

**Annual Report 2017**  
**Instituto de Astrofísica**  
**Facultad de Física**  
**Pontificia Universidad Católica de Chile**

*Av. Vicuña Mackenna 4860, 782-0436 Macul, Santiago, Chile*  
*<http://www.astro.uc.cl>*

## Abstract

The Institute of Astrophysics (IA) at the *Pontificia Universidad Católica de Chile* (PUC) has 15 active faculty members, one emeritus professor, 46 post-doctoral researchers, and about 50 graduate students. IA members published together 246 refereed articles in peer-review journals during 2017. In the academic year 2017, 11 students received their *Licenciatura* degree, 5 obtained a M.Sc., and 6 a PhD degree.

## 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 PhD and Master's programmes in Astrophysics.

The IA is becoming an international center 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 astronomers working in Chilean institutions 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 for astrophysical simulations data mining. In this report, we review the main activities at IA from January until December 2017.

## 2 Personnel Changes in 2017

### 2.1 Faculty

- Dr. Patricia Sánchez-Blázquez left the IA in 2017 and took a new position at Universidad Autónoma de Madrid, Spain.
- In August 2017, Professor Leopoldo Infante was appointed as Director of Las Campanas Observatory, Carnegie Institution for Science.

### 2.2 Postdoc Arrivals

- Dr. Matías Montesinos, from Universidad de Nice-Sophia Antipolis, France.
- Dr. Yu Rong, from University of Chinese Academy of Sciences, China.
- Dr. Christopher Russell, from University of Delaware, USA
- Dr. Linda Watson, from the Ohio State University, USA.

### 2.3 Postdoc Departures

- Dr. Karla Alamo left to take a Postdoc position in Brazil.
- Dr. Sonia Duffau left in 2017, continues living in Chile.
- Dr. Virginie Faramaz left to take a position as Exoplanetary Science Initiative Fellow at JPL-Caltech, USA.
- Dr. Jorge González left to take a China-CONICYT Postdoc Position hosted by UDP in Chile.
- Dr. Sebastien Guillot left to take a position as Postdoctoral fellow in the Institut de Recherche en Astrophysique et Planetologie, Toulouse, France.
- Dr. Madusha Gunawardhana left to take a Postdoc position in Netherlands.
- Dr. Benjamin Laevens moved to Belgium.
- Dr. Aiara Lobo moved to Belgium.
- Dr. Matías Montesinos left to take on a postdoc position at Universidad de Valparaíso, Chile.
- Dr. George Privon left to take a position as Prize Postdoctoral Fellow, Department of Astronomy, University of Florida, USA.
- Dr. Joshua Tan (*né* Schroeder) left to take a faculty position in LaGuardia Community College, USA.

- Dr. Nicolás Tejos left to take a faculty position at PUCV in Chile.
- Dr. Edith Millarca Valenzuela left in 2017 to take a position at SERNAGEOMIN.

### 3 IA Members

#### 3.1 Faculty

List of faculty members at the IA as of late 2017.

- Dr. Felipe Barrientos, Associate Professor (PhD University of Toronto, Canada, 1999) – *Galaxy evolution and morphology. Elliptical galaxies. Clusters of galaxies. Observational cosmology.*
- Dr. Franz E. Bauer, Associate Professor (PhD 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 (PhD Universidade de São Paulo, Brazil, 1996) – *Stellar structure and evolution. Globular clusters. Variable stars. Stellar Populations. Galaxy formation and evolution.*
- Dr. Julio Chanamé, Assistant Professor (PhD The Ohio State University, USA, 2005) – *Stellar dynamics. The Milky Way and the Local Group. Stellar structure and evolution.*
- Dr. Alejandro Clocchiatti, Full Professor (PhD University of Texas at Austin, USA, 1995) – *Supernovae, near and far. Radiative Transfer. Galaxy Clusters. Cosmology.*
- Dr. Jorge Cuadra, Associate Professor (PhD 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, Associate Professor, (PhD PUC, 2009) – *Large scale structure and cosmology. Astronomical instrumentation.*
- Dr. Gaspar Galaz, Full Professor and current IA Director (PhD 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, on leave as Director of Las Campanas Observatory, Carnegie Institution for Science. (PhD 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.*
- Dr. Andrés Jordán, Associate Professor (PhD Rutgers University, USA, 2004) – *Search and characterization of transiting exoplanets. Instrumentation, especially small telescopes.*
- Dr. Nelson Padilla, Full Professor (PhD Universidad Nacional de Córdoba, Argentina, 2001) – *Numerical astrophysics. Galaxy and Structure Formation. Cosmology.*
- Dr. Thomas H. Puzia, Assistant Professor (PhD 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 (PhD Cambridge University, UK, 1973) – *Observational astrophysics. Clusters of galaxies. Interacting galaxies. Large scale structure.*
- Dr. Andreas Reisenegger, Full Professor (PhD Caltech, USA, 1993) – *Theoretical and High-Energy Astrophysics. Neutron Stars. Stellar Magnetic Fields. Clusters and Superclusters of Galaxies.*
- Dr. Ezequiel Treister, Associate Professor (PhD Universidad de Chile, Chile, 2005) – *Extragalactic astronomy, active galactic nuclei, galaxy evolution, black holes.*
- Dr. Manuela Zoccali, Full Professor (PhD Università degli Studi di Padova, Italy, 2000) – *Stellar Populations in the Milky Way. The Galactic Bulge. Star Clusters. Chemical Abundances.*

#### 3.2 Postdoctoral Researchers

List of postdoctoral researchers at the IA as of late 2017:

- Dr. Karla Alamo Martinez (PhD, Universidad Nacional Autónoma de México, México, 2014) – *Relating globular cluster formation efficiency with dark matter halo properties.*

- Dr. Patricia Bessiere (PhD, The University of Sheffield, Reino Unido de Gran Bretaña e Irlanda del Norte (el), 2015) – *Understanding the life cycles of quasars and how they impact their host galaxies.*
- Dr. David Alan Boettger (PhD, University of California, USA, 2014) – *Measurements of the cosmic microwave background b-mode polarization.*
- Dr. Rafael Andrés Brahm Scott (PhD, Pontificia Universidad Católica de Chile, Chile, 2016) – *Cutting-edge Exoplanetary Science Using the First Generation of Chilean-funded Astronomical Optical Instrumentation.*
- Dr. Johannes Buchner (PhD, Universität Ludwig-Maximilian U, Germany, 2015) – *Robust constraints on the growth of super-massive black holes.*
- Dr. Julio Alberto Carballo Bello (PhD, Universidad de la Laguna, Spain, 2012) – *Near-field cosmology: mapping halo structure in the southern milky way.*
- Dr. Rodrigo Contreras (PhD, University of Bologna, Italy, 2010) – *Variable stars, proper motions, milky way.*
- Dr. Nicolás Cuello (PhD, Université Claude Bernard, France, 2015) – *Dust evolution in protoplanetary disks with complex morphologies.*
- Dr. Holger Drass (PhD, University of Bochum, Germany, 2014) – *MOONS and TARdYs the fields of investigation are Metrology and Near- Infrared spectroscopy.*
- Dr. Sonia Duffau (PhD, Universidad de Chile, Chile, 2008) – *RR Lyrae Stars as Tracers of Milky Way Structure.*
- Dr. Paul Eigenthaler (PhD, University of Vienna, Austria, 2011) – *Chasing ghosts in the nearby universe: An unprecedented study of the dwarf galaxy populations in the Centaurus A group and the former galaxy cluster.*
- Dr. Virginie Faramaz (PhD, Institut de Planétologie et d’Astrophysique de Grenoble, France, 2014) – *Exoplanetary systems dynamics.*
- Dr. Germán Arturo Gómez Vargas (PhD, 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 Ignacio González López (PhD, Heidelberg University, Germany, 2015) – *ALMA studies of dusty galaxies and AGN.*
- Dr. Sebastien Guillot (PhD, McGill University, Canada, 2014) – *Understanding ultra-dense matter with multi-wavelength observations of neutron stars.*
- Dr. Madusha Lakshani Prabha Gunawardhana (PhD, University of Sydney, Australia, 2014) – *Probing the nature of star formation across cosmic time.*
- Dr. Maren Hempel (PhD, Ludwig-Maximilian Universität München, Germany, 2004) – *The VVVX survey.*
- Dr. Sam Kim (PhD, University of California, USA, 2012) – *ALMA Observations for Gamma-ray Burst Afterglow of Binary Neutron Star Merger. - Gravitationally Lensed Extended Lyman Alpha Emission behind the Hubble Frontier Field.*
- Dr. Andrea Küller (PhD, Princeton University, USA, 2015) – *Extensions of halo abundance matching.*
- Dr. Iván Lacerna (PhD, Pontificia Universidad Católica de Chile, 2012) – *APOGEE South: "SDSS-IV APOGEE-2 Survey Observer Position".*
- Dr. Régis Lachaume (PhD, Université Joseph Fourier, France, 2003) – *Optical/IR long-baseline interferometry.*
- Dr. Benjamin Philippe M. Laevens (PhD, University of Strasbourg, France, 2015) – *Discovery and characterisation of new dwarf galaxies of the milky way.*
- Dr. Richard Reade Lane (PhD, The University of Sydney, Australia, 2010) – *Apogee: "sdss-iv apogee-2 survey observer position".*
- Dr. Aiara Lobo Gomes (PhD, Universität Heidelberg, Germany, 2015) – *Núcleo Milenio de Discos Protoplanetarios.*
- Dr. Carlos Hugo López Caraballo (PhD, Universidad de la Laguna, Spain, 2013) – *Instrumentación chilena para sondeos astronómicos.*
- Dr. Loïc Maurin (PhD, Université Paris Diderot, France, 2013) – *Looking for the cosmic microwave background b-modes of polarization.*
- Dr. Matias Alfredo Montesinos Armijo (PhD, University of Nice-Sophia Antipolis, France, 2012) – *Simulaciones de discos proto planetarios.*
- Dr. Marcelo Daniel Mora Genskowsky (PhD, Ludwig-Maximilian Universität München, Germany, 2008) – *Star forming regions in distorted galaxies and Star clusters.*

- Dr. Athanasios Papageorgiou (PhD, University of Patras, Grecia, 2015)– *Eclipsing binary stars in the era of massive surveys.*
- Dr. George C. Privon (PhD, University of Virginia, USA, 2014) – *Understanding galaxy evolution using dynamical models of luminous infrared galaxy mergers and dual agn hosts.*
- Dr. Roberto Puddu (PhD, Università Di Siena, Italy, 2016) – *Instrumentación chilena para sondeos astronómicos.*
- Dr. Markus Rabus (PhD, Universidad de la Laguna e Instituto de Astrofísica de Canarias, Spain, 2009) – *Exoplanets.*
- Dr. Álvaro Alonso Rojas Arriagada (PhD, Université de Nice, France, 2016) – *The nature of the Galactic bulge as seen by APOGEE, Gaia-ESO, Gaia and the VVVX surveys.*
- Dr. Yu Rong (PhD, University of Chinese Academy of Sciences, China, 2016) – *The evolution of galaxies and their host clusters.*
- Dr. Christopher Michael Post Russell (PhD, University of Delaware, USA, 2013) – *The inner parsec of the galactic center.*
- Dr. Joshua Paul Schroeder (PhD, University of Columbia, USA, 2014) – *Solving the mysteries of binary millisecond pulsars.*
- Dr. Nicolás Andrés Tejos Salgado (PhD, University of Durham, Reino Unido de Gran Bretaña e Irlanda del Norte (el), 2014) – *Galaxy halos as seen using gravitational-arc tomography.*
- Dr. Paulina Troncoso (PhD, La Sapienza di Roma, Italy, 2013) – *Instrumentación chilena para sondeos astronómicos.*
- Dr. Edith Millarca Valenzuela Picón (PhD, Pontificia Universidad Católica de Chile, Chile) – *Búsqueda, caracterización y análisis petrográfico, magnético, químico e isotópico de meteoritos del desierto de Atacama, para estudiar el flujo de material extraterrestre a la Tierra en el último millón de años.*
- Dr. Linda Watson (PhD, Ohio State University, USA, 2011) – *The resolved vertical structure of molecular gas in edge-on disk galaxies.*
- Dr. Hongxin Zhang (PhD, University of Chinese Academy Science, China, 2012) – *Origin of ultra-compact dwarfs.*

Support for the postdoctoral fellows comes mostly from the national FONDECYT program, 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 program (see § 7).

### 3.3 Administrative and Technical Staff

- Luis Mauricio Barz – *Caretaker*
- Karina Charris – *Administrative Assistant*
- Carmen Gloria Cordovez – *Administrative Assistant*
- Dr. José Miguel Fernández (PhD PUC, 2009) – *Astronomer at PUC Observatory at Santa Martina*; He left for a position in ALMA, and was replaced by Daniela Fernández.
- Daniela Fernández (B.Sc. PUC, 2014) – *Resident Astronomer at PUC Observatory at Santa Martina*
- Lilena Montenegro – *Administrative Assistant*
- Francisco Peralta – *IT Assistant*; He left IA in early 2017.
- Vincent Suc (Electrical Engineer, INSA, Lyon, France) – *Telescope Engineer at PUC Observatory at Santa Martina, and for HATSouth, HATPI and CHAT projects*
- Giselle Ulloa – *Administrative Assistant*
- Juan Véliz – *IT Systems Manager and Software Specialist*
- Mariela Villanueva – *IT Systems Assistant Manager*

### 3.4 Recognitions, Awards, Sabbaticals, others

Prof. Hernán Quintana received the 2017 American Astronomical Society Education Prize in January (first time awarded to someone working outside the U.S. and Canada). He was also invited to give a Plenary Talk at the 230th Meeting of the AAS in June 4-8 2017 at Austin, Texas, when the Prize was presented to him.

Prof. Andrés Jordán was on sabbatical leave at University of Heidelberg, Germany, between January 2017 and January 2018. Prof. Franz Bauer, who took a sabbatical between July 2016 and July 2017, visiting many universities and research centers in Europe and USA. Prof. Jorge Cuadra was also on sabbatical leave at MPE in Garching during part of 2017.

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

Hefei and at the Shanghai Astrophysical Observatory in Shanghai in 2017.

In December 2017, Dr. Gaspar Galaz was promoted to Full Professor.

In August 2017, Dr. Rolando Dünner was promoted to Associate Professor.

#### 4 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 2017, we taught 37 semester-long courses, which can be categorized 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)

##### 4.1 Graduate Programme

The IA offers PhD 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.

###### 4.1.1 Degrees obtained

- Dr. Néstor Espinoza obtained his PhD degree, defending his thesis entitled “*Unveiling Exoplanet Atmospheres with the ACCESS survey*”, supervised by A. Jordán, on Sep/2017. He then took on a position as a Bernoulli postdoctoral fellow, a joint fellowship between the Max-Planck-Institut für Astronomie (Heidelberg, Germany) and the University of Bern (Switzerland).
- Dr. Felipe Garrido obtained his PhD Degree, defending his thesis entitled “*Infalling clouds onto supermassive black hole binaries*”, on Aug/2017 supervised by J. Cuadra and V. Springel (University of Heidelberg).
- Dr. Sergio Contreras obtained his PhD Degree, defending his thesis entitled “*The correlation between halo and galaxy evolution*”, on Jul/2017 supervised by N. Padilla, C. Baugh (Durham University) and P. Norberg (Durham University).

- Dr. Rodrigo Leiva obtained his PhD Degree, defending his thesis entitled “*Stellar occultations by Trans-Neptunian Objects and Centaurs: application to Chariklo and its ring system*”, on Jul/2017 supervised by L. Vanzi and B. Sicardy (Université Pierre et Marie Curie and Observatoire de Paris)
- Dra. Claudia Aguilera obtained her PhD Degree, defending his thesis entitled “*Explaining Lithium Enriched Red Giant Branch Stars*”, on Jun/2017 supervised by J. Chanamé
- Dr. Sergio Vásquez obtained his PhD Degree, defending his thesis entitled “*Structure, Kinematics and Metallicity of the Galactic Bulge*”, on March/2017 supervised by M. Zoccali and I. Saviane (European Southern Observatory)
- Matías Gárate obtained his Master’s degree, defending his thesis entitled “*Effects of Planetary Feedback in the Circumplanetary and Coorbital Region*”, supervised by J. Cuadra.
- Francisco Aros obtained his Master’s Degree, defending his thesis entitled “*Axisymmetric dynamical models of dwarf spheroidal galaxies*”, supervised by J. Chanamé.
- Camilo Fontecilla obtained his Master’s degree, defending his thesis entitled “*Accretion discs around super massive black holes binaries: Long-term evolution, first and second decoupling*”, supervised by J. Cuadra.
- Tomás Muller obtained his Master’s Degree, defending his thesis entitled “*The Nickel Mass Distribution of Normal Type II Supernovae*”, co-supervised by A. Clocchiatti and José Luis Prieto (UDP).
- Enrique Paillas obtained his Master’s Degree, defending his thesis entitled “*Baryon effects on void statistics in the EAGLE simulation*”, supervised by N. Padilla.

###### 4.1.2 Lists of students

As of late 2017, 7 students were admitted to our PhD programme: Camilo Fontecilla, Jonathan Gómez, ????, Alejandra Hernández, Katerine Joachimi, Enrique Paillas, Miriam Rojas and Andrés Scherer.

As 2017, 4 students were admitted to our MSc programme: Manuel Barrientos, Esteban Jiménez, Julio Olivares and Pedro Poblete.

##### 4.2 Undergraduate Programme

The programme currently has 123 students, who are consistently drawn from the top 2% of the ~300,000 high

school seniors who take the nationally administered entrance examination (PSU) each year.

A group of 43 new students registered in the programme through the regular admission process started in March 2017. The last admitted student scored 679 points at the PSU. Additionally, eleven 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 2017, 11 students obtained a Bachelor degree. The students, their research subjects and supervisors were the following:

- Juan Arévalo, *Identificación automática de variables RR* – (M. Catelán)
- Matías Bravo, *Milky way dust absorption maps from extragalactic surveys* – (N.Padilla, E.Gawiser)
- Felipe Canales, *Estudios con Espectroscopia de Campo Integral Infrarrojo de AGN Duales Cercanos* – (E. Treister)
- Esteban Jiménez, *Halo Occupation Models for Accurate Clustering Predictions* – (N.Padilla, I.Zehavit)
- Sebastián Núñez, *Estructura geodésica de agujeros negros con acoples dependientes de la escala* – (B. Koch, Physics Institute)
- Fernando Peñaloza, *Gas molecular en galaxias activas del universo local* – (E. Treister)
- Pedro Poblete, *Estudio de la proestrella binaria HD142527 mediante simulaciones hidrodinámicas* – (N. Cuello, J. Cuadra)
- Gonzalo Prieto, *Evolucinde la relacin SFR - M y sSFR a z7 en el Hubble Frontier Fields* – (L. Infante)
- Emilio Sánchez, *Análisis de Curvas de Luz en el ptico del Sistema Binario PSR J1446-4701* – (J.Tan, J.Chanamé)
- Carlos Santander, *Galaxy scaling relation in the UVAS survey* – (P.Trncoso, L.Infante)
- Pascal Torres, *Spectroscopic monitoring of a selected sample of binary stellar systems* – (L.Vanzi)

## 5 Interdisciplinary Center: The UC Center for Astro-Engineering, AIUC

### 5.1 Overview

Since its creation in 2009 as a joint venture between the IA and the Faculty of Engineering, the AIUC Center, strategically located on the 6th floor of the Innovation Center at 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.

### 5.2 Achievements during 2017

During 2017, the AIUC continued the development of the areas supported by the PIA Anillo 1417 project (Chilean Instrumentation for Astronomical Surveys), which are CMB experiments, the MOONS project and the UVAS survey. In the area of CMB experiments, we increased our participation in the international collaborations ACT, Polarbear, CLASS, Simons Observatory and CCAT-prime. Our contributions included big-data processing for ACT, optical characterization and alignment for ACT, Polarbear and CLASS, technical and logistical developments for Simons Observatory, optical alignment planning for CCAT-prime, and on-site support for ACT, Polarbear and CLASS.

Rolando Dünner began the execution of the QUIMAL-160009 grant, which included the development of a new mm-wave laboratory for the design, construction and characterization of mm-wave antenna testing instruments. We began the development of a Drone-based characterization source, that will be tested in 2018.

## 6 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.

### 6.1 Colloquia during 2017

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### 6.2 Seminars and talks

Prof. Andreas Reisenegger gave invited talks on *Neutron star interiors: The densest plasma of the Universe* at the *8th International Conference on Frontiers of Plasma Physics and Technology (FPPT-8)* at Viña del Mar, Chile, in April, and on *Stable Magnetic Fields in Stars* at the workshop *Current Challenges in the Physics*

of White Dwarf Stars in Santa Fe, New Mexico, USA, in June 2017.

Prof. Jorge Cuadra gave an invited talk on *Self-gravitating Circumbinary Disks* at the *Sexten Conference: Disk Instabilities Across Cosmic Scales*, at the Sexten Center for Astrophysics, Italy in July 2018.

Prof. Franz Bauer gave the following talks: *Probing the Torus Structure of Nearby AGN* at the KIAA-PUC Bilateral Workshop on Active Galactic Nuclei and Galaxies in Beijing, China in February 2017; *A New, Faint Population of X-ray Transients* at the University of Science and Technology of China in Hefei, China and Nanjing University, Nanjing, China in February 2017, and at the Kavli Institute for the Physics and Mathematics of the Universe, Tokyo, Japan and Kyoto University in Kyoto, Japan in July 2017; *The ALMA Observations of the Frontier Fields and CDF-S* at the Institute of Astronomy at University of Hawaii-Manoa, Honolulu, Hawaii, USA in May 2017, and at the Institute for Cosmic Ray Research, University of Tokyo, Tokyo, Japan and the National Astronomical Observatory of Japan, Tokyo, Japan in July 2017; *The Ubiquity of extended narrow Fe K emission* at the Institute of Astronomy at University of Hawaii-Manoa, Honolulu, Hawaii, USA in June 2017, and at Kyoto University, Kyoto, Japan in July 2017; *SMGs and DSFGs at  $z > 1$  + LSST Deep-Drilling Fields (DDFs)* at the MOONS Team Meeting in Lisbon, Portugal in September 2017; and *Bright ALMA Survey of SCUBA-2 SMGs In the CDF-S (BASIC)* at the Distant Galaxies from the Far South conference in Bariloche, Argentina in December 2017.

Prof. Hernán Quintana was invited to give the Education Prize Lecture at the 230th Meeting of the AAS in June 4-8 2017 at Austin, Texas.

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## 7 Grants

### 7.1 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.

## 7.2 Group Grants

### 7.2.1 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, transients, exoplanets, and the observation of the central regions of the Milky Way. It was originally led by Mario Hamuy (U de Chile), who was awarded the Premio Nacional de Ciencias 2015 and is now president of CONICYT. As late as December 2017, the MAS is lead by M. Zoccali. About half 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 associate members of MAS at Universidad Católica are Susana Eyheramendy, Márcio Catelan, Alejandro Clocchiatti, Franz Bauer, Andrés Jordán, and Manuela Zoccali.

### 7.2.2 Núcleos 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.

*The Millennium Nucleus on Planet Formation (NPF)* is a center dedicated to study each fundamental step on the evolution of systems susceptible to planetary formation. Other of the main scientific goals of this center is design and produce indispensable mirrors to build the Planet Formation Imager (PFI), project whose main objective is to resolve spatially the Hill sphere of a planet under formation in the near and medium infrared. In this way, the Millennium Nucleus for Planet Formation seeks to position Chile in the development of the new generation of astronomical instrumentation. The Nucleus started in September 2017, and is lead by Prof Amelia Bayo (UV). One of the associated researchers is Prof Jorge Cuadra (PUC).

### 7.2.3 Anillos

*The Anillo on Chilean Instrumentation for Astronomical Surveys* is a CONICYT grant awarded to a team of as-

tronomers and engineers from PUC (main investigators: R. Dünner (PI), L. Vanzi, F. Barrientos, and associate investigators: N. Padilla, J. Alfaro, C. Jerez and A. Gue-salaga). The goal of the project is to support experimen-tal efforts aiming to produce large astronomical surveys from Chile. It is divided in three main areas: cosmo-logical experiments to measure the CMB, multi-element spectroscopy around the MOONS instrument, and the UVAS galaxy survey. It is deeply interdisciplinary, con-necting instrumental, computational and theoretical as-pects of these experiments, being hosted at the Center for Astro-Engineering (AIUC).

## 8 Exchange Agreements and International Net-works

### 8.1 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 § 8.3), Johns Hopkins, Maryland, Padova, and Princeton.

### 8.2 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.

### 8.3 Heidelberg University–PUC Agreement

The Heidelberg University–PUC exchange program was established in 2010 and the agreement for astron-omy, funded by the German DAAD, was extended for a period of another 2+3 years in 2015. The activ-ities of the program consist of a joint doctoral pro-gram, a strong academic exchange plan, the organiza-tion of summer schools, and a strong outreach program focused on school teacher workshops that is becoming a highly sought-after program in Chile, attracting ev-ery 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 pro-grams as well as stimulating future student and faculty exchanges. One new graduate student from the Univer-sity of Heidelberg (Sebastian Stammmler) was accepted to the exchange program and visited the IA in early 2016, [????? SACAR????] working in the group of Prof. J.

Cuadra.

## 8.4 Max Planck Partner Group on Galactic Centre Astrophysics

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. Cuadra’s group at PUC receives 20,000 per year to fund their research activities on Galactic Centre Astrophysics.

## 9 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 Santi-ago. This includes offices for faculty, postdocs, grad-uate 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 (§ 5) 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 jour-nal volumes. Staff members, students and visitors also have access to the University library system with more than 300,000 books and hundreds of periodical publica-tions, 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 in-cludes 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 architec-ture running over a 10 Gbps ethernet network (a 10 fold increase with respect to the previous year). Develop-ment 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 Com-



puting (NLHPC). In 2017 we installed additional CPU nodes with 1.5Tb ram and 120 cores from the Newton-CONICYT DPI20140114 (PI N. Padilla), and in 2018 additional 120 cores with 1.6Tb ram were financed by Basal CATA and Newton-CONICYT DPI20140114 (PI N. Padilla). To the original 30 TB of disk space we have added 350TB 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. Postdoctoral fellow Roberto González dedicates a fraction of their time to help manage the use of the computing cluster.

### 9.1 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.

### 9.2 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. The observatory was visited by more than 600 persons during the Astronomy Day in March 2017.

### 10 Meetings supported

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

### 11 Outreach

The members of the IA participated in several outreach activities during 2017:

- 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 ADN August 2017. She gave public talks at the Planetarium (4 April), at the public library in Valparaiso (8 May) at the Verbo Divino School (23 August), and at the Fundación Mundo Ideal (16 Dic). She also attended a speed date organized by Inspiring Girls, and delivered a TEDx talk organized by the Nucleo de Astronomía of the Universidad Diego Portales (4 Oct).
- Several members of the IA held outreach talks in schools around the country in the framework of the "Day of Astronomy" (21 March 2017), organized by the Planetarium of Santiago and "1000 científicos, 1000 aulas" (October to November 2017), organized 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 organized in the framework of the Heidelberg-PUC exchange program at the Heidelberg Center in Santiago in January 2017(see § 8.3).
- Rolando Dünner gave a talk on Cosmology to school teachers at the UC Library in May 2017; a talk on Cosmology at the "House of Engineers" at The Grange School in June 2017; a class in astronomy for the vocational program UC in July 2017; a talk on

RFI at the “Cumbre de la Red Chilena de Educación y Difusión de la Astronomía”, a talk in Cosmology at the “Feria de la Ciencia” in Osorno, and a TV interview on the solar Eclipse on August 2017.

- Hernán Quintana was interviewed at TVN news on January 8, at radios Oasis January 23, ADN on April 3, and Radio USACH April 11 2017. He also delivered a TEDx talk organized by the Nucleo de Astronomía of the Universidad Diego Portales (4 Oct). He was interviewed by the on-line joint Fermilab/SLAC Symmetry magazine published March 21, 2017, and by several Chilean newspapers. He also gave a talk on Gravitational Waves at The Grange School in October 26, 2017.

## 12 Refereed Publications

Members of the IA, including students and postdocs, participated in 246 refereed papers published in 2017. The full list is given below.

1. Abbott B. P., and 3675 authors: *Multi-messenger Observations of a Binary Neutron Star Merger*. ApJ 848, L12  
<http://adsabs.harvard.edu/abs/2017ApJ...848L..12A>
2. Abdul Wasay M., Bashir A., Koch B., Ghaffar A.: *Geometric description of the Schrödinger equation in  $(3n+1)$ -dimensional configuration space*. International Journal of Geometric Methods in Modern Physics 14, 1750149  
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3. Acero F., Aloisio R., Amans J., Amato E., Antonelli L. A., Aramo C., Armstrong T., Arqueros F., Asano K., Ashley M., Backes M., Balazs C., Balzer A., Bamba A., Barkov M., Barrio J. A., Benbow W., Bernlöhr K., Beshley V., Bigongiari C., Biland A., Bilinsky A., Bissaldi E., Biteau J., Blanch O., Blasi P., Blazek J., Boisson C., Bonanno G., Bonardi A., Bonavolontà C., Bonnoli G., Braiding C., Brau-Nogué S., Bregeon J., Brown A. M., Bugaev V., Bulgarelli A., Bulik T., Burton M., Burdakov A., Busetto G., Böttcher M., Cameron R., Capalbi M., Caproni A., Caraveo P., Carosi R., Cascone E., Cerruti M., Chaty S., Chen A., Chen X., Chernyakova M., Chikawa M., Chudoba J., Cohen-Tanugi J., Colafrancesco S., Conforti V., Contreras J. L., Costa A., Cotter G., Covino S., Covone G., Cumani P., Cusumano G., D’Ammando F., D’Urso D., Daniel M., Dazzi F., De Angelis A., De Cesare G., De Franco A., De Frondat F., de Gouveia Dal Pino E. M., De Lisio C., de los Reyes Lopez R., De Lotto B., de Naurois M., De Palma F., Del Santo M., Delgado C., della Volpe D., Di Girolamo T., Di Giulio C., Di Pierro F., Di Venere L., Doro M., Dournaux J., Dumas D., Dwarkadas V., Díaz C., Ebr J., Egberts K., Einecke S., Elsässer D., Eschbach S., Falceta-Goncalves D., Fasola G., Fedorova E., Fernández-Barral A., Ferrand G., Fesquet M., Fiandrini E., Fiasson A., Filipović M. D., Fioretti V., Font L., Fontaine G., Franco F. J., Freixas Coromina L., Fujita Y., Fukui Y., Funk S., Förster A., Gadola A., Garcia López R., Garczarczyk M., Giglietto N., Giordano F., Giuliani A., Glicenstein J., Gnatyk R., Goldoni P., Grabarczyk T., Graciani R., Graham J., Grandi P., Granot J., Green A. J., Griffiths S., Gunji S., Hakobyan H., Hara S., Hassan T., Hayashida M., Heller M., Helo J. C., Hinton J., Hnatyk B., Huet J., Huetten M., Humensky T. B., Hussein M., Hörandel J., Ikeno Y., Inada T., Inoue Y., Inoue S., Inoue T., Inoue Y., Ioka K., Iori M., Jacquemier J., Janecek P., Jankowsky D., Jung I., Kaaret P., Katagiri H., Kimeswenger S., Kimura S., Knödlseeder J., Koch B., Kocot J., Kohri K., Komin N., Konno Y., Kosack K., Koyama S., Kraus M., Kubo H., Kukec Mezek G., Kushida J., La Palombara N., Lalik K., Lamanna G., Landt H., Lapington J., Laporte P., Lee S., Lees J., Lefoucheur J., Lenain J.-P., Leto G., Lindfors E., Lohse T., Lombardi S., Longo F., Lopez M., Lucarelli F., Luque-Escamilla P. L., López-Coto R., Maccarone M. C., Maier G., Malaguti G., Mandat D., Maneva G., Mangano S., Marcowith A., Martí J., Martínez M., Martínez G., Masuda S., Maurin G., Maxted N., Melioli C., Mineo T., Mirabal N., Mizuno T., Moderski R., Mohammed M., Montaruli T., Moralejo A., Mori K., Morlino G., Morselli A., Moulin E., Mukherjee R., Mundell C., Muraishi H., Murase K., Nagataki S., Nagayoshi T., Naito T., Nakajima D., Nakamori T., Nemmen R., Niemiec J., Nieto D., Nieves-Rosillo M., Nikolaïjuk M., Nishijima K., Noda K., Nogues L., Nosek D., Novosyadlyj B., Nozaki S., Ohira Y., Ohishi M., Ohm S., Okumura A., Ong R. A., Orito R., Orlati A., Ostrowski M., Oya I., Padovani M., Palacio J., Palatka M., Paredes J. M., Pavy S., Pe’er A., Persic M., Petrucci P., Petruk O., Pisarski A., Pohl M., Porcelli A., Prandini E., Prast J., Principe G., Prouza M., Pueschel E., Pühlhofer G., Quirrenbach A., Rameez M., Reimer O., Renaud M., Ribó M., Rico J., Rizi V., Rodriguez J., Rodriguez Fernandez G., Rodríguez Vázquez J. J., Romano P., Romeo G., Rosado J., Roussele J., Rowell G., Rudak B., Sadeh I., Safi-Harb S., Saito T., Sakaki N., Sanchez D., Sangiorgi P., Sano H., Santander M., Sarkar S., Sawada M., Schioppa E. J., Schoorlemmer H., Schovanek P., Schussler F., Sergijenko O., Servillat M., Shalchi A., Shellard R. C., Siejkowski H., Sillanpää A., Simone D., Sliusar V., Sol H., Stanič S., Starling R.,

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