Annual Report 2015

Instituto de Astrofísica
Facultad de Física
Pontificia Universidad Católica de Chile

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Abstract

The Institute of Astrophysics (IA) at PUC has 15 active faculty members, 46 postdoctoral researchers, 20 PhD students and 20 Masters students as of late 2015. The IA members published 193 refereed articles during 2015. In the academic year 2015, seven students received their *Licenciatura* degree, four obtained a M.Sc., and three 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 mission of the IA is to be an international centre of excellence for studies in the field of Astrophysics, covering a broad range of topics in observational and theoretical astrophysics, and to prepare 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 2015.

2 Personnel

2.1 Changes in 2015

2.1.1 New Faculty

Dr. P. Sánchez-Blázquez arrived from Universidad Autónoma de Madrid, Spain.

2.1.2 New Postdocs

- Dr. K. Álamo-Martínez arrived from the Kavli Institute for Astronomy and Astrophysics at Peking University, Beijing, China.
- Dr. J. Buchner arrived from the Max-Planck-Institut für extraterrestrische Physik, Garching, Germany.
- Dr. J. Carballo-Bello arrived from Universidad de Valparaíso.
- Dr. X. Chen arrived from the Albert-Einstein-Institut, Potsdam, Germany.
- Dr. V. Faramaz arrived from IPAG, Grenoble, France.
- Dr. G. Gómez-Vargas arrived from the Institute of Physics, PUC.
- Dr. J. Gónzalez-López stayed after his PhD.
- Dr. S. Guillot arrived from McGill University, Montreal, Canada.
- Dr. R. Lane arrived from Universidad de Concepción.
- Dr. C. Ricci arrived from Kyoto University, Japan.
- Dr. J.P. Tan arrived from Columbia University, New York, US.
- Dr. H. Zhang arrived from Peking University, Beijing, China.

2.1.3 Postdoc Departures

- Dr. J. Alonso-García left to take on a faculty position at Universidad de Antofagasta.
- Dr. M. Bovill left to take on a postdoctoral position at the Space Telescope Science Institute, Baltimore, US.
- Dr. A.C. Dunhill left to take on a postdoctoral position at the University of Central Lancashire, Preston, UK.
- Dr. D.N.A. Murphy left to take on a postdoctoral position at the Institute of Astronomy, Cambridge, UK.
- Dr. S. Perina relocated to Bologna, Italy, where she is working in astronomical research at the Observatory.

2.2 IA Faculty

List of faculty members at the IA as of late 2015.

- 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. 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 IA Director (Ph.D. Université de Paris, France, 1998) – *Stellar population in galaxies. Galaxy evolution. Statistical properties of the galaxy distribution. Low surface brightness galaxies.*
- 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.*
- 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, Associate 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. Manuela Zoccali, Associate 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 2015

List of postdoctoral researchers at the IA as of late 2015:

- Dr. Karla Álamo-Martínez (Ph.D. UNAM, Morelia, Mexico, 2014) – Star Cluster Systems in Virgo. Stellar Populations. Galaxy Morphologies.
- Dr. David A. Boettger (Ph.D. University of California, San Diego, USA, 2014) – *TBD*
- Dr. Mark Booth (Ph.D. Cambridge University, UK, 2010) – *Debris discs. Planetary systems. Small Solar System Bodies. Astrobiology.*

- Dr. Johannes Buchner (Ph.D. Ludwig-Maximilians-Universität München, Garching, Germany, 2015) – *Active Galactic Nuclei and their nuclear obscuration. Galaxy–SMBH co-evolution. Gamma-ray bursts. X-ray obscuration modelling. Bayesian inference.*

- Dr. Julio Carballo-Bello (Ph.D. Instituto de Astrofísica de Canarias, Spain, 2012) – *Globular clusters. Tidal streams. Milky Way satellites.*

- Dr. Siu Kuen Josephine Chan (Ph.D. University of Calgary, Canada, 1992) – *Infrared astronomy. Astro-statistics. Astro-informatics. Interstellar dust/matter. Star-formation regions. YSOs. Nearby galaxies. Late-type stars. Stellar evolution. Circumstellar dust/matter. Galactic chemical evolution. Astro-chemistry.*

- Dr. Xian Chen (Ph.D. Peking University, China, 2010) – *Stellar and gas dynamics around massive black holes, and the corresponding high-energy electromagnetic radiation. Gravitational wave astronomy.*

- Dr. Rodrigo Contreras Ramos (Ph.D. University of Bologna, Italy, 2010) – *Stellar structure and evolution. Globular clusters. Variable stars. Stellar Populations. Galaxy formation and evolution. Photometry.*

- Dr. Jesús M. Corral-Santana (Ph.D. IAC, Spain, 2012) – *Observational studies of compact objects in X-ray binaries. Stellar evolution: Dynamical confirmation of stellar-mass black holes. Transient X-ray binaries. Photometry. Spectroscopy.*

- Dr. István Dékány (Ph.D. Eötvös Loránd University, Hungary, 2010) – *Photometry. Time-series analysis. Stellar pulsation. Stellar evolution.*

- Dr. Holger Drass (Ph.D. Ruhr–University of Bochum, Germany, 2014) – *Brown dwarfs and free-floating planetary mass objects in nearby star-forming regions. Instrumentation.*

- Dr. Sonia Duffau (Ph.D. Universidad de Chile, 2008) – *Stellar populations. Structure and chemistry of our Galaxy. Streams in the halo. Variable stars. RR Lyrae.*

- Dr. Paul Eigenthaler (Ph.D. University of Vienna, Austria, 2011) – *Dwarf Galaxies. Galaxy Surveys. Galaxy Groups and Clusters.*

- Dr. Cristóbal Espinoza (Ph.D. University of Manchester, UK, 2010) – *Pulsar Astronomy: timing, spin evolution, glitches and timing noise.*

- Dr. Virginie Faramaz (Ph.D. Université Joseph Fourier, Grenoble, France, 2014) – *Exoplanetary systems dynamics. Planets–debris disks interactions: asymmetric patterns in debris disks, exocometary activity, planetesimal-driven migration.*

- Dr. Germán Gómez-Vargas (Ph.D. Universidad Autónoma de Madrid, Spain, 2013) – *Astro-particle physics. Gamma-ray astronomy. Indirect searches for dark matter. Physics beyond the Standard Model of fundamental particles.*

- Dr. Roberto González (Ph.D. PUC, 2009) – *Cosmology: Large scale structure, DM–galaxy connection, environment. Computational Astrophysics: N-body codes, initial conditions, LSS and cluster/single galaxy zoom simulations, halo and structure identification.*

- Dr. Jorge Gónzalez-López (Ph.D. PUC, 2015) – *High redshift galaxies. Dusty star-forming galaxies. Lensed galaxies. Continuum and emission lines. Sub-mm/mm observations.*

- Dr. Sebastien Guillot (Ph.D. McGill University, Montreal, Canada, 2015) – *Observations of neutron stars (X-ray and optical). X-ray pulsars and magnetars. Dense matter equation of state.*

- Dr. Maren Hempel (Ph.D. Ludwig-Maximilians-Universität München, Germany, 2004) – *Globular cluster systems. Stellar Populations. Galaxy formation and evolution.*

- Dr. Matías Jones (Ph.D. Universidad de Chile, 2013) – *Stellar spectroscopy. Extrasolar planets. Instrumentation.*

- Dr. Sam Kim (Ph.D. University of California at Irvine, USA, 2012) – *Compact overdensity and protocluster study. High redshift galaxy evolution. Strong lensing phenomena of submm bright galaxies. Cosmological mass assembly.*

- Dr. Régis Lachaume (Ph.D. Université de Grenoble, France, 2003) – *Optical long-baseline interferometry. Young stellar objects. Multiple stellar systems.*

- Dr. Iván Lacerna (Ph.D. PUC, 2012) – *Formation and evolution of galaxies. Large-scale structure.*

- Dr. Richard Lane (Ph.D. University of Sydney, Australia, 2010) – *Globular clusters (both Galactic and extra-galactic). Dark matter. The evolution of the Milky Way and large elliptical galaxies.*

- Dr. Nicolas Laporte (Ph.D. Université de Toulouse III, France, 2013) – *First galaxies. Galaxy evolution.*

Epoch of reionization. NIR spectroscopy. Luminosity Function.

- Dr. Loïc Maurin (Ph.D. Université Paris Diderot, France, 2013) – *Cosmology. Polarization of the cosmic microwave background.*
- Dr. Adal Mesa-Delgado (Ph.D. Instituto de Astrofísica de Canarias, Spain, 2010) – *Interstellar Medium. HII regions. Chemical abundances.*
- Dr. Marcelo Mora (Ph.D. Ludwig-Maximilians-Universität München, Germany, 2008) – *Stellar populations. Extragalactic star clusters systems*
- Dr. Roberto Muñoz (Ph.D. PUC, 2009) – *Galaxy evolution. Galaxy dynamics. Galaxy clusters. Dark matter mass profiles. Gravitational lensing.*
- Dr. Sânzia Alves do Nascimento (Ph.D. Universidade Federal do Rio Grande do Norte, Brazil, 2012) – *Spectroscopy. Stellar abundances. Globular clusters. Variable stars. Astro-statistics.*
- Dr. Robert Nikutta (Ph.D. University of Kentucky, USA, 2012) – *Physics of AGN central regions. Clumpy torus. Dust radiative transfer. SED modeling. IR properties & X-ray variability of AGN. Bayesian inference. Astro-statistics. Big data.*
- Dr. Tali Palma (Ph.D. Universidad Nacional de Córdoba, Argentina, 2013) – *Stellar populations. Star clusters and star cluster systems. Stellar variability. Galactic and extragalactic chemical evolution.*
- Dr. Karla Peña Ramírez (Ph.D. Instituto de Astrofísica de Canarias, Spain, 2010) – *Brown dwarfs and planetary mass objects: circumstellar matter, luminosity function, mass function, open clusters and associations.*
- Dr. Markus Rabus (Ph.D. Universidad de la Laguna, Spain, 2009) – *Search and characterization of exoplanets.*
- Dr. Claudio Ricci (Ph.D. ISDC, University of Geneva, Switzerland, 2011) – *AGN Demographics. X-ray surveys. X-ray spectroscopy. Ray-tracing simulations. Infrared galaxies. Mergers and black hole activity. IR spectroscopy.*
- Dr. Cristina Romero-Cañizales (Ph.D. Universidad de Granada, Spain, 2011) – *AGN and star formation activity in luminous infrared galaxies. Core-collapse supernovae. Astronomical masers.*
- Dr. Luca Sbordone (Ph.D. Università di Roma Tor Vergata, Italy, 2005) – *Stellar chemical abundances. Stellar atmosphere modelling. Chemical evolution of the Milky Way and its satellites. Extremely metal poor stars.*
- Dr. Steve Schulze (Ph.D. University of Iceland, 2012) – *Gamma-ray bursts. Core-collapse Supernovae. High-redshift galaxies. Photometry. Spectroscopy.*
- Dr. Joshua (né Schroeder) Tan (Ph.D. Columbia University, New York, US, 2014) – *Optical observations and modeling of binary millisecond pulsars.*
- Dr. Paulina Troncoso (Ph.D. La Sapienza Università di Roma, Italy, 2013) – *Galaxy evolution. High redshift galaxies. 3D spectroscopy.*
- Dr. Aldo A.R. Valcarce (Ph.D. PUC, 2011) – *Stellar Evolution: Modelling, Chemical Abundances. Star Clusters: Formation, Evolution, Multiple Populations. Stellar Populations. Galaxy: Formation.*
- Dr. Millarca Valenzuela (Ph.D. Universidad de Chile, 2011) – *Flux of extraterrestrial matter to Earth (meteorites, micrometeorites and cosmic spherules). Petrology and geochemistry of ordinary and carbonaceous chondrites. Weathering processes in deserts. Atacama Desert Meteorite Collection. Antarctic multidisciplinary studies on Geology, Astrobiology, Astronomy and Glaciology. Impact cratering. Cosmogenic nuclides (10Be, 36Cl, 14C).*
- Dr. Jingcheng Yu (Ph.D. Shanghai Astronomical Observatory, China, 2012) – *Star Clusters. N-body Simulations.*
- Dr. Hongxin Zhang (Ph.D. University of Chinese Academy of Sciences, 2012) – *Compact stellar systems. Star-forming dwarf galaxies.*
- Dr. Zhenya Zheng (Ph.D. University of Science and Technology of China, 2012) – *High redshift emission line galaxies. Active Galactic Nuclei (AGN): x-ray properties and variability.*

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 Teaching Observatory at Santa Martina.*
- Giselle Ulloa *Administrative Assistant.*
- Juan Véliz *System Manager. Software Specialist.*
- Mariela Villanueva *IT Assistant.*

2.5 Recognitions, Awards and Sabbaticals

D. Calderón received an Excellence Prize from PUC's University-wide College of Doctoral Programmes.

A. Reisenegger took a sabbatical period from August 2014 until July 2015. During this period, he visited the University of Bonn (Germany), McGill University (Montreal, Canada), the Ioffe Institute (St. Petersburg, Russia), and the University of Barcelona (Spain) for scientific collaborations with colleagues at those institutions, as well as scientific seminars at each of them. He also visited the University of Heidelberg and the Max Planck Institute for Astronomy (Heidelberg, Germany) for scientific discussions, about the planned Cherenkov Telescope Array (CTA) and other topics. He also gave talks at international conferences in St. Petersburg and Moscow (Russia) and at a DFG-CONICYT meeting (including the presidents of both institutions) in Santiago, and hosted various international scientific visitors in Santiago. He represented Chile in the CTA Consortium meeting in Turku, Finland, in which Chile was admitted as a Consortium member and Reisenegger became its Representative in the CTA Consortium Board.

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 2015, we taught 30 semester-long courses, which can be categorised as follows:

- Astrophysics undergrad core courses (7)
- Astrophysics graduate core courses (5)
- Astrophysics elective courses (10)
- sections of Astronomy/Physics courses for non-majors (8)

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. Juan Carlos Beamín obtained his PhD degree, defending his thesis entitled "*Characterization of high proper motion stars and brown dwarfs from the VVV survey and WISE mission*", supervised by D. Minniti (UNAB), M. Zoccali & V. Ivanov (ESO). He then took on a postdoctoral position at Universidad de Valparaíso.
- Diego Calderón obtained his Master's Degree, defending his thesis entitled "*Thin-shell instabilities and clump formation due to colliding stellar winds in the Galactic centre*", supervised by J. Cuadra. He then joined the Ph.D. programme at the IA.
- Sofía Gallego obtained her Master's Degree, defending her thesis entitled "*Galaxy Clusters and their Properties in the CFHTLS/VIPERS Survey*", supervised by T. Puzia & D.N.A. Murphy. She then joined the Ph.D. programme at ETH, Zürich, Switzerland.
- Dr. Jorge González-López obtained his PhD degree, defending his thesis entitled "*Investigating the interstellar medium conditions of star formation in High Redshift Galaxies by studying dust emission and emission lines*", supervised by L. Infante & D.N.A. Murphy. He then took on a postdoctoral position at the IA.
- Felipe Gran obtained his Master's Degree, defending his thesis entitled "*Mapping the outer bulge with RRab stars from VVV Survey*", supervised by M. Zoccali & D. Minniti (UNAB). He then joined the Ph.D. programme at the IA.
- Dr. Alejandra Muñoz Arancibia obtained her PhD degree, defending her thesis entitled "*The Proxy+Matching Technique: Modeling Submillimeter Galaxies and Lyman Alpha Emitters*", supervised by N. Padilla. She then took on a postdoctoral position at Universidad de Valparaíso.
- Marcelo Tala obtained his Master's Degree, defending his thesis entitled "*FIDEOS: a high resolution spectrograph for the ESO 1m telescope at La Silla observatory*", supervised by L. Vanzi (Electrical Engineering Dept.). He then joined the Ph.D. programme at LSW, Heidelberg, Germany.

3.1.2 Lists of students

As of late 2015, the 20 students enrolled in our PhD programme were: Claudia Aguilera, Simón Ángel, Rafael Brahm, Paz Bluhm, Diego Calderón, Sergio Contreras, Néstor Espinoza, Pedro Fluxa, Felipe Garrido, Cristina García, Gergely Hajdu, Rodrigo Leiva, Javier Minniti, Camila Navarrete, Fatemeh Nikzat, Yasna Órdenes, Ricardo Pantoja, Mirko Simunovic, Matthew Taylor, and Sergio Vásquez.

As of late 2015, the 20 students enrolled in our MSc programme were: Jorge Anais, Francisco Aros, Ignacio Becker, Johanna Coronado, Marilyn Cruces, Diego Farías, Myriam Flores, Camilo Fontecilla, Matías Gárate, Francisco Ley, Paul Leyton, Nicolás Meza, Josefina Michea, Tomás Muller, Ismael Pessa, Enrique Paillás, María Sepúlveda, Francisco Surot, Bryan Townsend, and Felipe Zepeda.

3.2 Undergraduate Programme

The PUC undergraduate programme in Astronomy, *Licenciatura*, was accredited for six years in July 2015.

The programme currently has ∼100 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 28 new students registered in the programme through the regular admission process to start in March 2016. The last admitted student scored 718.65 points at the PSU. Additionally, twelve students registered through the Special Admissions process.

Undergraduate students work full time during the last semester of the program on a research project under the supervision of a faculty member. The seven students who obtained their degree during this period, the subject of their theses, and their supervisors are:

- Diego Díaz *Estudio de la interacción entre líquidos polares y superficies cubiertas con moléculas polares y apolares (alkanos / membranas artificiales) en función de la cobertura* – (U. Volkmann, Physics Inst.)
- Daniela Fernández *The K-band luminosity function of Abell 2744 (z=0.308) galaxy cluster* – (L. Infante)
- Rafael Fuentes *Actividad de glitches en una población de pulsares* – (C. Espinoza)
- Matías Gárate *Discos Protoplanetarios: Efectos de un feedback dependiente de la acreción variable del planeta* – (J. Cuadra)
- Cristóbal Reyes *Analysis of Hubble Space Telescope observations of old neutron stars* – (S. Guillot and A. Reisenegger)
- Karen Ribbeck *Structural Parameters of Galaxies in the Fornax Galaxy Cluster* – (T. Puzia and G. Galaz)
- Felipe Zepeda *Masa máxima de estrellas de neutrones: ¿Chandrasekhar o Schwarzschild?* – (A. Reisenegger)

4 Interdisciplinary Center: The UC Center for AstroEngineering, AIUC

AIUC was created in 2009 as a joint venture between the IA and the PUC Faculty of Engineering. The Center's mission is to serve as channel to carry out research and to generate new technological and computational opportunities in the areas of astronomy and engineering in Chile. Currently the AIUC includes three main parts: a Laboratory of Astronomical Instrumentation, a Center of data mining and numerical computation and a Astronomical Service area. The purpose of the first is to generate alliances with international observatories present in Chile, participate in the construction of optical and infrared instruments and trigger technological transfer to the country. The Computer Lab offers to the astronomical community a powerful tool for numerical computation and data analysis and provides the computing capability needed to handle large amounts of data collected by telescopes in Chile. Finally, the mission of the Service Area is to provide astronomical and engineering support to the international observatories located in Chile and facilitate specialised human resources.

The Astroengineering Center is an initiative of very high potential impact to promote a pro-innovation and entrepreneurship aimed primarily at research in astronomical technology culture, and thus, positively impact society. To increase the impact of this activity, in 2015 the Center relocated its premises at the PUC Anacleto Angelini Center for Innovation, so that these activities have a better integration and visibility. It is in the sixth floor of the building and occupies almost 600 square meters of laboratory and office space.

5 Colloquia, seminars and science activities

Starting in 2012, the IA organises a series of astronomy colloquia that, modeled after similar programs with long traditions at major astronomical institutions around 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.

Below is the programme of our Colloquia during 2015:

- 10/03 RICHARD DE GRIJS (Kavli Institute for Astronomy and Astrophysics, Peking University, China) *Not-so-simple stellar populations in resolved massive star clusters*
- 17/03 THOMAS BENSBY (Lund University, Sweden) *The age and abundance structure of the Galactic disk and bulge – clues from microlensed dwarfs and the Gaia-ESO survey*
- 24/03 MIKHAIL GUSAKOV (Ioffe Physical Technical Institute, Russia) *Superfluidity in neutron stars*
- 07/04 JORDI MIRALDA-ESCUDÉ (Universitat de Barcelona, Spain) *The Intergalactic Medium in Absorption and Emission: Studying Large-Scale Structure and Galaxy Formation at high redshift*
- 21/04 ŽELJKO IVEZIĆ (University of Washington, USA) *LSST: the greatest movie of all time*
- 28/04 CLAUDIA LAGOS (European Southern Observatory, Germany) *Testing galaxy formation models with observations of gas in early-type galaxies*
- 05/05 JACQUELINE RADIGAN (Space Telescope Science Institute, USA) *Weather on Substellar Worlds: observations of cloud and weather phenomena in the atmospheres of cool brown dwarfs*
- 12/05 CLAUDIA MARASTON (University of Portsmouth, UK) *Stellar population models: unveiling galaxy evolution*
- 19/05 TIMOTHY RODIGAS (Carnegie Department of Terrestrial Magnetism, USA) *High Resolution Views of Stars, Planets, and Disks*
- 26/05 KATHRYN JOHNSTON (Columbia University, USA) *Dark Matter and Stellar Halos: Formation, Histories and Structure*
- 02/06 ALINE VIDOTTO (Observatoire de Genève, Switzerland) *Interactions between exoplanets and stellar winds*
- 09/06 TIM BEERS (University of Notre Dame, USA) *Discovery of the Chemical Signature of First-Generation Massive Stars*
- 16/06 MARK PHILLIPS (Las Campanas Observatory, Chile) *On the Source of the Dust Extinction in Type Ia Supernovae*
- 23/06 RICK POGGE (The Ohio State University, USA) *Bringing order to chemical abundances of nearby spiral galaxies with CHAOS*
- 18/08 PATRICIA ARÉVALO (Universidad de Valparaíso, Chile) *AGN Feedback in Action*
- 25/08 ARIANE LANÇON (Observatoire Astronomique de Strasbourg, France) *Towards Consistency Between Optical and Near-IR Population Synthesis Predictions*
- 01/09 ROBERT WITTENMYER (University of New South Wales, Australia) *The Great Unveiling: A New Golden Age of Exoplanetary Science*
- 08/09 GUILLERMO BLANC (Universidad de Chile, Chile) *A Characteristic Transition Mass Scale in the Gas Phase Mass-Metallicity Relation of Local Star Forming Galaxies*
- 15/09 JOSHUA FRIEMAN (University of Chicago & Fermilab, USA) *Probing Cosmic Acceleration with the Dark Energy Survey*
- 29/09 MAISA ROJAS (Departamento de Geofísica, Universidad de Chile, Chile) *Climate Change: Dangerous Interference with our Planet?*
- 06/10 MANUEL ARAVENA (Universidad Diego Portales, Chile) *Studying the Evolution of Star Forming Galaxies Through Cosmic Time: An ALMA 1.2mm Molecular Deep Field*
- 14/10 MARIO HAMUY (Universidad de Chile & Millenium Institute of Astrophysics, Chile) *Cosmology from Type II Supernovae*
- 20/10 PETER GARNAVICH (University of Notre Dame, USA) *Catching Supernovae in the Act: Early Light Curves with the Kepler Space Telescope*
- 27/10 SERGEY KOPOSOV (University of Cambridge, UK) *Streams and Satellites: Galactic Archaeology with Large Surveys*
- 03/11 OLIVER PFUHL (Max-Planck-Institut für extraterrestrische Physik, Germany) *Galactic Center Science with GRAVITY – Measuring the Spin of the Massive Black Hole SgrA**
- 10/11 CLAUDIA PALADINI (Université Libre de Bruxelles, Belgium) *(Re)solving the Mass-Loss Process of AGB Stars with High Angular Resolution*
- 17/11 PAU AMARO-SEOANE (Albert Einstein Institute, Germany) *Capture of Compact Objects by Supermassive Black Holes: SgrA* as a Testbed for General Relativity*
- 24/11 LAURA PÉREZ (National Radio Astronomy Observatory, USA) *Studying the Process of Planet Formation with Radio Interferometers*

- 01/12 YUJIN YANG (Korea Astronomy and Space Science Institute, South Korea) *Gas Kinematics within Lyman Alpha Blobs*

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.

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. 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 centre 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.

ATLAS Andino is a CONICYT grant awarded to a team of scientists of the PUC Institute of Physics (M.A. Díaz [PI], J. Alfaro, M. Bañados, B. Koch, and U. Volkmann), the IA (G. Galaz, A. Reisenegger), and external collaborators. Its goals are: a better understanding of the elementary particles, to be studied by means of the ATLAS Detector of the Large Hadron Collider (LHC); the understanding of the nature of Dark Matter and its effects on Astrophysics and Cosmology; the creation of an ATLAS Grid node at PUC, including the expansion of the Grid technology to other areas; and the study of ATLAS muon chambers in view of the LHC upgrade. It promoted the establishment of Southern array of the Cherenkov Telescope Array (CTA) in Chile and the Chilean participation in the CTA Consortium, which was approved by the Consortium Board (CB) in May 2015. Since then, Prof. A. Reisenegger is the Chilean Representative in the CB and the coordinator of the CTA-Chile team, which includes astronomers, physicists, and engineers from seven Chilean universities.

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 § 7.6), Johns Hopkins, Maryland, Padova, and Princeton.

7.2 Marie Curie network LACEGAL

The Latin American–Chinese–European Galaxy Formation (LACEGAL) network was approved in November 2010 to bring together internationally recognised experts in the theory of galaxy formation and growth of cosmic structure. This network ended on April 2015, and it allowed new research collaborations to be made between the main groups working in the subject in Latin America and China, and the principal centres in computational galaxy formation and astrophysics in Europe. The local coordinator was Nelson Padilla.

Visiting trips during the year 2015 were awarded to Sergio Contreras, and we received one LACEGAL visitor, Antonella Garzilli.

7.3 DFG–Conicyt Joint Project

The research project "Magnetic Fields of Massive Stars and their Compact Remnants" was funded jointly by DFG (Germany) and CONICYT (Chile) over the 3-year period 2012–2014 (extended until September 2015) as part of a program to strengthen collaboration between scientists of both countries. The German team was composed of Norbert Langer (German PI; University of Bonn), Henk Spruit (Max-Planck-Institut für Astrophysik), and Jon Braithwaite (University of Bonn), while the Chilean researchers were Andreas Reisenegger (Chilean PI; IA-PUC) and Juan Alejandro Valdivia (Universidad de Chile). The project funded a "Chile-Germany Postdoctoral Fellow in Stellar Magnetism", Joseph Mitchell (PhD at Florida State University), who spent half of his time at PUC and the other half in Bonn, as well as graduate students and trips in both directions. It joined expertise in stellar evolution (Langer), magnetohydrodynamics (Spruit), compact objects (Reisenegger), and numerical simulations (Braithwaite and Valdivia), in order to gain a fuller understanding of the co-evolution of massive stars and their magnetic fields from birth to death.

7.4 RCUK–Conicyt Joint Project

"Near-Field Cosmology in the Era of Large Surveys" is a project involving astronomers from PUC (PI: M. Catelan) and the University of Cambridge (U.K.). It is supported by a grant jointly awarded by CONICYT and RCUK. The main goal of the project is to foster scientific collaboration between astronomers from these two institutions, in the booming field of Galactic archaeology and near-field cosmology. The latter consists in the search and characterization of substructure in the Milky Way spheroid and its neighborhood, in search for clues on the way our galaxy has formed and evolved over time. The full team is comprised of senior and junior scientists, postdoctoral fellows and students at both institutions, in addition to several experts from other institutions in Chile.

7.5 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.

7.6 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 Stammler) was accepted to the exchange program and will start his IA-PUC visit in early 2016, working in the group of Prof. J. Cuadra.

8 Office, Computing and Teaching facilities

The IA occupies 1,887 m^2 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 respect 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. Postdoctoral fellow Roberto González dedicates a fraction of his time to help manage the use of the computing cluster.

8.1 Santa Martina Observatory

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 new, built in-house fibre 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 maintains the historical observatory Manuel Foster in the Metropolitan Park on the 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 and is being opened to the public on selected days.

9 Meetings supported

One of the activities of the IA is to support meetings and graduate schools in Chile to foster the development of local professional astronomy. In the period reported, activities organised, sponsored, and/or supported were (name of meeting, place and date)

- *Unveiling the AGN–Galaxy Evolution Connection* (Puerto Varas, March 2014).
- *XII Annual Meeting SOCHIAS* (Puerto Varas, March 2014).
- *Columbia University / PUC Workshop* (Campus San Joaquín, May 2015)
- *CTA–Chile workshop* (Campus San Joaquín, August 2015)
- *Mini workshop Notre Dame / PUC* (Campus San Joaquín, October 2015)

- *Near-Field Cosmology in the Era of Large Surveys* (PUC–Cambridge project kick-off meeting, Campus San Joaquín, October 2015)
- *Towards Science in Chile With LSST* (La Serena, November 2015)
- *Korea-Chile Workshop 2015* (Campus San Joaquín, December 2015)

10 Outreach

The IA organized and supported several outreach activities during 2015:

- 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.
- Several members of the IA held outreach talks in schools around the country in the framework of the "Day of Astronomy" (21 March 2015), organised by the Planetarium of Santiago and "1000 científicos, 1000 aulas" (October 2015), 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 § 7.6).

11 Refereed Publications

Astronomers from the IA, including students, participated in 193 refereed papers published in 2015. The full list is given below.

1. Ade P. A. R., Arnold K., Atlas M., Baccigalupi C., Barron D., **Boettger D.**, Borrill J., Chapman S., Chinone Y., Cukierman A., Dobbs M., Ducout A., **Dunner R.**, Elleflot T., Errard J., Fabbian G., Feeney S., Feng C., Gilbert A., Goeckner-Wald N., Groh J., Hall G., Halverson N. W., Hasegawa M., Hattori K., Hazumi M., Hill C., Holzapfel W. L., Hori Y., Howe L., Inoue Y., Jaehnig G. C., Jaffe A. H., Jeong O., Katayama N., Kaufman J. P., Keating B., Kermish Z., Keskitalo R., Kisner T., Kusaka A., Le Jeune M., Lee A. T., Leitch E. M., Leon D., Li Y., Linder E., Lowry L., Matsuda F., Matsumura T., Miller N., Montgomery J., Myers M. J., Navaroli M., Nishino H., Okamura T., Paar H., Peloton J., Pogosian L., Poletti D., Puglisi G., Raum C., Rebeiz G., Reichardt C. L., Richards P. L., Ross C., Rotermund K. M., Schenck D. E., Sherwin B. D., Shimon M., Shirley I., Siritanasak P., Smecher G., Stebor N., Steinbach B., Suzuki A., Suzuki J.-i., Tajima O., Takakura S., Tikhomirov A., Tomaru T., Whitehorn N., Wilson B., Yadav A., Zahn A., Zahn O., Polarbear Collaboration: *POLARBEAR constraints on cosmic birefringence and primordial magnetic fields.* Phys.Rev.D 92, 123509
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   http://adsabs.harvard.edu/abs/2015ApJ...815...66A
4. **Alonso-García J.**, **Dékány I.**, **Catelan M.**, **Contreras Ramos R. Gran F.**, Amigo P., **Leyton P.**, **Minniti D.**: *Variable Stars in the VVV Globular Clusters. I. 2MASS-GC 02 and Terzan 10.* AJ 149, 99
   http://adsabs.harvard.edu/abs/2015AJ....149...99A
5. **Alves S.**, Benamati L., Santos N. C., Adibekyan V. Z., Sousa S. G., Israelian G., De Medeiros J. R., Lovis C., Udry S.: *Determination of the spectroscopic stellar parameters for 257 field giant stars.* MNRAS 448, 2749
   http://adsabs.harvard.edu/abs/2015MNRAS.448.2749A
6. Annuar A., Gandhi P., Alexander D. M., Lansbury G. B., Arévalo P., Ballantyne D. R., Baloković M., **Bauer F. E.**, Boggs S. E., Brandt W. N., Brightman M., Christensen F. E., Craig W. W., Del Moro A., Hailey C. J., Harrison F. A., Hickox R. C., Matt G., Puccetti S., Ricci C., Rigby J. R., Stern D., Walton

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8. **Armaza C.**, **Reisenegger A.**, Alejandro Valdivia J.: *On Magnetic Equilibria in Barotropic Stars*. ApJ 802, 121
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9. Ascaso B., Benítez N., Fernández-Soto A., Arnalte-Mur P., López-Sanjuan C., Molino A., Schoenell W., Jiménez-Teja Y., Merson A. I., Huertas-Company M., Díaz-García L. A., Martínez V. J., Cenarro A. J., Dupke R., Márquez I., Masegosa J., Nieves-Seoane L., Pović M., Varela J., Viironen K., Aguerri J. A. L., Olmo A. D., Moles M., Perea J., Alfaro E., Aparicio-Villegas T., Broadhurst T., Cabrera-Caño J., Castander F. J., Cepa J., Cerviño M., Delgado R. M. G., Cristóbal-Hornillos D., Hurtado-Gil L., Husillos C., **Infante L.**, Prada F., Quintana J. M.: *Galaxy clusters and groups in the ALHAMBRA survey*. MNRAS 452, 549
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