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**NRC · CNRC**

***American Astronomical Society***

*A Canadian Vision of International Astronomy and Astrophysics*

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201st AAS Meeting - Seattle Washington

January 2003

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**Canada**

## Introduction

Good morning and thank you.

It is a genuine honour to speak to you today.

First of all I have an apology to make. I am not an astronomer – not even a physicist. In fact I'm an inorganic chemist by training and as President of Canada's National Research Council since 1994 I have increasingly realized that I know less and less about more and more – a natural outcome of the diverse activities of our Council across a broad spectrum of science and technology. So I bring the perspective of a non-expert but deeply interested and committed supporter of astronomy to your deliberations today and this week.

Let me start off with a few brief words about Canada's NRC.

As the Federal Government of Canada's principal performing R&D agency, we carry out leading edge R & D in areas important to Canada, and we partner with universities and industry to generate knowledge, promote research excellence, and foster innovation.

NRC performs R&D in 19 institutes and 4 technology or innovation centers right cross the country in areas ranging from biotechnology (for example genomics for drug discovery and health care, aquaculture and plant biotechnology to quantum information technology and software for e-business; from aerospace and marine engineering to advanced manufacturing technologies; from nanotechnology to fundamental molecular sciences and of course astronomy.

We are a growing organization as a result of new investments in NRC by our federal government and while not all parts of our organisation have benefited from this new funding our budget has almost doubled since 1994-95.

Clearly, in an organization as diverse as ours, our institutes and their partners share many challenges and opportunities including globalization.

And in this context, astronomy surprising as it may seem provides some of the most persuasive examples of the benefits of international cooperation in science and technology.

So I consider myself privileged to have this wonderful venue to discuss not only astronomy, but also the issue of international cooperation.

I would like to describe

- The Canadian approach to astronomy, which I believe has some unique features
- Our country's commitments for the future, and finally

To suggest how we might work to build upon our international collaborations in the decade ahead.

I appreciate the invitation of AAS to speak and trust that it is a function of the respect you hold for Canadian astronomy – not only the great scientists past and present (such as Gerhard Hertzberg – Nobel Laureate shown here but also Canadian contributions to international astronomy – instrumental and observation.

Over the past decade, I have come to appreciate the value of astronomy not only as a fundamental by important scientific discipline, but also as a unique vehicle for encouraging national and international cooperation and for turning our young people on to science and technology.

I began to understand the very special nature of Canadian astronomy and the relationships it embraces even before I started my first term at NRC when two colleagues at the University of Waterloo one of whom, Gretchen Harris is here today, came to me after learning of my appointment.

They were not acting so much as advocates for the discipline of astronomy, but for the special partnership between universities, the private sector, and the national laboratories that have helped make astronomy a technological as well as a scientific success in Canada.

In the years since, my respect for astronomy and Canadian astronomers has grown enormously - notwithstanding the achievements, the pressures, and the exciting developments in the many other disciplines and other parts of our organization.

A large part of this respect of course, flows from the high quality of the work and a sustained quest by Canadian astronomers for excellence as judged by their international peers.

Canada's share of total world publications in astronomy is about the same as our fraction of world science. This is nicely illustrated in this table which shows, for example, that astronomy is ranked in general, as the top scientific discipline in Canada in terms of relative citation rates as a percentage of world citations.

Now a glowing national reputation is almost always the function of dedicated, brilliant individuals, and such is the case with Canadian astronomy.

But I believe the achievements of our astronomers are magnified by the Canadian context which is that of a smaller nation – not geographically of course but in terms of population and influence.

And it is, very much, a story of national and international collaboration.

So today, as I speak on behalf of Canada's interests in astronomy, I would like to encourage you to think on a grand scale.

I do so knowing that I am speaking to an audience that is quite capable of imagining and articulating immense challenges – an audience with a demonstrated capacity to “think outside the box”.

In the spirit of one of Arthur C. Clarke's favourite quotes, it is your job I believe, to think and to imagine, and to do so fuelled by an ever-expanding base of knowledge and by tools and techniques that make the “impossible” real.

Today, I want to ask you, the members and supporters of the American Astronomical Society, to use these talents to think globally.

And to pose the question of whether we are not now at the point where we might be able to craft, articulate, and advance a long term, world plan for astronomy and astrophysics.

One that not only unites humanity in a common vision, but one that makes the benefits to future generations clear to all – governments, national institutions, and all citizens of the world.

Although this will be a challenge, I believe that we might already be on the verge of such an international plan and that one is certainly possible within the decade.

To a certain extent, the exercise would be one of gathering together the elements of contemporary national and regional plans into a coherent form for global benefit. Such “synthesis” atop the shoulders of giants is not an ignoble process. Darwin, Newton, and others recognized that they owed much to it.

But I also believe that the development and expression of a collaborative global plan for astronomy would draw upon previously untapped creative forces and some of that inspired “poetic” thought that could combine to change the way we look at ourselves and our world. I believe that it would speak to a vision of a better world. I believe it could help to change the world for the better.

## **(1) The Canadian Scene**

And, as I have indicated, I believe that astronomers are up to that challenge. And I also believe Canada can make a unique contribution.

We are, indeed, a smaller country, but we have made our mark on astronomy and on the technologies that underpin it.

I have listed a very few examples outstanding Canadian contributors in the next two slides. As a nation, we are firmly committed to international collaboration and have demonstrated a determination to deliver on our long-term commitments.

Today we know, as everyone in attendance at this meeting will agree, that the world is entering the most extraordinary age of astronomical discovery.

Humanity has been gazing at the stars for millions of years and mapping the heavens for millennia. We certainly have a deeper knowledge of the chemistry and physics of the universe, but that, in no way, diminishes our rapidly expanding sense of wonder and excitement.

Even those with only a modest awareness of the developments in your field can appreciate the changes that our theories of the universe have undergone over the last hundred years.

A century seems like a small unit of time when you ponder humanity's move from the vision of a limited, static universe to one that is not only expanding, but that may be doing so at an increasing rate.

We have not only gone beyond our own galaxy, but seen evidence of billions more and even of other planetary systems. And, of course, these discoveries provide us with a base to look at other horizons, consider other questions, and plan further exploration.

Canada is proud of its contributions to this global voyage of discovery.

As you saw, in a previous slide, the scientists in our universities and institutions have been ranked very highly on a relative basis in terms of citation rates and other measures of performance. Centres at the Universities of Calgary, McMaster, Toronto, Montreal, Laval and many others including, of course, the nearby University of British Columbia and the University of Victoria provide a powerful focus for collaboration and education.

Canadian university astronomers and their students have been and will continue to be in the vanguard of this exploration of our universe and, we believe, will continue to be highly productive scientifically.

We also believe that we have contributed to and will continue to develop the enabling technologies that make new discoveries possible and facilitate new understanding through enhanced access to new data.

This is the focus of NRC's Canadian Astronomy Data Centre in Victoria and other programs as evidenced by the contributions in this slide.

But on the level of national policies, which is the focus of my remarks today, our concerns must address the broad need to provide access to the facilities, the vessels so to speak, that will carry scientists on this voyage of discovery.

In this regard, we are extremely proud of our track record and role in international collaborations to build observatories and astronomical research facilities.

The Canada-France-Hawaii Telescope on Mauna Kea, for example, shown here on the left, which has helped pioneer adaptive optics and other innovations, continues to be among the world's best optical telescopes in its class and is embarking this month on the ambitious, 500 night, 5 year CFHT Legacy Survey; the James Clerk Maxwell Telescope is making valued new discoveries in sub-millimetre radio astronomy, and the Gemini telescopes are ready to join the best 8-metre class observatories.

We have, in turn, benefited from international involvement in Canadian initiatives such as the Galactic Plane Survey.

The GPS evolved from a Canadian initiative to become a truly international undertaking as shown here.

These initiatives and others have laid the groundwork for the new era of astronomical research characterized by major new facilities – some call them World Observatories – unique in scale and degree of international involvement.

Time Magazine once talked of the “Beyond Hubble” era.

By whatever descriptor, the new era of world facilities is a context that all astronomy nations must consider and address.

It is potentially a unifying force. It is, perhaps, the basis for a world vision.

In Canada, we have tried to develop a strategy to address the issue and maintain our high impact in astronomy & astrophysics through our first, clear, long term national plan for astronomy and astrophysics.

The plan was based upon national consultations and high level peer reviews – I think there is a broad consensus that the development and promotion of the LRP over the past few years has been an enriching exercise.

And I would like to use our experience as a vehicle to describe the Canadian astronomy scene and our views.

But first let me state unreservedly, that we are very indebted to the United States of America for having pioneered this logical, yet visionary approach through its decadal reviews.

The American Astronomical Society is, of course, a major force behind this approach, and a major reason for its success.

The Long Range Plan for Canadian Astronomy and Astrophysics, or the L-R- P as we call it, has served to highlight both our national weaknesses and our national strengths.

One of our national strengths is the National Research Council of Canada's Herzberg Institute of Astrophysics.

NRC's H-IA is certainly unique in Canada and has been called "unusual in the world" <sup>1</sup>reflecting in part its combination of the activities handled by NOAO, NRAO and NASA centres in the United States.

It is set apart as an astronomy institute within Canada by the size and diversity of its engineering and computational expertise and its instrumentation development facilities. Our Institute is active in high precision instrument design, data management, software development, and several other fields which have technology spin-off value to industry.

Indeed, HIA is committed to working with industry and to supporting technology transfer and economic growth in many sectors. In fact, you might be surprised to know that H-IA has its own dedicated business development office to support these activities. In this way, NRC encourages astronomy to help generate the economic wealth that ultimately makes possible the pursuit of advancing the science of astronomy.

At the same time, we recognize the the key to our success to maintain a base of world-class research activity and to attract and retain the brightest and the best astronomers as employees.

People like Jim Hesser, David Crampton, Peter Dewdney, John Hutchings, Tom Landecker, Don Morton, Peter Stetson and Sydney van den Bergh and many others I could mention, have helped NRC maintain the essential link to science that opens doors and builds upon the legacy of Dr. Herzberg.

The quality and vision of their science helps us establish new international linkages essential to national goals.

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We also welcome active scientists as sabbatical visitors and post docs to HIA facilities.

For example, we were delighted to be able to bring Dr. Raja Guhathakurta from the University of California at Santa Cruz to NRC this year under a Herzberg Memorial Prize and Fellowship Award, our newly established and most distinguished award.

We also place great importance upon our leaders – our management team and, in this respect, I am very happy to use this occasion to formally announce the appointment of Dr. Greg Fahlman as the new Director General of NRC's Herzberg Institute of Astrophysics.

Greg, as the Executive Director of the CFHT has real-life experience in a particularly successful international collaboration. We are delighted to welcome him to our most senior position in astronomy at NRC.

Finally, I would like to mention our New Horizons – New Opportunities program initiated just last year at NRC to hire 50 outstanding young and established scientists and engineers into continuing positions in NRC including HIA. Great hopes.

So in summary, I believe that the expertise at H-I-A constitutes a strategic national asset for Canada, and we at NRC recognize the value of the contributions they make to Canadian science.

But there are other important players on the Canadian astronomy scene, and I would like to say a few words about how NRC relates to them and how those relationships differ from the situation in the U.S.

Specifically, the National Research Council's legislated responsibility is to manage and operate federal observatories within its broader mandate to stimulate research and industrial innovation across Canada.

We consider the university research community to be our partners and clients with respect to astronomy, and we seek to serve that community, but also to serve Canadian industry and the national interest at the same time.

NRC does not fund university research or university-based facilities. In fact, NRC in Canada has greater similarity to the national labs like NIST, Argonne, Brookhaven, etc in the United States and the Max Planck and Helmholtz institutes in Germany.

In Canada, the Natural Sciences and Engineering Research Council – NSERC – an organization that was created as a spin-off from NRC close to 25 years ago – is the major source of grants and scholarships to Canadian university astronomers. Thus, in Canada national astronomical facilities are currently

funded by NRC while research grants to university faculty come through NSERC, an approach quite different from that of the National Science Foundation.

NSERC has been bolstered in recent years by new programs such as the Canada Research Chairs – a \$900 million dollar-Canadian, federal program established in 2000 to create 2000 junior and senior chairs for researchers who are or have the potential to be world leaders in their fields. A number of top astronomers have been appointed to these positions in Canadian universities.

The Government of Canada has also created a separate foundation – the Canada Foundation for Innovation - to fund scientific infrastructure in universities and endowed it with over three (3) billion dollars – in Canadian funds - including some funds to support international collaborations. CFI is a unique and very powerful new force in Canadian science funding.

But because of the peculiarities of our government's Financial Administration Act and because of the Foundation's status as an independent arms length agency, it cannot flow funds directly back to government labs.

It, therefore, does not have a mandate to support national facilities such as those managed by NRC's HIA.

In total, these recent new initiatives by the current Government reflect a major increased commitment to research in Canada, and I believe it is fair to say that we have seen a dramatic stimulus to university research in our country in recent years.

The Canadian Space Agency is also very active in supporting Canadian involvement in space-based astronomy facilities and works in close partnership with NASA in projects that include work on the James Webb Space Telescope.

But unlike NASA, the Canadian Space Agency does not directly fund astronomical research by university faculty and focuses its efforts much more on industrial development and contract management in the space industry.

Finally, to complete the picture we have a very special engineering and industrial technology sector in Canada which has, among other things, established itself as one of the world's premier observatory dome builders as shown here by the circled domes on Mauna Kea.

The companies who have developed this expertise and built these enclosures are successful because they build on, worked with the insights and expertise of scientists active in leading edge research on frontline facilities, who help them understand the critical science drivers and of course the needs and opportunities in astronomy.

This is, in fact, an outstanding example of a mutually beneficial public-private sector relationship in fundamental science – one I might say which constantly surprises people, including politicians who think that there could not possibly be any return on investments in a very fundamental science such as astronomy.

Over the past few months, Canadian universities have begun the process of forming ACURA, the Association of Canadian Universities for Research in Astronomy. They are planning to request funds for design studies of the next generation large optical telescope, in the 20-m to 30-m aperture range. These studies will be conducted in partnership with Canadian industry, such as AMEC, Dynamic Structure and of course, NRC's HIA.

Let me now return to Canada's current strategy. This rests very heavily upon a national consensus around the LRP. The strong support of the LRP by university presidents is shown in this slide.

But, as I hope you can appreciate, we have a system with many players for a small nation, and it depends very much upon partnerships and mutual support.

Which brings me back to the unique set of skills and the diversity of human expertise that NRC's HIA embraces.

These underpin NRC's capacity to partner with universities, to extract national technological benefit from astronomy, and to contribute intellectually to international collaborations. And collaboration – both national and international - will undoubtedly be a cornerstone of our future.

## **(2) Canada and The Future**

When it comes to the construction and maintenance of facilities, we want to build substantive, technology-based collaborations.

We as Canadians are not only proud, for example, to be partners in the Gemini Observatory, but also to be contributors to unique instruments such as the G-MOS spectrophotograph.

As you may know, G-MOS, which was developed by HIA with partners in the U.K., took only two weeks for commissioning and saw success right "out of the box" upon installation in Gemini North.

We believe that in addition to the outstanding scientific capabilities provided to our researchers, this kind of technological and intellectual involvement makes Gemini a true international partnership.

Most if not all of you here will know that, Canada contributed the remote manipulator arm to the Space Shuttle program- it is hard to miss out there in space.

The Canadarm inspires national pride and played a big part in stimulating an interest in the space program in Canada.

Canada's National Research Council played a significant role in this success principally through our IAR and IIT institutes, initially as project manager and developer of the Canadarm and more recently as the source of the space vision system that has given "eyes" to the Canadarm and its International Space Station successors.

In the same way, we look to GMOS and other technologies for international observatories as Canadian connections that give us a special link to the collaboration in which our citizens may take pride.

So we are eagerly anticipating the release by Gemini of the first images taken using the Gemini Adaptive Optics system. Known as Altair, the system was built by NRC's HIA in Victoria, British Columbia and began commissioning on the Gemini North Telescope in November.

Participation in Gemini was, not surprisingly, among the priorities cited in Canada's Long Range Plan for Astronomy. But it is, in a sense, merely a hint of things to come.

The Atacama Large Millimetre Array and the James Webb Space Telescope or NGST as some still call it were the two top priorities of the LRP for new collaborative facilities.

Clearly, both facilities will be powerful new instruments. They will amplify astronomical research and empower their users in dramatic yet complementary ways.

The case for supporting these projects should be evident to any advanced nation.

But I must tell you that they are particularly attractive to Canada and to Canadian Astronomers as strong expressions of an international consensus on timely and critical steps in the quest for deeper understanding of the Universe, as well as the opportunities they present for Canada to contribute technologically, as we have in FUSE, Gemini and many other programs.

Consistent with Canada's Long Range Plan, the Canadian Space Agency is partnering in the J-W-S-T and has been investing in its development with plans for Canada to contribute the Fine Guidance Sensor and portions of the NIR-CAM.

And as many of you know, we have been working very hard at NRC to secure resources to make a meaningful, long term, and firm commitment to ALMA.

The strategy we worked out in recent years for ALMA with the NSF and AUI/NRAO involves intellectual contributions such as receivers and software to ALMA itself, contributions to the ALMA operating expenses, as well as the contribution of a new correlator to the Expanded Very Large Array. In combination these would fulfill the terms of the proposed North American Program for Radio Astronomy.

Our challenges to date in funding the complete package has much to do with the complexities of the funding system in Canada arising from the many players I described earlier. But we are extremely confident.

However, I do want to make it clear Canadian astronomers have had unprecedented political support in their quest for funding. Yet some days it has been a bit discouraging.

Plato said in the Republic that "it is clear to everyone that astronomy ... compels the soul to look upwards...". Socrates disagreed saying "It seems to me that astronomy, as now handled ... positively makes the soul look downwards."

I am afraid that some days in Canada we have vacillated between these two points of view in our quest for funding.

The uncertainty has been taxing for many people who recognize the importance of these projects to the future of Canadian astronomy.

Yet we have made progress, we have made significant decisions, and I personally am extremely confident that we will have the 5 year funding in place for ALMA/EVLA and the other aspects of the LRP.

There are also certain points upon which we always agree.

One is that we are better off as a nation for having a plan, a national consensus, and a unified, multi-partner approach.

We also agree that our American and other international partners have strengthened our cause by not only welcoming our contributions, but recognizing our capacity to contribute significantly through first class science, valued technologies and engineering expertise.

Again, we know that our case within Canada was strengthened by the fact that we were advancing priorities shared by the rest of the world.

We have - through the exercise - developed a tremendous commitment to the national benefits that will flow including those through industrial and innovation. There is, in other words, an uplifting optimism that will ultimately see success.

Astronomy in Canada enjoys an unprecedented level of support and awareness.

Not only from universities and research bodies, but industry leaders, educators, politicians of all stripes, and visionary government leaders.

It is a function of a unified plan that has been promoted on the basis of its benefits to all Canadians in all walks of life. We are, in a modest way, a better country for it.

So, it is with this backdrop that I come to you with a vision of even greater collaboration in astronomy and astrophysics.

### **(3) World Collaboration in Astronomy**

As I said earlier, we are in many ways already entering a new era characterized by world observatories typified by ALMA and the James Webb Space Telescope.

Proposals for the next generation of large optical telescopes and the Square Kilometre Array have the capacity to bring nations together in new levels of cooperation.

We certainly have the raw material for a set of global priorities and, at least, some important points of consensus.

I believe it could be within this room.

You have within your ranks at AAS an appreciation and an awareness of facilities around the world today and those envisioned for tomorrow.

Many of you have experience as pioneers in the development and promotion of priorities for new facilities founded upon a world view and decadal plans.

Today you and your colleagues around the world are, for example, developing the Virtual Observatory as another truly world wide project.

It is one that will not only integrate knowledge, but bring the diverse parts together into a sum that could have an impact far beyond your own discipline.

It is an exemplary initiative to which we as Canadians anticipate making strong, unique contributions.

And the members of the American Astronomical Society have shown the courage, vision, and intellectual capacity to help make such ideas real over the years.

As a group, you have also shown leadership in recognizing and communicating the impact that investments in astronomy have beyond even the immediate technological developments they inspire.

You have taken courageous and enlightened positions on public education, the promotion of minority groups, the value of public institutions, and the need to maintain international cooperation as a complement to national security initiatives. This speaks of a responsible and visionary perspective. One that is up to the task and one that can get the job done.

This should be true in all science, and in many fields we need to do more to promote international cooperation the way you, as astronomers, have demonstrated it can be done.

Indeed, astronomy and astrophysics – issues that reach beyond our planet and our immediate concerns – may well be the best – if not the only field – where a true global collaboration and vision is possible.

I believe that we can see a world plan for astronomy within a decade.

And if it is, you – the people who have driven bold projects such as the Sudbury Neutrino Observatory, the Gemini Telescopes, and now ALMA and the JWST, are the ones who can make it happen.

Thank you for your kind invitation.