

THE ORIGINS OF STRUCTURE IN THE UNIVERSE

CANADIAN ASTRONOMY AND ASTROPHYSICS IN THE 21ST CENTURY



## **2018 Pre-Budget Consultation**

### **Submission of the Coalition for Canadian Astronomy**

**August 2017**

## **Executive Summary**

Canada is a world leader in Astronomy and Astrophysics, the result of a long-term plan that identifies priority projects to sustain excellence in the field. That plan has been a remarkable success, with Canadian scientists, universities and industry reaping the benefits of participation in major international astronomy facilities.

The Coalition for Canadian Astronomy, comprising all astronomy stakeholders in this country, offers one general recommendation and three specific recommendations for Budget 2018.

The general recommendation is to establish a federal funding mechanism for big science projects, a need also identified in the report on Canada's Fundamental Science Review. Without this, Canada risks being left out of the next generation of major science facilities.

The specific recommendations deal with near-term priority projects for Canadian astronomy, including:

- Allocate \$1 billion to the Canadian Space Agency to support space science as part of a decadal plan of small, medium and large project competitions. These funds would also support Canadian leadership of a space mission;
- Continue funding engineering work on the Square Kilometer Array, and begin consultations with the astronomy community on anticipated funding requirements;
- Secure a second-to-none partnership for Canada in the Maunakea Spectroscopic Explorer.

These recommendations are designed to sustain Canada's international leadership in ground-based astronomy, while also seizing on opportunities to expand that leadership to space-based astronomy.

Finally, involvement in all these projects will deliver significant returns to the economy, while also boosting productivity and competitiveness.

## **Introduction**

The Coalition for Canadian Astronomy is composed of:

- Academia: represented by the Association of Canadian Universities for Research in Astronomy (ACURA) and its 20 member universities;
- Professional astronomers: represented by the Canadian Astronomical Society (CASCA);
- Industry: represented by Canadian companies involved in major astronomy projects.

At a general level, the Coalition endorses the findings of Canada's Fundamental Science Review, and its conclusion that investments in basic or research-oriented science are critical to productivity and competitiveness. As stated in the review report, "with careful tracking back over time, it will be shown time and time again that basic research is the upstream source of the foundational building blocks for innovations of transformative importance to the world."

More specifically, the Coalition believes there are pending investments in astronomy that will allow Canada to maintain its international leadership in this field, while also delivering significant returns to the economy.

However, the opportunities available require a nimble funding approach, and that has been lacking for decades. Without that, Canada risks being left behind in major international science projects.

## **Canadian Astronomy and Astrophysics: A Scientific and Economic Success Story**

In standard analyses of per capita impact, Canada is ranked #1 in the G8 in Astronomy and Astrophysics. Within Canada, the field has a higher world impact than any other science or engineering research area.

The Council of Canadian Academies and a report by Hickling, Arthurs & Low to the National Research Council (NRC) have documented this success, from which all astronomy stakeholders have benefited. For example, the number of universities with graduate programs in astronomy has grown from 3 in the 1960s to 20, and the population engaged in astronomy research in Canada doubles every decade. The membership of CASCA has more than tripled. Meanwhile, Canadian industry has reaped hundreds of millions of dollars in direct astronomy support work and resulting spin-offs, with new industries and companies created – and with more to come.

None of this happened by chance. The Canadian astronomy community is united behind the Long Range Plan for Astronomy and Astrophysics (LRP), which calls for Canadian participation in the next generation of global astronomy projects. The horizon for this planning document is ten years (2010-20) and it is based on extensive consultation with the astronomy community and external peer review. A Mid-Term Review (MTR), which was recently completed, takes place to ensure the LRP remains on track.

Finally, while fundamental scientific research has always been the primary goal of Canadian astronomy, we are also proud of the resulting economic benefits. Things like WiFi, laser eye surgery and high-resolution x-ray imaging are spin-offs from astronomy research. The priority projects identified in the LRP and MTR for future investments offer great potential in new technology areas like optical science, high speed data networking, remote sensing, space technology and large-scale computation. That is why Canadian industry has always been a partner in the Coalition, along with our scientists and universities.

### **General Recommendation: Funding Mechanism for Big Science Projects**

Like most scientific disciplines, astronomy is moving to next generation facilities, or what are commonly known as “big science” projects. These are facilities with huge price tags (often in the billions of dollars), multiple international partners, long planning and construction cycles, and even longer operational lifetimes.

Without a mechanism to fund big science projects, scientists are forced to spend huge amounts of time lobbying for financial support as a decision on engaging in a project lands at the political level and requires a commitment outside existing budget planning, which is a huge challenge.

The Coalition has previously recommended the establishment of a big science fund or funding mechanism, a view that was echoed by the report on the Fundamental Science Review. The latter recommended creating a National Advisory Committee on Research and Innovation (NACRI), whose duties would include providing advice “on large-scale domestic and international research infrastructure projects, and on unusual requests for research support that fall outside the usual remit of the granting councils and Canada Foundation for Innovation.” In addition, the report recommended establishing a Standing Committee on Major Research Facilities (MRFs) as part of NACRI to “consider international MRFs in which Canada has a significant role, such as astronomical telescopes of global significance.”

Media reports suggest the Science Minister is not planning to pursue the recommendation to establish NACRI. Regardless, Canada still needs a funding mechanism for big science projects with adequate capacity to take advantage of the opportunities available to Canada’s leading disciplines. As our own experience has shown, without a nimble funding mechanism opportunities can be lost.

Finally, as part of that funding mechanism the Government should consult with disciplines on their emerging priorities. In the case of astronomy, for example, we have identified our decadal plan and priority projects. With a reasonable degree of accuracy, we can project infrastructure and operational costs on a long-term basis. If all disciplines had a similar approach the Government would have some ability to plan financially over a long timeframe for potential big science projects.

***Recommendation #1:** Establish a long-term and adequately resourced funding mechanism for big science projects.*

### **Specific Recommendations: Priority Astronomy Projects**

There are three near term priorities for Canadian astronomy, as detailed in the Mid-Term Review (MTR) of the Long Range Plan (LRP).

#### **New Vision for Space Astronomy**

Canada’s position as a global leader in ground-based astronomy was secured with funding of the Thirty Meter Telescope (TMT) in 2015, a project in which Canada is a leading partner, along with ongoing involvement in the Square Kilometer Array (see below).

Canada also has the potential to be a leader in space astronomy. However, that requires a vision for space astronomy within the Canadian Space Agency (CSA) and funding to support regular space missions.

The Coalition recommends an initial decadal plan for space science supported with a \$1 billion investment in the CSA. A fraction of this money (determined competitively) would be used to support space astronomy, with regular competitions for small, medium and large space projects, including Canadian leadership of a flagship space exploration mission (costing roughly \$400 million out of the proposed \$1 billion) – something identified as a priority in the MTR.

These regular competitions would replace the current piecemeal approach to project funding for space science. They would also stimulate vigorous interaction between scientists and aerospace companies, building on Canada's already strong reputation for industrial work to support space projects.

To put this need for a plan in perspective, Canada is currently a partner in the James Webb Space Telescope (JWST), scheduled for launch in 2018. The JWST has a lifespan of roughly a decade. Given the long timelines to conceive, build and launch space projects, Canada needs to start thinking about a successor to the JWST, else we could be left out of space astronomy within a decade.

***Recommendation #2:*** *Allocate \$1 billion to the Canadian Space Agency to support a decadal plan of small, medium and large project competitions, including Canadian leadership of a space mission.*

### **Square Kilometre Array (SKA)**

The SKA will be the largest and most powerful radio telescope ever built. It is a landmark global research facility (on the scale of the Large Hadron Collider), with an estimated scientific lifetime of at least 50 years. It aims to address some of the largest questions in physics and cosmology, like the nature of dark energy, dark matter, gravity and magnetism, and the origin of life.

Much of its science case was conceived and developed by Canadian astronomers and Canada has been a member of the SKA consortium since its inception. We have been engaged in planning and governance for 20 years, spending around \$25 million on design studies, technology demonstrators and pre-construction.

Participation in the SKA is one of the top two recommendations in the LRP. Canada is positioned to deliver the “correlator” for the first phase of the project that will combine the signals from the thousands of dishes in the array into a single image. The correlator is the central and most challenging component of this phase.

All work anticipated for Canada is in highly skilled sectors. Previous investments in radio astronomy research have a proven track record of delivering long-term economic spin-offs (everything from WiFi to brain imaging). A 2014 report prepared for the NRC projected the market for SKA-related technologies will be US\$138 billion by 2019.

***Recommendation #3:*** *Continue funding engineering work on the SKA, and begin consultations with the astronomy community on anticipated funding requirements.*

### **Maunakea Spectroscopic Explorer (MSE)**

The 3.6-metre Canada-France-Hawaii Telescope (CFHT), located on Maunakea, Hawaii, has been one of the most successful and productive facilities in astronomy over the past four decades. It has been determined that the existing pier and building for the CFHT could accommodate a larger telescope. The MSE is an ambitious redevelopment project to transform the existing CFHT into an 11-metre facility with a dedicated wide field multi-object spectrograph.

This project has considerable international interest. Its science case is universally recognized and it would have a transformative impact in a wide range of fields, including stellar structure and evolution, transient phenomena, large-scale structure, active galactic nucleus physics, the nature of dark matter, and the epoch of reionization. The MSE is also highly complementary to other projects in which Canada has a stake.

A project office is currently in the design phase and the total estimated cost is \$250-300 million. When this cost is divided by the number of significant partner (~6) and reduced through the reuse of Canada's current investments in the CFHT infrastructure, the estimated cost for a "second-to-none" share for Canada is around \$40 million. The goal is to have the redeveloped facility operational by 2025.

As Canadian industry is already the world leader in the design and construction of large telescopes, there is a very strong possibility much of that work would be done here.

***Recommendation #4: Secure a second-to-none share for Canada in the MSE.***

### **Conclusion**

The Fundamental Science Review noted the direct link between investments in basic science and the productivity, innovation and competitiveness of the Canadian economy. The experience with Canadian astronomy offers ample evidence to support that assertion.

The Coalition has a plan to continue Canada's success in astronomy. There is enormous scientific and economic potential stemming from the projects detailed in this submission. However, much of it is tied to developing a federal funding mechanism for big science projects and a vision for space astronomy.