PROCEEDINGS OF SCIENCE

Instrumentation at the UC Centre for Astro-Engineering (AIUC)

Leopoldo Infante
Pontificia Universidad Católica de Chile
Centre for Astro-Engineering
Av. Vic. Mackenna 4860
7820436, Macul, Santiago
Chile
linfante@astro.puc.cl

Andrés Guesalaga, Leonardo Vanzi, Andés Jordán, Nelson Padilla and Dani Guzmán
Pontificia Universidad Católica de Chile
Centre for Astro-Engineering
Av. Vic. Mackenna 4860
7820436, Macul, Santiago
Chile

A mayor instrumentation effort is being carried out at the Pontificia Universidad Católica of Chile. A Center for Astro-Engineering (AIUC) was created in 2009. It is the first of its class in Chile. The Centre has two laboratories (instrumentation and computing) and an astronomical service area. In collaboration with several groups in Europe, USA and Japan, new concept instruments are being developed. These include wide field Adaptive Optics and NIR spectrographs for the new generatiion of giant telesscopes in Chile (E-ELT, GMT, TAO, etc.). Here we present the Centre structure, research activities, science cases, instrument concepts and schedule planes.

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1.Introduction

Recent advances in astronomical research have reshaped our worldview and our comprehension of life and evolution in the universe. This has been possible, to a large extend, to recent technological develpments, new telescopes and better instruments. Science and technology go together; science aims drive technological progress, which in turn enable new science.

By the end of the decade Chile will host two of three largest optical/IR telescopes in the world, the European Extremely Large Telescope (E-ELT) and the Giant Magellan Telescope (GMT) and two of the world largest mm/submm telescopes, the Atacama Large Millimeter Array (ALMA) and the Cornel Caltech Atacama, CCAT, telescopes.

The fact that these telescopes will operate in Chile, and the requirement that they be equipped with world-class instrumentation, opens up a wealth of opportunities for the development of high technology in Chile. Aware of this, the Center for Astro-Engineering (AIUC) was created as a joint effort between Astronomy and Engineering of the Pontificia Universidad Católica of Chile (PUC).

In turn, we describe the structure of the Centre and summarize research activities and the various instrumentation projects which are currently being carried out.

2. AIUC Structure

The Center's mission is to serve as channel to carry out research and to generate new technological and computational opportunities in the area 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 allianses 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 specialized human resources.

The Center operates under a Board of Directors. The Director of the Center, currently professor L. Infante, and the Sub-Director, professor A. Guesalaga, have the responsibility to manage and execute the Center's tasks and respond to the board. Currently the AIUC (see fig. 1) has 2 optical labs, 1 instrumentation lab, 1 detector lab, a 512 cores cluster and a astro-service area. Our instrumentation and computation laboratories are lead by professors L. Vanzi , from the PUC Engineering Faculty, and by A. Jordan, from the PUC Physics Faculty, respectively. Our simulation area is lead by professor N. Padilla from the PUC Physics Faculty.

Currently there are 16 faculty members (F. Barrientos, M. Catelan, D. Celentano, A. Clocchiatti, R. Dunner, G. Galaz, M. Guarini, D. Guzmán, L. Infante, A. Jordán, D. Minniti, N. Padilla, M. Torres, L. Vanzi, A. Guesalaga and M. Zoccali), 5 postdocs (T. Anguita, P. Escarate, R. Lachaume, A. Orsi and M Rabus), 8 graduate students (P. Aguirre, A., Ananías, I, Blanchard, J. Chacón, A, Cortés, F. Henriquez, R. Olguín and M. Salas) and 8 engineers and technisians (J. Gonzalez, V. Suc, M, Baffico, J. Véliz, L. Valdes, I. Toledo, L. Montenegro and G. Ulloa) associated to he Center.

Fig.1, The recently inaugurated building that hosts the Center AIUC, located in Campus San Joaquín of the Pontificia Universidad Católica de Chile.

3.Research Activities

Our activities focus mainly on high resolution spectroscopy observing mode in the optical and near IR observing bands, and are motivated by interesting science cases which count on a strong local community; for instance, study of exo-planets, stellar physics and high-z galaxies. Our focus is high competitivity on ground based observations, and high complementarily with future facilities.

Our research interests are:

- **Wide-field Adaptive Optics: Multi-conjugated AO and Multi-object AO and AO Control algorithms**. A number of projects are being pursued:

- *Atmospheric Characterization from AO loop data:* Atmospheric characterization integrated with the AO instrument to provide the system and the user with accurate turbulence measurements at Gemini South.
- *Vibrations Characterization/Mitigation***:** Vibrations characterization at Gemini South; Vibrations identification; and Vibration Mitigation for GeMS
- *Point Spread Function (PSF) Reconstruction for Multi-Conjugate Adaptive Optic Systems*: We are working to tnderstand the point spread function (PSF) associated to a given AO run at GeMS. This is necessary for a proper AO data reduction.

- **Planet finding**: AIUC is part of Hat-South. This is a network of six identical, fully automated wide field telescopes, located at three sites (Chile: Las Campanas, Australia: Siding Springs, and Namibia: HESS site) in the Southern hemisphere. The primary purpose of the network is to detect and characterize a large number of extra-solar planets transiting nearby bright stars, and to explore their diversity. The three sites will permit near round-the-clock monitoring of selected fields, and the continuous data-stream will greatly enhance recovery of transits.
- **Cosmic Microwave Background**: Our group is collaborating in the operation of the Atacama Cosmology Telescope (ACT). This telescopes, which operates in three bands, 145, 220 and 280 MHz, is located on Cerro El Toco at 5,400 mt above the see level in the second region in Chile. We are part of the development of a new detector for ACT, the ACTpol. This instrument will detect polarized light in the Cosmic Microwave Background on small scales. Currently, AIUC members are testing and charactizing the main reflecting surfaces of the telescope.
- **Cosmological Simulations**: We also carry out large simulations of the large scale structure of the universe and its evolution with Geryon, our 512 cores cluster computer. These simulations are an important tool to understand galaxy and structure evolution.

4. AIUC Participation in Instrument Design

Our Center is currently participating in the design of several instruments for the large telescopes in Chile. These instruments are:

G-CLEF: This is the Giant Magellan Telescope (GMT) CFA Large Earth Finder: An optical fiber fed echelle spectrograph for the 24 meter GMT. The spectrograph has been designed to allow extremely high precision radial velocity measurements (~0.1m/s). The main science purpose is to discover earth-mass planets orbiting solar-type stars in the habitable zone, i.e., where liquid water may exist. The AIUC participate in building the science case and the data modeling. Our responsibility during the design process is the developemnt of the ETC. Also, we are designing the two CCD cameras for G-Clef, using a new 6K x 6K 10 um detector from e2v. The cameras will be cooled with a continuous flow liquid nitrogen cryocooler and will be integrated into the G-Clef instrument chamber. Each camera will run red and blue optimized CCDs. We are implementing detailed thermal FEA as part of the design effort.

CONDOR: Condor is an instrument concept for the VLT under design stage at the moment, with the goal of becoming a Multi-Object Adaptive Optics (MOAO) module to be installed at the Adaptive Optics Facility (AOF) of the VLT. It will offer high-resolution Integral-Field channels to be imaged by the existing NIR instrument Hawk-I, using laser guide star wavefront sensors from GRAAL, part of the AOF. We are collaborating with Durham University and other French institutions on this concept.

SIMPLE: This is a high resolution spectrograph for the E-ELT, with $R \sim 50{,}000$ to 130,000 and covering from 0.8 to 2.5 microns spectrum in a single exposure. It is a collaboration between Istituto Nazionale di Astrofisica – INAF Osservatorio di Roma, Bologna, Arcetri, Italy, the Uppsala Astronomica Observatory in Sweden, TLS – Tautenburg in Germany and the PUC in Chile. The science goals are the study of exoplanets, abundances, kinematics, spectro-astrometry and spectro-polarimetry. SIMPLE has successfully passed the ESO/E-ELT Phase A review on April 2010. We expect it will be one of the recommended first generation E-ELT instruments.

5.Instruments in Construction at the AIUC

The Center is building a number of small instruments. Among them:

PUCHEROS: This is an echelle spectrograph, R=20.000, with 2x image slicer, fiber-fed with 50 μm core fiber. It works in the spectral range 400 - 700 nm, in one shot. It was built using mostly off-the-shelf components and an FLI CCD 1K with 24 μm pixels. This instrument has been comissioned at the 50cm telescope of the PUC Observatory in Santa Martina, Santiago, Chile.

ARNICA: This is a Near IR camera based on NICMOS. Its spectral range is 0.9 - 2.5 μm. It works in Imaging mode plus low resolution spectroscopy.