Review of the Center for Excellence in Astrophysics and Associated Technologies (CATA), Code PFB06

Universidad de Chile – Director: Maria Teresa Ruiz (UC)
Pontificia Universidad Católica de Chile (PUC)
Universidad de Concepción (UdeC)

Executive Summary

Faculties at UC, PUC and UdeC are a large and influential constituency in the global astrophysical research community. UC has a faculty of consisting of 21 assistant, associate and full professors. This is to be compared with 18 Harvard Astronomy Department faculty members. The trend in this census is in the positive direction. As an example, in 2008, there were 27 CATA postdocs, in 2015 the cohort had grown to 79 individuals. The scientific output has been enormous – in 2015 CATA research staff wrote or co-authored 348 ISI publications. The various research groups within CATA contribute to all frontier subfields of astrophysics.

The message from the junior research staff was extremely positive in both locations. The recent addition of younger faculty members has formed an effective bridge between the generations. The postdocs and graduate students are extremely positive about their career opportunities and their ability to participate in astrophysical research on a global scale. There is wide-spread recognition that the ability to conduct world-class research and travel internationally is enabled by the CONICYT Basal funding, and that funding is seen as essential to a fertile, robust research environment.

Outreach and educational activities are numerous and high quality. They clearly contribute to the Chilean intellectual landscape.

The most resonant complaint, made at all institutions this reviewer (ASz) visited, was that Internet connectivity was abysmally slow and poor connectivity was hampering research. At Cerro Calán, this exacerbates the fact that the Observatory is at a considerable remove from UC campus - 1+ hour, each way. While this isolation might be mitigated with modern video conferencing technology, the available Internet connection is too slow to support video conferencing.

The CATA team is a center of excellence within the broader Chilean national research community. CATA exploits a tangible Chilean national asset – the best ground-based telescope sites in the world. While the economic impact of astronomical research is not as direct as more applied research areas, it spin-offs, secondary impacts and inspirational effects are numerous. It is imperative that CONICYT, or a parallel national funding source, find a mechanism to continue supporting this initiative at least at the level CATA currently enjoys.

Review Narrative:

On 3 Oct 2016, Terry Cutler, Jean-Claude Saut, Gino Segrè and Andrew Szentgyorgyi attended presentations at the Cerro Calán Observatory operated by UC. Representatives of the PUC Department of Astronomy were in attendance.

Gino Segrè and Andrew Szentgyorgyi were to review the Concepcion CATA site on 5 Oct 2016, however Prof. Segrè was unable to attend, so only Dr. Szentgyorgyi attended the UdeC presentations.

At both Cerro Calán and UdeC, the review panel had a closed-door meeting with the junior research staff, principally graduate students and post-docs.

Review
The research and activities at CATA were divided into 8 themes in the presentation at UC:

1. The birth of cosmic structure
2. Stellar populations
3. Distance scale
4. Star formation
5. Exoplanets and brown dwarfs
6. High performance computing
7. Instrumentation
8. Education & Outreach

The PUC/UC team's portfolio is synoptic, while the focus of the UdeC group is centered on topics 2, 3 & 8. The UdeC group, with more targeted research goals, especially Gieren's work on Cepheids, is internationally recognized as authoritative. The Santiago institutions, with their larger staff, do high-impact research in a broader cross section of research areas. Together, they contribute to every area of extra-solar system astrophysics. While this portfolio is far too large to discuss exhaustively, it is worth mentioning a few recent high points:

- CATA team members have been participants in the Faint Blue Dot Project, which discovered the existence of an exoplanet orbiting the star that is nearest to the Sun (Proxima Cen). Studies of an initiative to send spacecraft to Proxima Cen b have already been funded by Yuri Milner and the Breakthrough Foundation, and are currently in progress.
- CATA contributions to cosmology are profound and numerous. During 2015, CATA researchers produced the deepest-ever image of Malin 1, the most extended and faintest spiral galaxy in the nearby Universe. They also discovered one of the faintest galaxies seen in the early Universe.
- PUC has a leadership position in the Arizona-CfA-Católica Exoplanet Spectroscopy Survey (ACCESS) which is producing a uniform sample of measurements of exoplanet atmospheres, yielding information about the cloudiness and dustiness of those exoplanet atmospheres.
- The UC program exploits the ALMA's potential to finally understand the formation of massive stars, an unsolved puzzle in our understanding of how the first stars formed.
- The submillimetric instrumentation led by Bronfmann is an extremely shrewd exploitation of access to a one-in-the-world research platform (ALMA) and a technology that is well-matched to the capabilities of locally available CATA infrastructure.
- The UdeC education/outreach effort seemed particularly innovative and successful. One student project team built a 3- meter radio telescope that mapped galactic hydrogen.

While this is not a scientific breakthrough, the end-to-end nature of this collaborative project gave the participants an in-depth understanding of the processes that are involved in designing, building and using scientific instruments.

The CATA group publishes prodigiously in high-impact journals – 348 ISI publications in 2015. They interact regularly on the global stage, attend international conferences and make extended collaborative visits. They similarly host numerous international visitors.

CATA is a powerful engine for both specialist education and public outreach. In 2015, the were 50 CATA Master students and 11 Master degrees awarded. During that time 52 students were studying toward a PhD and 7 theses were competed. This is a large number of graduate level degrees by any measure. Public outreach, measured by media attention ("1113 appearances of CATA members at Medias in 2015, including Newspapers, Television, Radio and New Internet Webpages.") has been effective and nationally affecting.

The trends are all positive. The faculty is adding junior positions, which invigorates the institution, brings in new ideas and connects to the graduate students and postdocs. The positive impact of a new, young faculty cohort was emphasized by comments made during the graduate student/postdoc meetings at both review locations.

We note that UdeC has added a new floor to the physics building, thus consolidating the astrophysics group. This was seen as an extremely positive development by everyone. However, they are close to filling the available space, but have the capacity to add a third and fourth floor as needed.

Recommendations
We note two minor suggestions that emerged from discussions with the junior research staff:

1. As we mentioned previously, the speed of Internet access needs to be improved. Slow Internet service undercuts the funding in other sectors.

2. At Cerro Calán, there was some feeling that interactions between the observer/theorist and the astro-engineering communities needs to be encouraged.

The CATA initiative must be seen as a major success of the CONICYT Basal funding program - measured by any metric. The research the team members conduct, the outreach and the ascension of the Chilean astrophysical community on the world stage are remarkable. The CATA team is principally engaged in curiosity-driven research. Their work products are both aspirational and inspirational. While some researchers stay in a purely academic setting, many astronomers and astrophysicists with graduate degrees are skilled manipulators of "big data" and thus feed information technology and finance sectors. The inspirational value of astronomy should also not be undervalued when it comes to motivating the next generation of students to become technologists, engineers, analysts and teachers.

It is out conclusion that some mechanism must be found to maintain funding continuity for CATA beyond the current three-year extension.