

THE ORIGINS OF STRUCTURE IN THE UNIVERSE

CANADIAN ASTRONOMY AND ASTROPHYSICS IN THE 21ST CENTURY



2020 Pre-Budget Submission

Coalition for Canadian Astronomy

August 2019

Recommendations

- Consider a model similar to the economic strategy tables for Canada's top sciences to ensure their continued growth and international leadership.
- Create a funding entity for big science projects with sufficient resources for Canadian researchers to take advantage of international collaboration opportunities on big science projects.
- Establish a new vision for the Canadian Space Agency that includes space science, with annual funding of \$100 million to support competitions for small, medium and large space missions.

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 members;
- Professional astronomers: represented by the Canadian Astronomical Society (CASCA);
- Industry: represented by Canadian companies involved in major astronomy projects.

The Coalition is united behind the Long-Range Plan for Astronomy and Astrophysics (LRP), a decadal plan first launched in 2000 and renewed in 2010, with a view to sustaining Canada's international leadership in this field. The next LRP will be released in 2020.

The LRP process, backed by Coalition support, has created a legacy of success, with astronomy consistently ranking as Canada's top science and Canadians at the forefront of this field globally. At the same time, Canadian astronomy is becoming increasingly diverse as it moves towards a better understanding of career barriers facing certain underrepresented groups. CASCA has been surveying members on equity issues since 2005, has conducted a climate survey of members through its Equity and Inclusivity Committee, and is actively involved in international discussions on diversity within the astronomy community.

At the present time, two significant and related challenges require attention for Canada to maintain its international leadership. First, for ground-based astronomy, there is no funding mechanism for big science projects, like international telescope collaborations, which are critical to maintaining Canada's leadership. Second, the same problem exists for space-based astronomy and recent investments in the Canadian Space Agency (CSA) do not resolve that.

Our submission offers recommendations to address both challenges, but first provides background on the scientific and economic success story of Canadian astronomy.

Canadian Astronomy and Astrophysics: A Scientific and Economic Success Story

In standard analyses of per capita impact, Canada is ranked #1 in the G7 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 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; it is the outcome of the LRP and Coalition approach. The LRP calls for Canadian participation in a carefully crafted portfolio of next generation projects and is renewed each decade based on extensive consultation with the astronomy community and external peer review.

While fundamental research has always been the primary goal, we are also proud of the resulting economic benefits. Things like WiFi, laser eye surgery, high-resolution x-ray imaging and even the technology being used to search for Ebola and Zika vaccines are spin-offs from astronomy research. The priority projects identified in the LRP 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.

Moreover, the deep innovation that leads to high precision technologies and algorithms designed to image and measure molecular and atomic processes millions of light years away can frequently be adapted to ground-breaking studies of the Earth from space. That is why Canadian industry has always been a partner in the Coalition, along with our scientists and universities.

The Federal Government has been an important partner in this success, largely through the National Research Council. However, significant opportunities continue to be missed, partly for the reasons detailed in the next sections, but also because there does not seem to be a policy focus that embraces Canada's top performing sciences.

For example, the Government has “economic strategy tables” to nurture specific economic sectors it believes are poised for high growth and for which Canada has existing expertise. However, when it comes to science, despite there also being huge economic opportunities from nurturing top disciplines, there is no equivalent. The economic strategy tables provide a model that could be applied to Canada's top sciences, as they are designed to set ambitious growth targets, identify sector-specific challenges and bottlenecks, and lay out an actionable roadmap to achieve their goals. Much of that already exists for Astronomy in the LRP, but it is missing the Government buy-in to the notion of nurturing specific sciences for further growth and leadership.

Recommendation #1: Consider a model similar to the economic strategy tables for Canada's top sciences to ensure their continued growth and international leadership.

Funding Mechanism for Big Science Projects

Like most scientific disciplines, astronomy is moving to next generation facilities, or “big science” projects: facilities requiring significant investments with multiple international partners, long planning and construction cycles, and even longer operational lifetimes.

While this applies to both ground- and space-based astronomy, this section focuses on the former since there is a logical home for funding big science in space, namely the CSA. For ground-based astronomy, the lack of an official big science funding mechanism means scientists are forced to spend time away from their research 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 and creates uncertainty with project partners.

The Coalition has previously recommended the establishment of a big science funding mechanism, a view that was echoed by the report on the Fundamental Science Review. Canada needs a formal entity to which applications for big science projects can be made, and the funding needs to be of a sufficient scale to take advantage of opportunities for international scientific collaborations.

To determine what that number should be, the Government should consult with disciplines on their emerging priorities. For astronomy, for example, with our decadal plan we can project infrastructure and operational costs on a long-term basis with a reasonable degree of accuracy. 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 #2: Create a funding entity for big science projects with sufficient resources for Canadian researchers to take advantage of international collaboration opportunities on big science projects.

A New Vision for the Canadian Space Agency

Canada is a leader in ground-based astronomy and that same potential exists in space – including the very real possibility of leading an international space mission. However, the CSA is not structured in a manner that allows this, even with the new space strategy and funding announced in March 2019. While the CSA works diligently to support human spaceflight and is now highly focused on the Lunar Gateway, it is not resourced to support and reap the benefits of an active space-based science portfolio.

In advance of the release of the new space strategy, the Coalition had recommended a reconstituted CSA with a vision for planetary exploration and space astronomy and funding to support regular space missions. A \$100 million annual investment would have allowed for regular competitions for small, medium and large space projects, including Canadian leadership of a flagship space exploration mission. This money would flow to high technology industry-university partnerships and leverage entry into technology markets hundreds, if not thousands, of times larger. The \$100 million figure represents a per capita investment in space astronomy that is roughly half the scaled per capita astrophysics budget of NASA.

This annual investment would have covered the existing and emerging opportunities for space astronomy and a portfolio of around a dozen other projects that would realize Canada's potential to be a space leader while growing the industries that support space science. Unfortunately, without that investment space astronomy in Canada faces a very uncertain future at a time when our international collaborators are increasing their investments and want to partner with our expertise. Without funding, there will be no space astronomy projects and the researchers and students who focus on space astronomy will have to go abroad, as will the industries that support this work.

Recommendation #3: Establish a new vision for the CSA that includes space science, with annual funding of \$100 million to support competitions for small, medium and large space missions.

As part of the above, Canada could take the lead on its own space mission, rather than acting as a supplier for other countries' projects. The Cosmological Advanced Survey Telescope for Optical and Ultraviolet Research (CASTOR) is a proposed Canadian-led mission that would make a unique, powerful and lasting contribution to astrophysics by providing panoramic, high-resolution imaging in the UV/optical spectral region. This versatile and innovative 'smallSAT'-class mission would far surpass any ground-based optical telescope in terms of angular resolution and provide the highest resolution UV/optical survey ever taken over an area 1/8th of the entire sky.

While simultaneously breaking new ground in science areas such as galactic archaeology, quasar monitoring, star formation and stellar astrophysics, it would also provide ultra-deep imaging in three broad filters to supplement longer-wavelength data from planned international dark energy missions. CASTOR would combine the largest focal plane ever flown in space with an innovative optical design that delivers quality images over a field two orders of magnitude larger than Hubble. No planned or proposed astronomical facility would exceed CASTOR in its potential for discovery at these wavelengths.

While the science is our priority, there is also economic opportunity from such investments. Space is the window into everything happening on our planet and beyond. Technologies that allow us to look out to the Universe beyond also help to look down and understand problems closer to home. Climate change, communications, natural resource management and national defence owe many advances to space science and exploration. Investing in space science would stimulate vigorous interaction between scientists and aerospace companies, building on Canada's already strong reputation for industrial work to support space projects.

Past investments in space science have generated and advanced technologies like fine guidance sensors, metrology systems, digital frequency multiplexing readout systems, while imaging Fourier transform spectroscopy and wavefront sensor technology, which have both ground- and space-based applications, are about to energize export markets. Looking ahead, the market for the space industry is projected to grow from \$350 billion to \$1-2.7 trillion by the 2040s. For example, the market for industrial metrology is projected to be \$13 billion by 2023, and for intersatellite communications \$5 billion by 2025.

Conclusion

Canada is a world leader in astronomy, but we could do more, both on the ground and in space, if the Government embraces its leading scientific disciplines in the same manner it is with certain industries. Establishing a fund for big science projects would be an important step in that regard. Moreover, if the CSA was given a mandate and funding to support space astronomy, another frontier of research excellence would be attainable, including the exciting prospect of Canada leading a space mission. Rather than celebrating putting a part on someone else's mission, Canada could lead its own – and that would stimulate the next generation to pursue a career in the STEM fields. Finally, in sustaining that scientific leadership, the Government can also stimulate the hundreds of companies that support astronomy work, with enormous – and proven – spinoffs that create jobs and position Canadian industry for the economy of the future.