. Andrés Jordán, Associate Professor (Ph.D. Rutgers University, USA, 2004) – *Search and characterization of transiting exoplanets. Galaxies in nearby clusters. Star clusters.*
- Dr. Nelson Padilla, Full Professor (Ph.D. Universidad Nacional de Córdoba, Argentina, 2001) – *Numerical astrophysics. Galaxy and Structure Formation. Cosmology.*
- Dr. Thomas H. Puzia, Assistant Professor (Ph.D. Ludwig-Maximilians-Universität München, Germany, 2003) – *Large-Area Surveys of Baryonic Structures of nearby Galaxy Clusters and Groups. Hierarchical Structure Formation. Mass Assembly of Clusters and Galaxies. Star clusters and Star Cluster Systems. Chemical evolution and enrichment histories of galaxies. Galaxy formation and evolution. Stellar dynamics. Stellar populations. Population synthesis models. Stellar abundances.*
- Dr. Hernán Quintana, Professor Emeritus (Ph.D. Cambridge University, UK, 1973) – *Observational*

*astrophysics. Clusters of galaxies. Interacting galaxies. Large scale structure.*

- Dr. Andreas Reisenegger, Full Professor (Ph.D. Caltech, USA, 1993) – *Theoretical Astrophysics and Cosmology. Neutron Stars. Stellar Magnetic Fields. Structure Formation. Clusters and Superclusters of Galaxies.*
- Dr. Patricia Sánchez-Blázquez, Assistant Professor (Ph.D. Universidad Complutense de Madrid, Spain, 2004) – *Stellar Populations. Galaxy formation and evolution. Chemical enrichment. Population synthesis models. Numerical modelling. Resolved properties of galaxies.*
- Dr. Ezequiel Treister, Associate Professor (Ph.D. Universidad de Chile, Chile, 2005) – *Extragalactic astronomy, active galactic nuclei, galaxy evolution, black holes.*
- Dr. Manuela Zoccali, Full Professor (Ph.D. Università degli Studi di Padova, Italy, 2000) – *Stellar Populations in the Milky Way. The Galactic Bulge. Star Clusters. Chemical Abundances.*

### 2.3 Postdocs 2016

List of postdoctoral researchers at the IA as of late 2016:

- Dr. Karla Alamo (Ph.D. Universidad Nacional Autónoma de México, México, 2014)– *relating globular cluster formation efficiency with dark matter halo properties*
- Dr. Sanzia Alves (Ph.D. Universidad Federal do Rio Grande do Norte, Brasil, 2012)– *Stellar Populations*
- Dr. Patricia Bessiere (Ph.D. The University of Sheffield, UK, 2015)– *understanding the life cycles of quasars and how they impact their host galaxies*
- Dr. David Boettger (Ph.D. University of California, USA, 2014)– *measurements of the cosmic microwave background b-mode polarization*
- Dr. Mark Booth (Ph.D. University of Cambridge, UK, 2011)– *the place of debris discs in planetary systems*
- Dr. Rafael Brahm (Ph.D. Pontificia Universidad Católica de Chile, Chile, 2016)– *Exoplanets*
- Dr. Johannes Buchner (Ph.D. Ludwig-Maximilians-Universität München, Germany, 2015)– *robust constraints on the growth of super-massive black holes*
- Dr. Julio Carballo (Ph.D. Universidad de la Laguna, Spain, 2012)– *near-field cosmology: mapping halo structure in the southern milky way*
- Dr. Xian Chen (Ph.D. Peking University, China, 2010)– *Extragalactic Astronomy*
- Dr. Rodrigo Contreras (Ph.D. Universidad de Bologna, Italy, 2010)– *the history of the milky way told by its variable stars*
- Dr. Jesus Corral (Ph.D. Universidad de la Laguna e Instituto de Astrofísica de Canarias, Spain, 2012)– *increasing the census of galactic stellar-mass black holes in x-ray binaries*
- Dr. Nicolás Cuello (Ph.D. Université Claude Bernard, France, 2015)– *Extragalactic Astronomy*
- Dr. Istvan Dékány (Ph.D. Eotvos Lorand University, Hungary, 2010)– *Stellar populations*
- Dr. Holger Drass (Ph.D. Ruhr/ University of Bochum, Germany, 2014)– *from the optical to the near-infrared: installation and commissioning of a new optical, high-resolution spectrograph and development of optics for near-infrared spectroscopy*
- Dr. Sonia Deffau (Ph.D. Universidad de Chile, Chile, 2008)– *Stellar populations, stellar kinematics*
- Dr. Paul Eigenthaler (Ph.D. University of Vienna, Austria, 2011)– *chasing ghosts in the nearby universe -an unprecedented study of the dwarf galaxy populations in the cen-taurus a group and the formax galaxy cluster*
- Dr. Cristóbal Espinoza (Ph.D. University of Manchester, UK, 2009)– *physics under extreme conditions via observations of neutron stars*
- Dr. Virginie Faramaz (Ph.D. Institute de Planétologie et d’Astrophysique de Grenoble, France, 2014)– *exoplanetary systems dynamics*
- Dr. Germán Gómez (Ph.D. Universidad Autónoma de Madrid, Spain, 2013)– *disentangling a possible dark matter-induced gamma-ray signal from known astrophysical emitters toward the galactic center*
- Dr. Jorge González (Ph.D. Heidelberg University, Germany, 2015)– *high-z universe. sub-mm astronomy*
- Dr. Roberto González (Ph.D. Pontificia Universidad Católica de Chile, Chile, 2010)– *extragalactic astronomy, galaxy surveys, clusters of galaxies*
- Dr. Sebastien Guillot (Ph.D. McGill University, Canada, 2014)– *understanding ultra-dense matter with multi-wavelength observations of neutron stars*

- Dr. Madusha Gunawardhana (Ph.D. University of Sydney, Australia, 2014)– *probing the nature of star formation across cosmic time*
- Dr. Maren Hempel (Ph.D. Ludwig-Maximilians-Universität München, Germany, 2004)– *Stellar populations, galactic structure*
- Dr. Sam Kim (Ph.D. University of California, USA, 2012)– *study of the relation between compact overdensity regions and protoclusters detected in submillimeter survey*
- Dr. Andrea Küller (Ph.D. Princeton University, USA, 2015)– *extensions of halo abundance matching*
- Dr. Iván Lacerna (Ph.D. Pontificia Universidad Católica de Chile, Chile, 2012)– *Numerical cosmology, extragalactic astronomy*
- Dr. Régis Lachaume (Ph.D. Université Joseph Fourier, France, 2003)– *exoplanets*
- Dr. Benjamin Laevens (Ph.D. Université de Strasbourg, France, 2015)– *discovery and characterisation of new dwarf galaxies of the milky way*
- Dr. Richard Lane (Ph.D. The University of Sydney, Australia, 2010)– *surveys*
- Dr. Aiara Lobo (Ph.D. Universität Heidelberg, Germany, 2015)– *Stellar populations*
- Dr. Carlos López (Ph.D. Universidad de la Laguna, Spain, 2013)– *instrumentacion chilena para sondeos astronomicos*
- Dr. Loic Marin (Ph.D. Université Paris Diderot, France, 2013)– *Instrumentation, sub-mm astronomy*
- Dr. Adal Mesa (Ph.D. Instituto de Astrofísica de Canarias / Universidad de la Laguna, Spain, 2010)– *multiwavelength study of protoplanets: observational constraints to define possibilities of planet formation in hostile environments*
- Dr. Marcelo Mora (Ph.D. Ludwig-Maximilians-Universität München, Germany, 2008)– *extragalactic astronomy, galaxy evolution*
- Dr. Robert Nikutta (Ph.D. University of Kentucky, USA, 2012)– *dust obscuration in active galactic nuclei*
- Dr. Athanasios Papageorgiou (Ph.D. University of Patras, Greece, 2015)– *eclipsing binary stars in the era of massive surveys*
- Dr. Karla Peña (Ph.D. Universidad de la Laguna e Instituto de Astrofísica de Canarias, Spain, 2012)– *towards the understanding of the formation and evolution of low mass stars, brown dwarfs and planets in star forming regions*
- Dr. George Privon (Ph.D. University of Virginia, USA, 2014)– *understanding galaxy evolution using dynamical models of luminous infrared galaxy mergers and dual agn hosts*
- Dr. Roberto Puddu (Ph.D. Università di Siena, Italy, 2016)– *instrumentacion chilena para sondeos astronomicos*
- Dr. Makus Rabus (Ph.D. Universidad de la Laguna e Instituto de Astrofísica de Canarias, Spain, 2009)– *Exoplanets*
- Dr. Claudio Ricci (Ph.D. Université de Genève, Italy, 2011)– *extragalactic Astronomy*
- Dr. Álvaro Rojas (Ph.D. Université de Nice, France, 2016)– *Galactic Structure*
- Dr. Cristina Romero (Ph.D. Universidad de Granada, Spain, 2011)– *an extinction-free view of star forming galaxies and their constituents through radio and mm/sub-mm observations.*
- Dr. Luca Sbordone (Ph.D. Università di Roma 2 "Tor Vergata", Italy, 2005)– *stellar populations, Galactic structure*
- Dr. Joshua Schroeder (Ph.D. University of Columbia, USA, 2014)– *solving the mysteries of binary millisecond pulsars*
- Dr. Steve Schulze (Ph.D. University of Iceland, Iceland, 2012)– *probing the nature of gamma-ray bursts with high-luminosity supernovae in sub-luminous dwarf galaxies*
- Dr. Nicolás Tejos (Ph.D. Universidad de Durham, UK, 2014)– *Active galactic Nuclei, QSOs*
- Dr. Paulina Troncoso (Ph.D. La Sapienza di Roma, Italy, 2013)– *on the evolution of the galaxy population in clusters over seventy percent of the universe's lifetime*
- Dr. Aldo Valcarce (Ph.D. Pontificia Universidad Católica de Chile, Chile, 2011)– *modelamiento computacional de estrellas y aplicaciones para el estudio de las observaciones astronómicas*
- Dr. Edith Millarca Valenzuela (Ph.D. Universidad de Chile, Chile)– *study of the flux of extraterrestrial matter to earth with (micro) meteorites from new strewnfield areas at Atacama desert, chile*

- Dr. Jincheng Yu (Ph.D. Shanghai Astronomical Observatory, China, 2007)– *dynamical properties of star cluster*
- Dr. Hongxin Zhang (Ph.D. University of Chinese Academy Science, China, 2012)– *origin of ultra-compact dwarfs*
- Dr. Zheng Zhenya (Ph.D. University of Science and Technology of China, China, 2012)– *extragalactic Astronomy, high-z universe*

Support for the postdoctoral fellows comes mostly from the FONDECYT programme, grants from the Joint ESO–Chile Committee for the Development of Astronomy in Chile, the ALMA–CONICYT and Gemini–CONICYT funds, the Millennium Scientific Initiative, and the Basal programme (see § 6).

## 2.4 Technical Staff and Assistants

- Luis Mauricio Barz *Caretaker.*
- Karina Charris *Administrative Assistant.*
- Carmen Gloria Cordovez *Administrative Assistant.*
- Lilena Montenegro *Administrative Assistant.*
- Vincent Suc (Electrical Engineer, INSA, Lyon, France) *Local engineer for HAT-South and Megacam / MMIRS. Engineer at Teaching Observatory at Santa Martina.*
- Dr. José Miguel Fernández (Ph.D. PUC, 2009) *Astronomer at PUC Observatory at Santa Martina.* He left for a position in ALMA, and replaced by Daniela Fernández.
- Daniela Fernández (B.Sc. PUC, 2014) *Resident Astronomer at PUC Observatory at Santa Martina.*
- Giselle Ulloa *Administrative Assistant.*
- Juan Véliz *System Manager. Software Specialist.*
- Mariela Villanueva *IT Assistant.*
- Francisco Peralta *IT Assistant.*

## 2.5 Recognitions, Awards and Sabbaticals

F. Bauer started a sabbatical period from August 2016 until July 2017. During this period, he visited several universities in the US and Europe.

N. Padilla and M. Zoccali were promoted to Full Professor. M. Zoccali was also appointed as Director of the Millennium Institute for Astrophysics (MAS).

A. Reisenegger was named Alternate Director of the FONDECYT Study Group of Astronomy, Cosmology, and Particle Physics.

H. Quintana received the 2016 SOCHIAS (Sociedad Chilena de Astronomia), Development Prize for his lifetime activities in support of the development of Chilean astronomy at various levels. It is the first time this prize is granted to a Chilean national.

The Max Planck Society (MPG) has appointed J. Cuadra as Head of a Partner Group of the Max Planck Institute for Extraterrestrial Physics (MPE) at PUC. The partner group programme aims to support Max Planck alumni of proven scientific excellence to carry out promising and innovative research in collaboration with a Max Planck institute. Cuadras group at PUC will receive 20,000 per year to fund their research activities on Galactic Centre Astrophysics.

The Pontificia Universidad Católica de Chile and Santander Universidades awarded the Top China UC Santander 2017 to L. Infante. He will spend research time at the University of Science and Technology of China in Hefei and at the Shanghai Astrophysical Observatory in Shanghai in 2017.

## 3 Academic Programmes and Teaching

The IA offers graduate and undergraduate programmes in Astrophysics, as detailed below. Our faculty members are in charge of all Astrophysics courses, both for our programmes and for students from other majors, plus some courses on Physics.

During 2016, we taught 30 semester-long courses, which can be categorised as follows:

- Astrophysics undergrad core courses (9)
- Astrophysics graduate core courses (7)
- Astrophysics elective courses (10)
- sections of Astronomy/Physics courses for non-majors (11)

### 3.1 Graduate Programme

The IA offers Ph.D. and Master programmes in Astrophysics. They include core courses on Physical Processes in Astrophysics, Advanced Stellar Astrophysics, and Advanced Extragalactic Astrophysics. The programmes are completed with elective courses, supervised research, and a thesis. Students typically start research projects during their first year.

#### 3.1.1 Degrees obtained

- Dr. Rafael Brahm obtained his PhD degree, defending his thesis entitled “*Detection and Characterization of Transiting Extrasolar Planets: Expanding the Parameter Space*”, supervised by A. Jordán. He then took on a postdoctoral position at the MAS, PUC.

- Dr. Cristina Garcia obtained her PhD Degree, defending her thesis entitled “*Quasar environment at  $z \sim 4$* ”, supervised by F. Barrientos and Joseph Hennawi (University of Heidelberg). She then took a postdoctoral position at the Universidad de Valparaiso, Chile.
- Dr. Matthew Taylor obtained his PhD Degree, defending his thesis entitled “*The Globular Cluster System of the Nearby Giant Elliptical Galaxy NGC 5128*”, supervised by T. Puzia.
- Marilyn Cruces obtained her Master’s degree, defending her thesis entitled “*On the low magnetic fields of millisecond pulsars: magnetic field decay before accretion*”, supervised by A. Reisenegger and Thomas Tauris (U. of Bonn).
- Josefina Michea obtained her Master’s Degree, defending her thesis entitled “*The Evolution of the Galaxy Cluster Red-Sequence at Intermediate Redshift*”, supervised by F. Barrientos. Moved to University of Heidelberg for her PhD work.
- Johanna Coronado obtained her Master’s degree, defending her thesis entitled “*Assembling the most distant sample of halo wide binaries from SDSS*”, supervised by J. Chanamé.
- Carol Rojas obtained her Master’s Degree, defending her thesis entitled “*Litio en estrellas de campo y su relación con rotación*”, supervised by J. Chanamé.
- Dr. Mirko Simunovic obtained his PhD Degree, defending his thesis entitled “*Blue Straggler Star Populations in Galactic Globular Clusters*”, supervised by T. Puzia and Eva Grebel (University of Heidelberg). he then accepted a postdoctoral position at the Institute of Astronomy in Honolulu, Hawaii.

### 3.1.2 Lists of students

As of late 2016, 4 students were admitted in our PhD programme: Rodrigo Carvajal, Eudald Font, Felipe Gran, and Marco San Martin.

As of late 2016, 7 students were admitted in our MSc programme: Byron Cornejo, José Fuentes, Jonathan Quirola, Karen Ribbeck, Eva Riveros, Joaquín Armijo, and Lorena Gutierrez.

## 3.2 Undergraduate Programme

The programme currently has 156 students, who are consistently drawn from the top 2% of the  $\sim 300,000$  high school seniors who take the nationally administered entrance examination (PSU) each year.

A group of 30 new students registered in the programme through the regular admission process to start

in March 2017. The last admitted student scored 715.2 points at the PSU. Additionally, twelve students registered through various special programs.

Undergraduate students work full time during the last semester of the program on a research project under the supervision of a faculty member.

During 2016 13 students obtained a Bachelor degree during. The students, their research subjects and supervisors were the following:

- Tomás Ahumada *Finding quasars in ATLAS fields* – (L. F. Barrientos)
- María Guadalupe Lizana *Cúmulos de galaxias a través del cúmulo Fornax* – (G. Galaz, Paulina Troncoso)
- María Gabriela Navarro *The RR Lyrae variable population close to the Galactic Center* – (M. Zoccali)
- Juan Antonio Paredes *Compatibilidad del modelo WIMP de materia oscura con la emisión de rayos gamma del Centro Galáctico* – (B. Koch, Physics Institute)
- Tomás Hidd *Impacto de la experimentación en física sobre el aprendizaje y motivación de los estudiantes* – (A. Clocchiatti)
- Marco San Martín *Cosmology in Delta gravity* – (J. Alfaro, Physics Institute)
- Joaquín Armijo *Properties of cosmic voids in modified gravity models* – (N. Padilla)
- Cristóbal Reyes *Analysis of Hubble Space Telescope observations of old neutron stars* – (S. Guillot & A. Reisenegger)
- Germán Cheuque *LSB galaxies in a hydrodynamical simulation* – (N. Padilla, G. Galaz)
- Cristián Vargas *Detectando el efecto Sunyaev-Zel’dovich térmico en cúmulos y grupos de galaxias asociados a galaxias más brillantes en cúmulos usando mapas del Telescopio Cosmológico de Atacama* – (R. Dünner)
- Cristóbal Laporte *Optimal scale setting in QED* – (B. Koch)
- Julio Olivares *Distribución de metalicidad en estrellas del bulbo interno* – (M. Zoccali)
- Manuel Barrientos *Binarias Anchas con Componentes Evolucionadas como Calibradoras de la Initial-to-Final Mass Relation de Enanas Blancas* – (J. Chanamé)

## 4 Interdisciplinary Center: The UC Center for AstroEngineering, AIUC

### 4.1 Overview

Since its creation in 2009 as a joint venture between the IA and the faculty of Engineering, the AIUC Center, strategically located in the 6 th floor of the Innovation Center at the Universidad Católica, led by L. Infante, has assembled a unique combination of staff, facilities and alliances to provide state-of-the-art research in astronomy and engineering applied to astronomy, building collaborations between academia, industry and government, and engaging with students to stimulate applied science education and innovation.

### 4.2 Achievements during 2016

During 2016, the AIUC has experienced an important progress developing the areas of Astronomical Instrumentation, CMB Experiments, UVAS Survey, UC Observatory, the consolidation of the High Performance Computing Cluster and the Astronomical Service area. Additionally, a new area was incorporated to the activities of the center, the area of Astronautic. The attraction and development of Human Capital has been another area of important impact during this period. The astronomical instrumentation group, led by L. Vanzi, focused on optical and near-infrared spectroscopy, achieved during 2016 some important milestones: Chile has got now its first astronomical spectrograph (FIDEOS) entirely designed, build, and operating in Chile. FIDEOS is an high-resolution, temperature stabilized, optical spectrograph dedicated to the search for extra solar planets, currently installed at the La Silla Observatory. Following the line of exoplanet search to the next level the near-infrared spectrograph TARDYS was designed and key-components were developed. The second large area of near-infrared spectroscopy here at the AIUC is the development of a precise determination of fibres for the MOONS spectrograph. The Multi-Object Optical and Near-infrared Spectrograph (MOONS) is a new fibre-fed spectrograph for the VLT. MOONS will exploit the full 500 square arcmin field of view offered by the Nasmyth focus of VLT and will be equipped with two dual-arm spectrographs covering the wavelength range  $0.645 \mu m - 1.8 \mu m$ . AIUC is part of HIRES (High Resolution Echelle Spectrometer) to be install in the E-ELT. The AIUC team will be working in the software developing and calibration. HIRES is in a very early stage. During 2016 AIUC started the execution of the 3-year project Anillo ACT-1417 (“Chilean Instrumentation for Astronomical Surveys”, PI: R. Dünner), funded by CONICYT for a total of 450 million pesos. The project groups scientists and engineers from different disciplines around three main top-

ics: millimeter-wave surveys to measure the Cosmic Microwave Background (CMB), multi-object infrared spectroscopy of the MOONS instrument, and large extragalactic surveys like ATLAS U-band. Some radio instrumentation group highlights are: 1.- to hire a highly qualified team of scientists and technicians that will make this ambitious project possible. 2.- The Institute of Astrophysics became official members of the Simons Observatory project. 3.- We were able to store and help reduce the full ACT dataset. This was done using our own computer cluster and RAID storage. The data were selected and calibrated for later mapping in servers abroad. 4.- We finished the design and construction of a robotic arm for measuring and characterizing the antenna response of mm-wave sources. This is part of a larger project to build an anechoic chamber, equipped with a cryogenic detector to help develop testing equipment for mm-wave telescopes installed in Chile. 5.- We developed computer simulations to precisely understand the diffractive and polarizing effects observed in mm-wave telescopes. This was done using the GRASP simulation software, in conjunction to photogrammetrical measurements of the actual geometry of the telescopes. 6.- We correctly measured and aligned the optics of the CMB telescopes (ACT, Polarbear and CLASS) using photogrammetrical techniques. 7.- We began the development of new interdisciplinary academic project to teach very long baseline interferometry and perform interesting measurements of Jupiters cyclotron radiation. The current project is to install 2 antennas, one on Campus San Joaquín and the other in the Academic Observatory UC, 13 km away, and measure the strong cyclotron bursts produced by the variable magnetic field in Jupiter. The High Performance Computing Cluster and Simulation area, led by N. Padilla, offers to the astronomical community and the society a powerful tool for numerical computation and data analysis: During 2016, using funds from the Newton- CONICYT grant we were able to acquire three new nodes for the Geryon2 cluster housed by the AIUC. These new nodes provide a total of 162 new CPUs to the cluster, with additional memory of 1.5Tb in ram, for large runs. In total, 1400 cores of CPU and more than 500Tb of storage provides the computing capability needed to handle large amounts of data collected by telescopes in Chile and to provide service of data analysis and data modeling to companies, students, universities and society. This increase in RAM memory, open the possibility for the largest shared memory runs in the cluster thus far. We also upgraded the suite of compilers to Intel, which allows a wider range of codes to be run (funds from BASAL). Regarding opening our resources to the non-academic world, we made contact with INRIA Chile, who were given access to the Geryon2 cluster to test their parallel computing capabilities. The AIUC was

the host of the Workshop “Mock Santiago: preparing for the next generation surveys”, which had an attendance of 65, including  $\sim 40$  visitors from abroad. The AIUC has spent resources on the UVAS Survey. This survey Project (PI: L. Infante) aims to cover  $4700\text{deg}^2$  of the sky in the u-band using the VST/OmegaCAM. During 2016, much progress was achieved on the data reduction and data injection into the Chilean data-hub. The survey is available to the Chilean community through a well-developed local (AIUC) data interphase. The Center has developed a new area: Astronautics, led by professor Cristian Chavez, of the Faculty of Engineering. They develop applied projects based on the design and manufacturing of satellite prototypes focused on educational goals, and potential use in other areas or industries. Service Area at AIUC has been growing during the last year, providing astronomical and engineering support to international observatories located in Chile and facilitates specialized human resources. During 2016, AIUC has been a driven force for human capital development. Through doctoral training, graduates/postgraduate students and engineers attain the intellectual and technical skills necessary for the advanced, hi-tech work and development, complex data analytics and reflective thinking. The different areas of development in the AIUC center provide both, conceptual and practical skills advancement in research and development that is easily transferred to other applied fields in Chile and abroad. AIUC has, therefore, helped attract a number of students into science, engineering and technology disciplines. During 2016, 4 new Postdoc were incorporated to the AIUC. Approximately 6 undergraduates student made their training period here at the AIUC during summer time. Additionally, two new professors were incorporated as part of the AIUC Centre; Clementine Bechet and Cristian Chavez, both professors from the School of Engineering PUC. During 2016, 15 professors, 15 postdoc, 4 engineers and 8 professionals for administration are part of the AIUC Team. During 2016, the AIUC center raised funds for more than CHMM 1.000.- from Public funds. Ten new projects were awarded funding during this year.

### 4.3 Other benchmarks

- The beginning of a 3-year project Anillo ACT-1417 (Chilean Instrumentation for Astronomical Surveys), funded by CONICYT for a total of 450 million pesos. The project groups scientists and engineers from different disciplines around three main topics: millimeter-wave surveys to measure the Cosmic Microwave Background (CMB), multi-object infrared spectroscopy of the MOONS instrument, and large extragalactic surveys like ATLAS U-band. During this first year we hired a highly qualified team of scientists and technicians that will make

this ambitious project possible.

- The IA/AIUC became official member of the Simons Observatory project. This is a new international collaboration that formed around the 40 million dollar donation done by the Simons Foundation for the development of CMB science. The main goal is to try to answer the largest questions in Cosmology, like the existence of an inflationary after the Big Bang, or to measure the mass of the neutrinos. Our team is carrying out an important role in the design of the new instruments to come and of the science that we expect to achieve.
- The team led by Rolando Dünner was able to store and help reduce the full 2016 ACT dataset. This was done using our own computer cluster and RAID storage. The data were selected and calibrated for later mapping in servers abroad.
- The same team finished the design and construction of a robotic arm for measuring and characterizing the antenna response of mm-wave sources. This is part of a larger project to build an anechoic chamber, equipped with a cryogenic detector to help develop testing equipment for mm-wave telescopes installed in Chile.
- The same team developed computer simulations to precisely understand the diffractive and polarizing effects observed in mm-wave telescopes. This was done using the GRASP simulation software, in conjunction to photogrammetrical measurements of the actual geometry of the telescopes. Among other things, we were able to understand the effects of gaps in segmented mirrors, work which was presented in the SPIE meeting of Astronomical Telescopes + Instrumentation in Edinburgh.
- The measurement and alignment of the optics of the CMB telescopes (ACT, Polarbear and CLASS) using photogrammetrical techniques. This is a critical step to optimize those telescopes and achieve their scientific measurements.
- The development of new interdisciplinary academic project to teach very long baseline interferometry and perform interesting measurements of Jupiters cyclotron radiation. The current project is to install 2 antennas, one on Campus San Joaquín and the other in the Academic Observatory UC, 13 km away, and measure the strong cyclotron bursts produced by the variable magnetic field in Jupiter.
- The AIUC advised the National Museum Museo Interactivo Mirador in the permanent astronomy exhibition to be inaugurated in 2017.

## 5 Colloquia, seminars and science activities

Colloquia and seminars in the IA started early in 1990. However, since 2012, under the leading role of J. Chanamé, the Institute organizes each year an aggressive series of astronomy colloquia that, modeled after similar programs with long traditions at major astronomical institutions in the world, targets outstanding speakers selected not only for their scientific achievements but also for their ability to communicate them well to a diverse audience. Among the obvious advantages of a Colloquium series of such characteristics, this plan is part of an integral effort by our Institute to improve the quality of our Graduate program, adding even more stimulating experiences to our daily scientific atmosphere.

### 5.1 Colloquia during 2016

- 08/03 CRISTÓBAL PETROVICH (CITA, Canada), “Disrupting planetary systems in stellar binaries across the HR diagram?”
- 15/03 IVÁN RAMÍREZ (University of Texas at Austin, USA), “Searching for our Sun’s Long-lost Siblings and Reconstructing the Galaxy with Chemical Tagging”
- 22/03 ANDREAS REISENEGGER (PUC, Chile), “Gravitational Waves: a new channel of information from the Universe”
- 29/03 JAVIERA GUEDES (ETH Zurich, Switzerland), “Transitioning from Academia to Industry: Motivation and Practical Advice”
- 05/04 SOFIA FELTZING (Lund Observatory, SWEDEN), “Galactic Archeology - Current Status and Future Prospects with 4MOST and WEAVE”
- 20/04 ZHENG ZHENG (University of Utah, USA), “Lyman-alpha Emitting Galaxies: Anisotropic Emission and Anisotropic Clustering”
- 26/04 ALICE ZURLO (Universidad Diego Portales, CHILE), “New results on exoplanets with the high-contrast imaging technique”
- 03/05 CRISTÓBAL ESPINOZA (Universidad de Santiago de Chile, CHILE), “The rotational history of pulsars”
- 10/05 LAURA LOPEZ (The Ohio State University, USA), “Investigating the Symmetry, Progenitors, and Particle Acceleration of Supernova Remnants”
- 17/05 MARC PINSONNEAULT (The Ohio State University, USA), “Precision Stellar Astrophysics: Asteroseismology and Large Spectroscopic Surveys”
- 24/05 GIUSEPPE LODATO (Università degli Studi di Milano, ITALY), “Substructures in protostellar discs: gaps, spirals and warps”
- 31/05 KATIE MORZINSKI (University of Arizona, USA), “Direct Imaging of Exoplanets with MagAO and GPI: Measuring fundamental properties of extrasolar planets”
- 21/06 LEONARDO VANZI (Pontificia Universidad Católica de Chile, CHILE), “Zen and the Art of building Astronomical Instruments”
- 09/08 LORENZO MONACO (Universidad Nacional Andres Bello, CHILE), “The Lithium Content of Globular Clusters and in Giant Stars”
- 17/08 JENNIFER MARSHALL (Texas A&M University, USA), “GMACS: The First-Light Wide Field Multi-object Optical Spectrograph for the Giant Magellan Spectrograph”
- 23/08 ROBERTO ASSEF (Universidad Diego Portales, Chile), “Hot Dust Obscured Galaxies”
- 30/08 ALEXANDRE GALENNE (European Southern Observatory, CHILE), “The Need of High-Angular Resolution: Astrophysical Results from Long-Baseline Interferometry”
- 06/09 MÓNICA RUBIO (Universidad de Chile, CHILE), “The lowest metallicity molecular clouds with ALMA”
- 13/09 CLAUDIO DIB (Universidad Tecnica Federico Santa Maria, CHILE), “ANDES: An International Underground Laboratory in South America”
- 27/09 XIAOHUI FAN (University of Arizona, USA), “The Most Massive Black Holes in the Early Universe”
- 11/10 JAYANT NARLIKAR (Inter-University Center for Astronomy and Astrophysics, INDIA), “Outstanding Problems in Cosmology”
- 18/10 PAULA JOFRE (University of Cambridge, UK), “Probing the Structure and Evolution of the Milky Way in the Era of Large Spectroscopic Surveys and Gaia”
- 25/10 PATRICIA SÁNCHEZ-BLÁZQUEZ (PUC, CHILE), “The Formation of Disk Galaxies Through Galaxy Archaeology”
- 08/11 BENJAMIN SHAPPEE (Carnegie Observatories, USA), “The Progenitors of Type Ia Supernovae”

- 15/11 DOMINIK SCHLEICHER (Universidad de Concepcion, CHILE), “Magnetic Fields in Astrophysics - From Stars to Galaxies”
- 22/11 JAYMIE MATTHEWS (University of British Columbia, CANADA), “REVISING THE BIOGRAPHY OF THE SUN: From ultrasound of stellar embryos to cardiology of red giants”
- 01/12 BARRY MADORE (Carnegie Observatories, USA), “Philosophical and Astrophysical Challenges Arising from the Tension over the Hubble Constant”
- 06/12 RADEK POLESKI (The Ohio State University, USA), “Ice Giant Exoplanets”

## 5.2 Seminars and talks

In addition to the colloquium series, we are running a very active seminar program, hosting typically one talk per week from collaborators visiting the IA, and from astronomers stopping by before or after their observing runs at one of the observatories based in Chile.

Additionally, every day after lunch, graduate students, postdocs, and faculty meet for an informal, 30-minute discussion of the latest developments in astronomy. Usually 2–3 topics are debated each day, and these are typically based on papers posted during the last few days on the arXiv Preprint Server (astro-ph) and on astronomy news appearing in the public press. These daily meetings are also used to introduce our many visitors and colleagues upon their arrival to the IA.

## 5.3 Invitations to Conferences, SOCs and other Science Highlights

Marcio Catelan organized, along with W. Gieren of Universidad de Concepcion, the International Conference Wide-Field Variability Surveys: A 21st- Century Perspective, held in San Pedro de Atacama between 27 November and 2 December 2016.

Franz Bauer was invited to several colloquia outside Chile, among them: Colloquium, ALMA observations of the Frontier Fields, Observatoire de Lyon, Lyon, France, 10/2016; Colloquium, ALMA observations of the Frontier Fields, Bologna Observatory, Bologna, Italy, 10/2016; Colloquium, ALMA observations of the Frontier Fields, University College London, London, UK, 10/201; Colloquium, A New, Faint Population of X-ray Transients, MPE, Garching, GE, 11/2016; Colloquium, Probing the Torus Structure of Nearby AGN, MPE, Garching, GE, 11/2016;

Colloquium, ALMA observations of the Frontier Fields, Geneva Observatory, Geneva, Switzerland, 12/2016. Franz Bauer also began to serve on Board of Reviewing Editors, Science Magazine, 04/2016-present.

Prof. Manuela Zoccali was invited to present review talk at the European Week of Astronomy and Space Science, Atenas, The Galactic bulge, an observational perspective, July 2016.

Prof. Andreas Reisenegger organized the 3rd scientific workshop of the CTA-Chile team, held on 13 October 2016, and co-organized the Second Chilean Workshop of Theoretical and Numerical Astrophysics, on 14–15 November, both on our campus. He was also Member of the Scientific Organizing Committee of the Latin American Regional IAU Meeting (LARIM), Cartagena de Indias, Colombia.

Prof Patricia Sánchez-Blázquez was part of the scientific organizing committee of two international conferences; (1) ”IAU321 The Outskirts of galaxies” (03, 2016), Toledo, Spain (also member of the local organizing committee), and (2) ”Escape of Lyman radiation from galactic labyrinths” (04/2016), Crete, Greece. She was an invited speaker at the XII Annual meeting of the SOCHIAS (03/2016).

## 6 Grants

### 6.1 Institute Grants

*The BASAL Centre for Astrophysics and Associated Technologies (CATA)* is a large institutional grant from CONICYT, Chile, awarded to the IA, the Astronomy Department of Universidad de Chile, and the Astrophysics Department of Universidad de Concepción. This Centre supports research in astrophysics, national and international academic exchange, and collaborations with the Observatories in Chile, providing funds for research, graduate student fellowships, organisation of workshops and conferences, and travel. The focus of the UC node is currently incrementing its efforts in astronomical instrumentation and large databases and computing for future observing facilities, in association with the IA and the Center for Astro-Engineering.

### 6.2 Group Grants

#### 6.2.1 Instituto Milenio

*The Millennium Institute of Astrophysics (MAS)* is funded by the Millennium Scientific Initiative. It is dedicated to the study of stellar populations, supernovae and the observation of the central regions of the Milky Way. It is lead by Mario Hamuy (U de Chile), who was awarded the prestigious Premio Nacional de Ciencias 2015. At present the MAS is lead by M. Zoccali. However, two thirds of its core researchers belong to the Institute of Astrophysics. One of the main characteristics of MAS is the multidisciplinary approach, because the team is composed not only by astronomers but also by statisticians, who would help to handle and exploit large observational databases becoming available. The

members of MAS at Universidad Católica are Susana Eyheramendy, Márcio Catelan, Alejandro Clocchiatti, Franz Bauer, Andrés Jordán, Manuela Zoccali, Felipe Barrientos, and Julio Chanamé.

### 6.2.2 Núcleo Milenio

*The Millennium Nucleus on Proto-planetary Discs (MAD, for Millennium ALMA Discs)* is a center for research on planet formation funded by the Millennium Scientific Initiative. It is a joint collaboration hosted by Universidad de Chile (S. Casassus, PI), Universidad Diego Portales (L. Cieza, deputy PI), PUC (J. Cuadra) and Universidad de Valparaíso (M. Schreiber). The project aims to understand the dynamics and evolution of proto-planetary discs and the process of planet formation using the newly available observational facilities, such as ALMA, Sphere and GPI, together with numerical models.

### 6.2.3 Anillos

*Establishing the Role of Mergers in Black Hole Growth and Galaxy Evolution* is a grant from CONICYT awarded to a team of astronomers from U de Concepción (E. Treiester [PI], N. Nagar, R. Demarco), PUC (F. Bauer, J. Cuadra), U de Chile (A. Escala), and U de Valparaíso (P. Arévalo). The goal of the project is to understand the role of super-massive black hole growth in galaxy evolution, by characterising this growth observationally and interpreting it through comparisons with simulations. Using the new facilities and instruments such as ALMA, NuSTAR, and optical/NIR IFUs, as well as start-of-the-art simulations, the project seeks to refine our knowledge about how and when this growth occurs, and what the observable effects on galaxy evolution are. This Anillo terminated in August 2016.

## 7 Exchange Agreements and International Networks

### 7.1 Bilateral agreements

The IA has agreements with several institutions with the goal of strengthening its research activity and its graduate program. These agreements allow exchange visits of researchers and students. In some cases, the thesis is recognised by both institutions, resulting in a double PhD degree. Currently, we have agreements with the Universities of Heidelberg (see § 7.3), Johns Hopkins, Maryland, Padova, and Princeton.

### 7.2 UMI-FCA

The French–Chilean Joint International Astronomy Unit (UMI-FCA) was established by agreement between the CNRS and PUC, U. de Chile and U. de Concepción. This “Joint International Unit” facilitates collaborations

between astronomers of the participating institutions, and allows them to use the facilities of their counterpart.

### 7.3 Heidelberg University–PUC Agreement

The Heidelberg University–PUC exchange program was established in 2010 and the agreement for astronomy, funded by the German DAAD, was extended for a period of another 2+3 years in 2015. The activities of the program consist of a joint doctoral program, a strong academic exchange plan, the organization of summer schools, and a strong outreach program focused on school teacher workshops that is becoming a highly sought-after program in Chile, attracting every year more than 40 teachers. A delegation from IA-PUC faculty visited the Astronomisches-Recheninstitut (ARI), Landessternwarte (LSW), and the Institute for Theoretical Astrophysics (ITA) of Heidelberg University, fostering existing collaborations and discussing new programs as well as stimulating future student and faculty exchanges. One new graduate student from the University of Heidelberg (Sebastian Stammer) was accepted to the exchange program and visited the IA in early 2016, working in the group of Prof. J. Cuadra.

## 8 Office, Computing and Teaching facilities

The IA occupies 1,887 m<sup>2</sup> in a building at the San Joaquín Campus of PUC, to the south of downtown Santiago. This includes offices for faculty, postdocs, graduate students and administrative and technical staff, a special room for our super-computers, and multimedia conference rooms. The same building also hosts the “Ninoslav Bralić” auditorium, shared with Physics and Mathematics, which seats 100 people. Since October 2015, some of the IA members who are also affiliated to the Centre for Astro-Engineering (§ 4) are housed in the newly-built UC Innovation Center, also in the San Joaquín Campus.

Next to the IA building, the “Gauss” Physics and Math library has a collection of ~30,000 books and journal volumes. Staff members, students and visitors also have access to the University library system with more than 300,000 books and hundreds of periodical publications, including around 60 titles in different branches of physics. The University supports, in addition, on-line access to all major astrophysics journals. Finally, the IA hosts since 1998 the first Latin-American mirror of NASA’s Astrophysical Data System (ADS).

The IA has a computer network maintained by a full-time software engineer and two assistants. It includes a cluster, managed by the AIUC, consisting of 64 nodes with a total of 128 Intel Xeon Quad-Core CPUs (512 cores), 1024 GB of RAM, 40 TB of disk space (iSCSI), and a Linux system for 64-bit architecture running over a 10 Gbps ethernet network (a 10 fold increase with re-

spect to the previous year). Development and execution tools include Intel Fortran and Intel C compilers (ifort, icc), mpich2, Distributed Resource Management (DRM) software SGE (Sun Grid Engine), and other standard tools (gcc, g++, gfortran, etc). In early 2013, this cluster was complemented by a brand-new 520-core CPU cluster, with 18 Tflops, and 3 TB of memory. In 2015 we installed the 64-core CPUs with 1TB of ram memory corresponding to the participation of the IA in the National Lab for High Performance Computing (NLHPC). To the original 30 TB of disk space we have added 150TB of normal access disks and 45 TB of fast I/O disks, using funds provided by QUIMAL 130008 (PI N. Padilla). We also house a GPU cluster with 1792 NVidia Tesla Cores, with 96 GB of memory. Users at IA have access to the cluster via personal accounts and get access to the cluster resources by the DRM system that defines use and priority of each user to the total resources. Post-doctoral fellow Roberto González dedicates a fraction of their time to help manage the use of the computing cluster.

### 8.1 UC Observatory at Santa Martina

The IA maintains a small Observatory (OUC) in the eastern outskirts of Santiago at an altitude of 1450 m, some 60-minute drive from Campus, mostly dedicated to teaching and astronomy laboratories for our undergraduate students. Permanently installed in a joint dome are a 50 cm telescope (the old ESO 50 cm), and a 40 cm telescope (one of the two old CTIO 16-inch telescopes) and, in a separate dome, a commercial Meade 40 cm used with a CCD camera for basic teaching. The two professional telescopes have locally-upgraded control systems and new instrumentation, including CCD and IR cameras, spectrographs and a built in-house fiber spectrograph at the 50 cm. All three are controlled from a common control room when needed. The two professional telescopes are partly used for testing and developing instrumentation and for some advanced student research programs. A Meade 30 cm is available for visual observations by students and visitors. Besides, the site hosts the dome of one of the SLOOH world network telescopes, remotely controlled via the Web. In addition to the optical telescopes, two radio telescopes were installed in the Observatory to teach radioastronomy. They are 2.5 and 3 meters in diameter and are equipped to observe at 21 cm wavelength in both single dish and interferometric configurations. A small planetarium is also available to teach students the celestial coordinate systems. Current activities take place three to four times weekly (weather permitting) and include teaching, scientific and outreach experiences.

### 8.2 Manuel Foster Historical Observatory

The IA also maintains this historical observatory in the Metropolitan Park on San Cristóbal hill near downtown Santiago. It was established in 1903 by an expedition from the Lick Observatory of the University of California, and purchased and donated to PUC in 1929 by the lawyer, politician, and PUC professor Manuel Foster, in this way starting astronomical activities at the University. It was used on and off until the early 1990s, but is now no longer useful for research because of the strong light pollution. In 2010, it was declared a National Historic Monument. It is being opened to the public on selected days.

### 9 Meetings supported

- The week of 18 April, the conference "Mock Santiago" was organized at the Centro de Innovación.

### 10 Outreach

The members of the IA participated in several outreach activities during 2016:

- The IA, through the journalist Lorena Guzmán, organizes the ongoing series of weekly articles on astronomy for the general public "Tendencias de la Astronomía", in the online version of the national newspaper "El Mercurio". All these articles are written by professors of the Institute.
- Manuela Zoccali was interviewed at radio Universidad de Chile, October 2016. She was also invited to a round table on Women and Science, November 2016. and gave a public talk at Antofagasta "Exploring the Heart of the Milky Way".
- The Director Gaspar Galaz was invited in several opportunities to the radio and Television to talk about astronomical discoveries, and invited to give talks to Puerto Varas, Melipilla, San Fernando, Rancagua, Curicó, Valparaiso, and the Planetario in Santiago.
- Andreas Reisenegger gave 13 outreach talks in different cities of Chile and to very different audiences (from school children to professional scientists), as well as various TV, radio, and newspaper interviews, about the first detection of gravitational waves, announced by the LIGO collaboration on 11 February 2016. He also gave a Fermi-LAT Masterclass for high-school students and their teachers, held on our campus on November 12 and 19.
- Several members of the IA held outreach talks in schools around the country in the framework of the "Day of Astronomy" (21 March 2016), organised by the Planetarium of Santiago and "1000 científicos,

1000 aulas” (October 2016), organised by Explora-CONICYT.

- Professors of the IA and the Institute of Physics gave talks to physics high-school teachers at special days devoted to them at the Faculty of Physics.
- Several IA professors gave talks at teacher workshops, which were organized in the framework of the Heidelberg–PUC exchange program at the Heidelberg Center in Santiago (see § 7.3).

## 11 Refereed Publications

Members of the IA, including students and postdocs, participated in 228 refereed papers published in 2016. The full list is given below.

1. Abbott B. P., et al. (1574 authors, including **Gómez-Vargas, G. A., Padilla N., Schulze S.**): *Localization and Broadband Follow-up of the Gravitational-wave Transient GW150914*. ApJ 826, L13  
<http://adsabs.harvard.edu/abs/2016ApJ...826L...13A>
2. Abbott B. P., et al. (1574 authors, including **Gómez-Vargas, G. A., Padilla N., Schulze S.**): *Supplement: “Localization and Broadband Follow-up of the Gravitational-wave Transient GW150914” (2016, ApJL, 826, L13)*. ApJS 225, 8  
<http://adsabs.harvard.edu/abs/2016ApJS...225...8A>
3. Acero F., et al. (161 authors, including **Gómez-Vargas, G. A.**): *The First Fermi LAT Supernova Remnant Catalog*. ApJS 224, 8  
<http://adsabs.harvard.edu/abs/2016ApJS...224...8A>
4. Ackermann M., et al. (161 authors, including **Gómez-Vargas, G. A.**): *Fermi-LAT Observations of the LIGO Event GW150914*. ApJ 823, L2  
<http://adsabs.harvard.edu/abs/2016ApJ...823L...2A>
5. **Aguilera-Gómez C., Chanamé J.**, Pinsonneault M. H., Carlberg J. K.: *On Lithium-rich Red Giants: Engulfment on the Giant Branch of Trumpler 20*. ApJ 833, L24  
<http://adsabs.harvard.edu/abs/2016ApJ...833L...24A>
6. **Aguilera-Gómez C., Chanamé J.**, Pinsonneault M. H., Carlberg J. K.: *On Lithium-rich Red Giants. I. Engulfment of Substellar Companions*. ApJ 829, 127  
<http://adsabs.harvard.edu/abs/2016ApJ...829...127A>
7. Ahumada A. V., Vega L. R., Clariá J. J., Oddone M. A., **Palma T.**: *Determination of Reddening and Age for Ten Large Magellanic Cloud Star Clusters from Integrated Spectroscopy*. PASP 128, 094101  
<http://adsabs.harvard.edu/abs/2016PASP...128i4101A>
8. Ajello M., et al. (123 authors, including **Gómez-Vargas, G. A.**): *Fermi-LAT Observations of High-Energy Gamma-Ray Emission toward the Galactic Center*. ApJ 819, 44  
<http://adsabs.harvard.edu/abs/2016ApJ...819...44A>
9. Amaro-Seoane P., Casanellas J., Schödel R., Davidson E., **Cuadra J.**: *Probing dark matter crests with white dwarfs and IMBHs*. MNRAS 459, 695  
<http://adsabs.harvard.edu/abs/2016MNRAS.459...695A>
10. Amaro-Seoane P., **Chen X.**: *Relativistic mergers of black hole binaries have large, similar masses, low spins and are circular*. MNRAS 458, 3075  
<http://adsabs.harvard.edu/abs/2016MNRAS.458.3075A>
11. Aravena M., et al. (32 authors, including **Bauer F. E., González-López J., Infante L.**): *The ALMA Spectroscopic Survey in the Hubble Ultra Deep Field: Search for [CII] Line and Dust Emission in 6*. ApJ 833, 71  
<http://adsabs.harvard.edu/abs/2016ApJ...833...71A>
12. Aravena M., et al. (34 authors, including **Bauer F. E., González-López J., Infante L.**): *The ALMA Spectroscopic Survey in the Hubble Ultra Deep Field: Continuum Number Counts, Resolved 1.2 mm Extragalactic Background, and Properties of the Faintest Dusty Star-forming Galaxies*. ApJ 833, 68  
<http://adsabs.harvard.edu/abs/2016ApJ...833...68A>
13. Aravena M., et al. (21 authors, including **González-López J.**): *A survey of the cold molecular gas in gravitationally lensed star-forming galaxies at  $z > 2$* . MNRAS 457, 4406  
<http://adsabs.harvard.edu/abs/2016MNRAS.457.4406A>
14. Archibald R. F., Gotthelf E. V., Ferdman R. D., Kaspi V. M., **Guillot S.**, Harrison F. A., Keane E. F., Pivovarov M. J., Stern D., Tendulkar S. P., Tomsick J. A.: *A High Braking Index for a Pulsar*. ApJ 819, L16  
<http://adsabs.harvard.edu/abs/2016ApJ...819L...16A>
15. Assef R. J., Walton D. J., Brightman M., Stern D., Alexander D., **Bauer F.**, Blain A. W., Diaz-Santos T., Eisenhardt P. R. M., Finkelstein S. L., Hickox R. C., Tsai C.-W., Wu J. W.: *Hot Dust Obscured Galaxies with Excess Blue Light: Dual AGN or Single AGN Under Extreme Conditions?*. ApJ 819, 111  
<http://adsabs.harvard.edu/abs/2016ApJ...819...111A>
16. Awan H., Gawiser E., Kurczynski P., Jones R. L., Zhan H., **Padilla N. D., Muñoz Arancibia A. M.**, Orsi A., Cora S. A., Yoachim P.: *Testing LSST Dither Strategies for Survey Uniformity*

- and Large-scale Structure Systematics. ApJ 829, 50  
<http://adsabs.harvard.edu/abs/2016ApJ...829...50A>
17. Barbuy B., Cantelli E., Vemado A., ErnanDES H., Ortolani S., Saviane I., Bica E., Minniti D., Dias B., Momany Y., Hill V., **Zoccali M.**, Siqueira-Mello C.: *High-resolution abundance analysis of red giants in the metal-poor bulge globular cluster HP 1*. A&A 591, A53  
<http://adsabs.harvard.edu/abs/2016A%26A...591A..53B>
  18. Barrera-Ballesteros J. K., Heckman T. M., Zhu G. B., Zakamska N. L., Sánchez S. F., Law D., Wake D., Green J. E., Bizyaev D., Oravetz D., Simmons A., Malanushenko E., Pan K., Roman Lopes A., **Lane R. R.**: *Do galaxy global relationships emerge from local ones? The SDSS IV MaNGA surface mass density-metallicity relation*. MNRAS 463, 2513  
<http://adsabs.harvard.edu/abs/2016MNRAS.463.2513B>
  19. Battaglia N., et al. (42 authors, including **Dünner R.**): *Weak-lensing mass calibration of the Atacama Cosmology Telescope equatorial Sunyaev-Zeldovich cluster sample with the Canada-France-Hawaii telescope stripe 82 survey*. JCAP 8, 013  
<http://adsabs.harvard.edu/abs/2016JCAP...08..013B>
  20. Bayliss M. B., et al. (78 authors, including **Clocchiatti A.**): *SPT-GMOS: A Gemini/GMOS-South Spectroscopic Survey of Galaxy Clusters in the SPT-SZ Survey*. ApJS 227, 3  
<http://adsabs.harvard.edu/abs/2016ApJS...227...3B>
  21. Benedetti-Rossi G., et al. (29 authors, including **Leiva R.**): *Results from the 2014 November 15th Multi-chord Stellar Occultation by the TNO (229762) 2007 UK<sub>126</sub>*. AJ 152, 156  
<http://adsabs.harvard.edu/abs/2016AJ....152..156B>
  22. Bielby R. M., Tummuangpak P., Shanks T., Francke H., Crighton N. H. M., **Bañados E.**, **González-López J.**, **Infante L.**, Orsi A.: *The VLT LBG redshift survey - V. Characterizing the z 3.1 Lyman  $\alpha$  emitter population*. MNRAS 456, 4061  
<http://adsabs.harvard.edu/abs/2016MNRAS.456.4061B>
  23. **Bluhm P.**, Jones M. I., Vanzi L., Soto M. G., Vos J., Wittenmyer R. A., Drass H., Jenkins J. S., Olivares F., Mennickent R. E., Vučković M., Rojo P., Melo C. H. F.: *New spectroscopic binary companions of giant stars and updated metallicity distribution for binary systems*. A&A 593, A133  
<http://adsabs.harvard.edu/abs/2016A%26A...593A.133B>
  24. Boissay R., **Ricci C.**, Paltani S.: *A hard X-ray view of the soft excess in AGN*. A&A 588, A70  
<http://adsabs.harvard.edu/abs/2016A%26A...588A..70B>
  25. Boldt L., **Mitchell J.**, Braithwaite J.: *A hydrostatic MHD code for modeling stellar interiors*. A&A 585, A127  
<http://adsabs.harvard.edu/abs/2016A%26A...585A.127B>
  26. Boorman P. G., et al. (22 authors, including **Bauer F. E.**, **Ricci C.**): *IC 3639 – a New Bona Fide Compton-Thick AGN Unveiled by NuSTAR*. ApJ 833, 245  
<http://adsabs.harvard.edu/abs/2016ApJ...833..245B>
  27. **Booth M.**, **Jordán A.**, Casassus S., Hales A. S., Dent W. R. F., **Faramaz V.**, Matrà L., Barkats D., **Brahm R.**, **Cuadra J.**: *Resolving the planetesimal belt of HR 8799 with ALMA*. MNRAS 460, L10  
<http://adsabs.harvard.edu/abs/2016MNRAS.460L..10B>
  28. Borissova J., Ramírez Alegría S., **Alonso J.**, Lucas P. W., Kurtev R., Medina N., Navarro C., Kuhn M., Gromadzki M., Retamales G., Fernandez M. A., Agurto-Gangas C., Chené A.-N., Minniti D., Contreras Pena C., **Catelan M.**, **Decany I.**, Thompson M. A., Morales E. F. E., Amigo P.: *Young Stellar Clusters Containing Massive Young Stellar Objects in the VVV Survey*. AJ 152, 74  
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