

THE ORIGINS OF STRUCTURE IN THE UNIVERSE

CANADIAN ASTRONOMY AND ASTROPHYSICS IN THE 21ST CENTURY



2021 Pre-Budget Submission

Coalition for Canadian Astronomy

August 2020

Recommendations

- Secure a partnership in the Square Kilometre Array that provides Canada with scientific and technological leadership, and allocate funding of \$160 million over the next decade.
- Provide \$250 million over the next decade to pursue CASTOR, a Canadian-led space mission poised to be the successor to the Hubble Telescope.
- Maintain Canada's already funded contribution to construction of the Thirty Meter Telescope.

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 this fall, though this submission is built around its main recommendations.

The LRP process, backed by Coalition support, has created a legacy of success, with astronomy consistently ranking as Canada's top science¹ and Canadians at the forefront of this field globally. As will be outlined in the 2020 LRP, there are three main project priorities over the next decade, two of which require consideration outside regular funding opportunities through the granting councils and Canada Foundation for Innovation (CFI). These are large projects that will keep Canada at the forefront of this field, energize future generations to pursue a career in STEM fields, and position Canadian industry to secure billions of dollars in direct work and spin-off opportunities.

Canadian Astronomy and Astrophysics: A Scientific and Economic Success Story

In addition to being ranked as Canada's top science, in standard analyses of per capita impact, Canada is ranked #1 in the G7 in Astronomy and Astrophysics.² 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 billions 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, which is why Canadian industry has always been a Coalition partner. 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.

¹ https://cca-reports.ca/wp-content/uploads/2018/09/Competing_in_a_Global_Innovation_Economy_FullReport_EN.pdf

² https://www.scimagojr.com/countryrank.php?category=3103&area=3100&order=cd&ord=desc&min=1000&min_type=it

The broad skill set required means that astronomy trains graduates that go into careers as diverse as fundamental research, instrumentation, optics, data science, satellite operations, laser technology, medical physics, archiving, and numerical modelling, to name just a few.

Finally, the Federal Government has also been an important partner in this success, largely through the NRC, granting councils and CFI. Astronomy has demonstrated that Canada can be a world leader when all its stakeholders unite behind a common plan. With that in mind, the following sections detail three priority projects in the 2020 LRP, two of which exceed the scope of funding opportunities through existing mechanisms and require consideration outside that. Fortunately, however, the third is already funded.

Priority #1: Square Kilometre Array (SKA)

The SKA is a global observatory that will enable transformational science about the history, contents, extreme conditions, and prospects for life in the Universe. The SKA is Canada's top unfunded ground-based astronomy project and construction is due to begin in 2021.

There are two recommendations with the SKA. First, Canada's share of construction and operation costs will be roughly \$160 million over the period from 2021-2030. This cannot be funded within any existing mechanisms and therefore needs a separate budget allocation.

The funding is divided roughly 50/50 between construction and operations. Of that, roughly 70% of construction costs would be allocated domestically as Canadian industry is the world leader in manufacturing the correlators integral to the project. In addition, around two-thirds of the annual operational costs could also be retained in Canada assuming we provide one of the project's Regional Data Centres. In fact, Canada could provide the only such facility in all of the Americas. Therefore, of the \$160 million allocation, about \$106 million would be kept in Canada and would be a helpful stimulus to the economy.

Second, the SKA is in the process of establishing a treaty-based governance model. For Canada to be a scientific and technological leader, we must be either a treaty partner (ideally) or at least an associate member. Without that, Canada could still participate, but would have no say in SKA governance, procurement decisions, and so on, hence potentially missing out on many economic benefits. Therefore, the first recommendation is for Canada to join the SKA either through a treaty or as an associate member.

Recommendation #1: Secure a partnership in the Square Kilometre Array that provides Canada with scientific and technological leadership, and allocate funding of \$160 million over the next decade.

Priority #2: Cosmological Advanced Survey Telescope for Optical and UV Research (CASTOR)

CASTOR is the natural successor to the Hubble Space Telescope, which is perhaps the most famous telescope ever, and is the top priority in space astronomy in the 2020 LRP. CASTOR will be the world's preeminent telescope at ultraviolet and blue-optical wavelengths and its scientific impact will be immense, from the nature of dark energy to the search for ghostly planets in the outer fringes of our Solar System.

Now consider this: CASTOR is a Canadian-conceived and led project. For almost a decade, Canadian universities, industry and Government agencies have been working on plans for CASTOR, which will outperform Hubble (100x larger field of view) at a fraction of the cost. Furthermore, with Hubble likely to end its mission by the end of the decade, CASTOR is the emerging successor and interest is growing from space agencies and research entities in the U.S., U.K. and India, though there is a risk India could move first and manoeuvre themselves into the leadership position, leaving Canada as a potential future partner, but not at the helm.

CASTOR is a remarkable opportunity for Canada to demonstrate its space leadership and to inspire the next generation to pursue a career in STEM fields. With all due respect to the Canadarm, which has inspired Canadians for decades, that was a component of someone else's project. CASTOR is a Canadian-led mission, putting the maple leaf on Hubble's successor.

Along with 16 Canadian universities, three Canadian companies are already heavily involved in project planning: Honeywell Aerospace (Cambridge and Ottawa), Magellan Aerospace (Winnipeg) and ABB (Montreal and Quebec City). CASTOR will showcase Canada's state-of-the-art aerospace and engineering capabilities to a global audience and position Canadian industry in sectors with high export potential, including low-cost and lightweight optical components, high-speed laser links, optical communications hardware, massive data processing and archiving, and spacecraft bus platforms and subsystems. The market for the space industry is projected to grow from \$350 billion to \$1-2.7 trillion by the 2040s. CASTOR will associate Canadian science and engineering with these opportunities.

Given the pandemic, the Coalition feels the timing is ideal for an investment to move CASTOR from conception to reality and support our high-tech industries. The fully Canadian mission cost is estimated around \$400 million, with operational costs of \$20 million annually. A launch date of 2026 is feasible and desirable. A commitment of \$250 million will ensure Canadian scientific and industrial leadership, with international partners covering the rest and sharing operations costs.

Ideally, CASTOR would be funded through the Canadian Space Agency (CSA). However, the CSA is not structured in a manner that allows this. 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. We have previously recommended an increase in the CSA budget of \$15 million annually to support competitions for small and mid-level space astronomy projects.

In addition, we believe Canada has the capacity to support one large space project each decade, with CASTOR the best such opportunity. We recommend that the Government work with Canadian astronomers and industry to make CASTOR a reality.

Recommendation #2: Provide \$250 million over the next decade to pursue CASTOR, a Canadian-led space mission poised to be the successor to the Hubble Telescope.

Priority #3: Thirty Meter Telescope (TMT)

Substantive participation in a very large optical telescope (VLOT) has been a priority since the first LRP in 2000. A VLOT is defined as an optical or infrared facility with a mirror diameter of approximately 30 metres, which is around ten times the collecting area of the world's current largest telescopes and represents the scale of facility needed to answer frontier questions in observational astronomy, including discovery and characterization of exoplanets, the oldest Milky Way stars and the first galaxies, new tests of general relativity and cosmology, measurements of supermassive black holes in nearby galaxies, and detection and spectral characterization of distant icy bodies in the solar system.

There is good news to report on this priority: since 2003, Canada has been a partner in the TMT, along with China, India, Japan, the University of California and Caltech. The even better news is that Canada's \$243 million financial commitment to TMT construction was secured in 2015.

However, there have been delays in construction due to the local situation in Hawaii, where the TMT was to be built atop Maunakea. Many processes are underway in an effort to resolve those, but as this is an internal matter to Hawaii that extends well beyond any issues related to the TMT itself, the Coalition feels it is best left to local stakeholders to resolve. In the event those issues cannot be resolved, a back-up site has been selected in Spain's Canary Islands.

Canada has been a leader in the conception and design of TMT from day one, and Canadian industry is poised to build the critical telescope enclosure and Canadians are also leading work on the facility's adaptive optics system, an area with enormous economic spin-off potential. The TMT is an excellent example of Canadian scientific leadership and should be celebrated as such.

Recommendation #3: Maintain Canada's already funded contribution to construction of the Thirty Meter Telescope project.

Conclusion

Canada is a world leader in astronomy and the three priority projects identified in this submission have been selected because they will enable us to remain in this position for the next decade. Better yet, one is already funded. That said, the Coalition recognizes the other two have large price tags, but those figures should be considered within the context of the ten-year plan. These are also investments that will generate significant direct and indirect opportunity for Canadian industry, as has been proven already with the TMT.

If nothing else, this Committee – and indeed all Parliamentarians – should be thrilled at the prospect of Canada leading the successor mission to the Hubble telescope. Think of all the articles you have read about the discoveries made by Hubble, and then imagine a few years from now all such stories crediting a Canadian-led mission for the next frontier of space astronomy discoveries.