

Technologías emergentes: *Investigación Desarrollo e Innovación en Canadá*

Metrology at NRC Canada: *An NMI in an RTO Context*

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NRC Measurement Science and Standards**

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Bogotá, Colombia
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NRC: Canada's Research Technology Organization

VISION

To be the most *effective research and technology organization* in the world, stimulating *sustainable domestic prosperity*.



NRC: Canada's Research Technology Organization

MISSION

Working with clients and partners, we provide *innovation support, strategic research, scientific and technical services* to develop and deploy solutions to meet Canada's current and future industrial and societal needs.



NRC: Canada's Research Technology Organization

GOVERNANCE

- James Moore, Minister of Industry
- Ed Holder, Minister of State (Science & Technology)
- John McDougall, President



National Research Council Canada bridges the innovation gap between early stage R&D and commercialization, focusing on socio-economic benefits for Canada and increasing national performance in business-led R&D and innovation.

NRC: Canada's Research Technology Organization

MANDATE

- Undertaking, assisting or promoting *scientific and industrial research* in fields of importance to Canada;
- Providing vital *scientific and technological services* to the research and industrial communities;
- Investigating *standards and methods of measurement*;
- Working on the *standardization and certification* of scientific and technical apparatus, instruments and materials used or usable by Canadian industry;

NRC: Canada's Research Technology Organization

MANDATE (2)

- Operating and administering any *astronomical observatories* established or maintained by the Government of Canada;
- Establishing, operating and maintaining a *national science library*; and
- Publishing and selling or otherwise distributing such *scientific and technical information* as the Council deems necessary

NRC: By The Numbers



- 2014-15 budget: \$896M
- Over 4,500 employees and visitors
- Organized in 3 scientific divisions, with 12 research portfolios

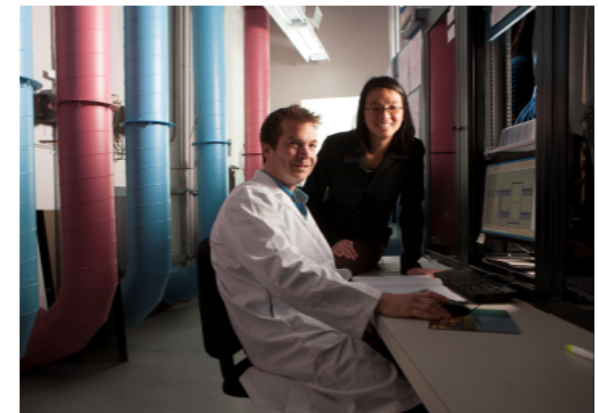
Research Technology Organizations

COMMON CHARACTERISTICS

- Solvers of *innovative* and *competitive* problems
- Technology developers, adapters and transfer intermediaries
- State-of-the-art technology specialists, fashioning *multidisciplinary solutions* fitted to the needs of various industries and trades in traditional and emerging sectors

RTO Model

- Mission-oriented providers of *innovation services* to firms and governments
- Dedicated to building *economic competitiveness* and improving quality of life
- Driven by improving *national productivity* and competitiveness



NRC Organizational Structure – Research Divisions

DIVISIONS

Emerging Technologies

Engineering

Life Sciences

PORTFOLIOS

Information and Communications Technologies

Measurement Science and Standards

National Science Infrastructure

Security and Disruptive Technologies

Aerospace

Automotive and Surface Transportation

Construction

Energy, Mining and Environment

Ocean, Coastal and River Engineering

Aquatic and Crop Resource Development

Human Health Therapeutics

Medical Devices

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MSS By The Numbers

- Budget: **\$27M**, includes **\$6M** in revenues reinvested
- Over **145** employees, and 25 volunteer and independent visitors
- Organized in **3 programs**, with **12 scientific disciplines**
- National research and technology development facilities in Ottawa and Halifax



Measurement Science and Standards at NRC

VISION

As Canada's National Metrology Institute, NRC is universally respected for providing *trusted measurement science*, *advice* and *technical services* to government and industrial clients, ensuring the basis for fair trade and commerce, enhancing societal well-being, and enabling innovation through evolving and emerging technologies that *rely on precision measurement*.

Canada's National Metrology Institute

MISSION

MSS executes the NRC *mandate* to *conduct research* and *provide metrology services* in support of partners in government and industry, improving social and economic prosperity by enabling both product and process innovation in areas where *precise and reliable measurements are critical to success*.

Guiding Principles

CONTINUOUS IMPROVEMENT

- *We focus on a **quality management systems approach** to our science and services, relying on our established strengths and our international reputation while transparently addressing weaknesses identified through a peer review process.*



Guiding Principles

IMPACT DRIVEN

- We *define and target our efforts* for strategic research and measurement services by establishing clear objectives, choosing our scope and placing our investments to serve our clients and stakeholders now and in the future.



Guiding Principles

WORKING TOGETHER AS COLLEAGUES

- We emphasize the *sharing of responsibility and accountability* through a climate of teamwork, involving staff in the program and project improvement planning process while ensuring that we enjoy a safe and respectful workplace.



MSS Programs and Core Businesses

Metrology for Industry and Society

- Enable vital Canadian sectors, where *high precision and credible measurement* have a significant impact on *market success*, to better compete, conform and connect on a global stage

MSS Programs and Core Businesses

Measurement Science for Emerging Technologies

- Enable Canadian industry to capitalize on *market opportunities* involving emerging technologies, while ensuring the *responsible introduction of new technologies* to the marketplace

MSS Programs and Core Businesses

Scientific Support for the National Measurement System

- Deliver coherent scientific advice to *improve and inform national decision-making* for commerce, standards development, regulation, and trade agreements

The Complete Metrologist

- Scientific Expert: *strategic R&D*
- Client Focus: *technical services*
- Diplomat: *international awareness*
- Professional: *business-like behaviour*
- Helpful: *understand and explain*

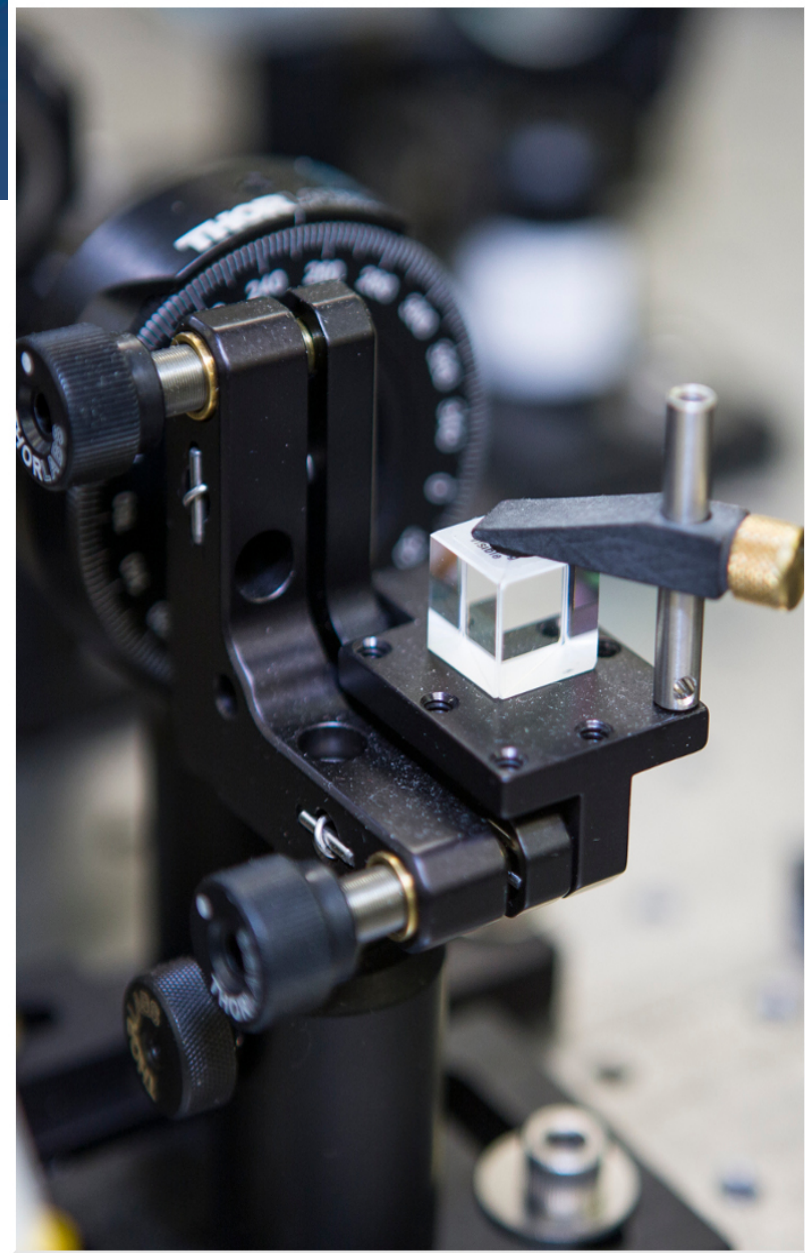


Understanding Metrology Impact: Value for Industry

- This is a tough problem!
 - No *market data* for metrology in industrial value chains
 - Metrology *crosses industrial sectors*, introducing an additional layer of complexity
- There is a mixture of social and economic prosperity advantages to building and maintaining a strong NMI
- Macroeconomic studies show ROI of $> 30\times$
 - Exploring *market size and growth of the industries* within which the 12 metrology disciplines operate

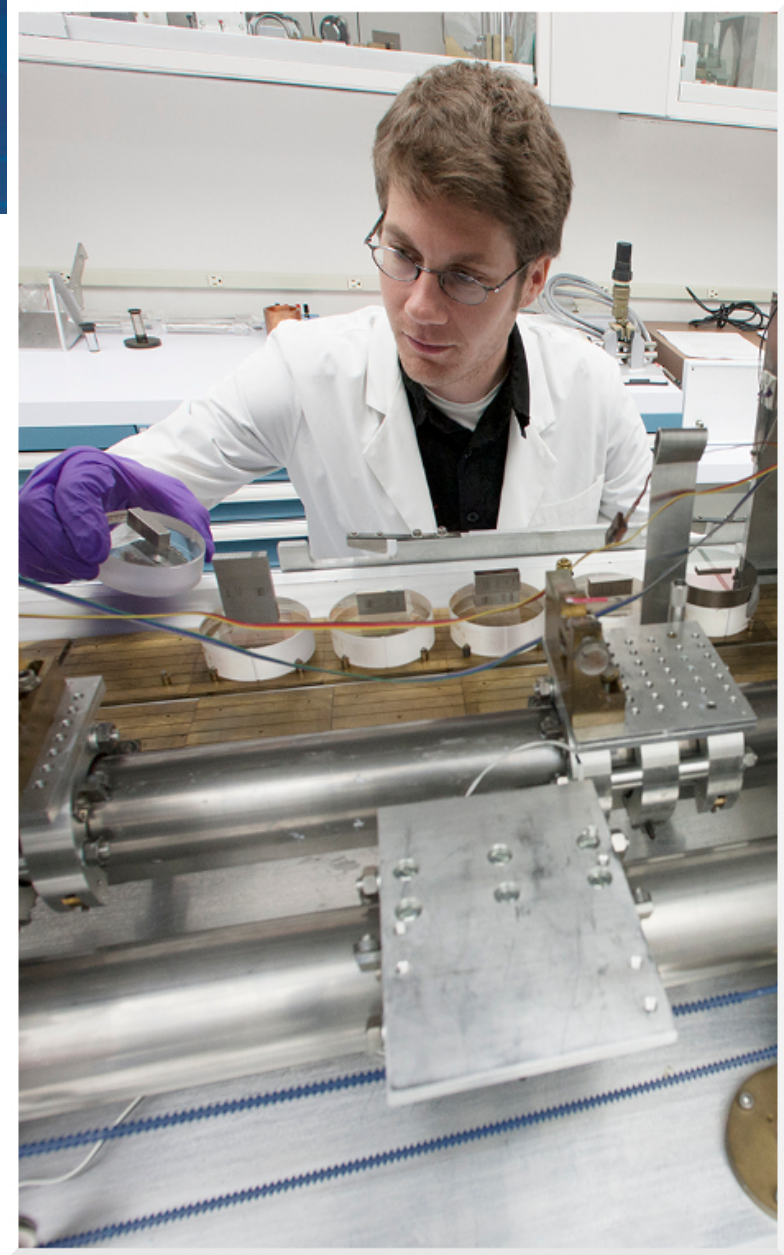
Strategic R&D

- Mission-oriented research and technology development
- Delivering high impact for Canada
- Advancing existing metrology capabilities
- Addressing emerging measurement needs



Technical Services

- NRC helps clients solve immediate problems
- Calibration services
- Certified reference materials
- Laboratory assessment services



How Canada Benefits

TODAY'S OFFERINGS

TOMORROW'S POTENTIAL

		TODAY'S OFFERINGS	TOMORROW'S POTENTIAL
MSS DISCIPLINES	 ELECTRICITY	Electricity metering, smart asset management	Smart grid
	 LIGHT	Improved efficiency for LED lighting	Secure/encrypted communications
	 TEMPERATURE	Environmental monitoring	Highly efficient engines
	 RADIATION	Safe treatment dosages for cancer patients	New methods for medical isotopes
	 CHEMISTRY	Food safety	Nutraceuticals & functional foods
	 MASS	Fair trade of weighed goods	Shipbuilding & aviation
	 LENGTH	Manufacturing precision in aviation	Enabling the nano-economy
	 TIME	Safe air traffic control	High resolution imaging
	 NANOSCALE	Characterization of nanocarbon and nanocellulose materials	Enabling the nano-economy
 BLACK CARBON	Engine emission certification and environment monitoring	Traceable quantification for climate and health	

MSS Highlights

THE KILOGRAM

- Paving the way for the imminent redefinition of the kilogram and other units of the SI
- NRC watt balance achieves the most precise determination of the Planck constant to date: the CCM threshold of 20 ppb achieved !



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Metrologia
UNCORRECTED PROOF

A determination of Planck's constant using the NRC watt balance

C A Sanchez, B M Wood, R G Green, J O Liard and D Inglis
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18.7 ppb

Abstract
We have measured Planck's constant and have obtained a value of $6.626\,070\,34(12) \times 10^{-34}$ J s. To our knowledge this measurement of h has the **lowest uncertainty reported to date**. This result has been obtained from measurements of four masses of different material and nominal values varying from 1 kg to 250 g. The experimental procedures and the measurement uncertainties are described in detail.

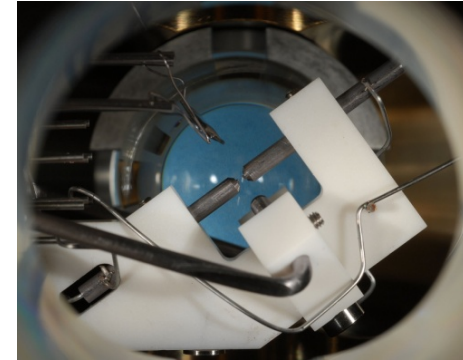
Keywords: watt balance, Planck's constant, kilogram



MSS Highlights

THE SECOND

- Paving the way for the not-so-imminent redefinition of the SI second
- NRC has world leading capability using $^{88}\text{Sr}^+$ ion
- Published uncertainty for the $5s_2S^{1/2} - 4d_2D^{5/2}$ transition: 2.3×10^{-17}
- Latest results on polarizability and black body radiation shift accepted in *PRL*: 1.2×10^{-17} !



PHYSICAL REVIEW LETTERS



High-Accuracy Measurement of the Differential Scalar Polarizability of a $^{88}\text{Sr}^+$ Clock Using the Time-Dilation Effect

Pierre Dubé,^{*} Alan A. Madej, Maria Tibbo, and John E. Bernard
*Frequency and Time Group, Measurement Science and Standards Portfolio, National Research Council of Canada,
Ottawa, Canada K1A 0R6
(Received 27 February 2014)*

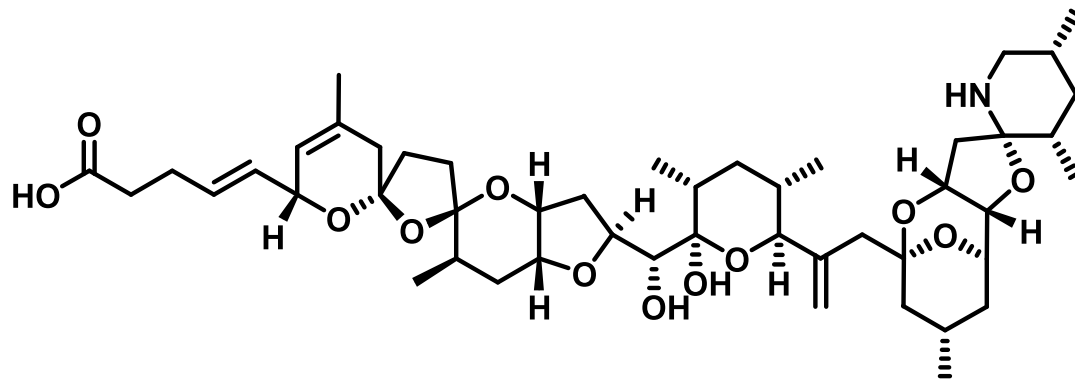
We report a high-accuracy measurement of the differential static scalar polarizability $\Delta\alpha_0$ of the $5s_2S_{1/2} - 4d_2D_{5/2}$ transition of the $^{88}\text{Sr}^+$ ion. The high accuracy is obtained by comparing the micromotion-induced positive scalar Stark shift to the negative time-dilation shift. Measurement of the trap drive frequency where these shifts cancel is used to determine $\Delta\alpha_0$ without the need to determine the electric field. $\Delta\alpha_0$ is a critical parameter for the operation of frequency standards as it determines the blackbody radiation frequency shift coefficient, the largest source of uncertainty in the $^{88}\text{Sr}^+$ ion clock. The measured value of $\Delta\alpha_0$ is $-4.7938(71) \times 10^{-40} \text{ J m}^2/\text{V}^2$. Taking into account the dynamic correction, the blackbody shift at 300 K is 0.247 99(37) Hz. The contribution of the blackbody shift coefficient to the uncertainty of the ion standard has been reduced by a factor of 24, from 2×10^{-17} to 8.3×10^{-19} . The revised total uncertainty of our reference standard is 1.2×10^{-17} , limited by the blackbody field evaluation. An additional benefit of the low uncertainty of $\Delta\alpha_0$ is the ability to suppress, by a factor of about 200, the net micromotion frequency shifts.

DOI:

PACS numbers: 32.10.Dk, 06.30.Ft, 32.60.+i, 37.10.Ty

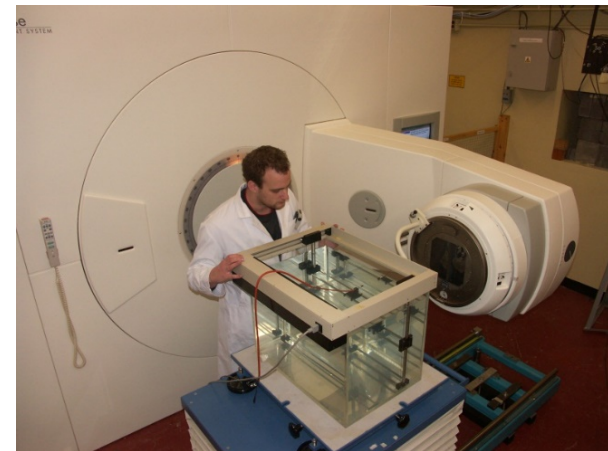
CERTIFIED REFERENCE MATERIALS

- Invaluable tools for instrument calibration, quality assurance and analytical method validation
- From a range of biotoxin, inorganic and organic samples
- Collaborative R&D agreements with OGDs



IONIZING RADIATION STANDARDS

- Addressing needs for medical isotopes as part of a large public private partnership on use of non-reactor production methods
- Recognized global leadership evidenced by technology transfer contracts with other NMIs
- Innovating security threat detection using an imaging camera for identification and localization of radioactive materials in a multi-partner collaboration



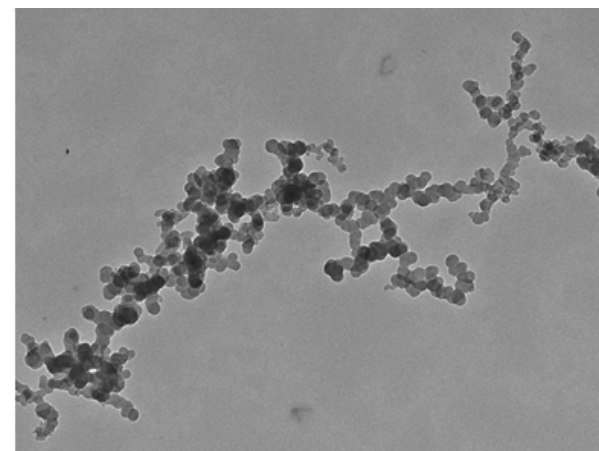
METROLOGY IN THE WILD

- Addressing needs for field measurements of electrical power
- Huge dollar cost associated with established infrastructure including:
 - Transformers
 - Transmission Cables
 - Generating Equipment
- Deregulated marketplace has put focus on credible and independent calibrations



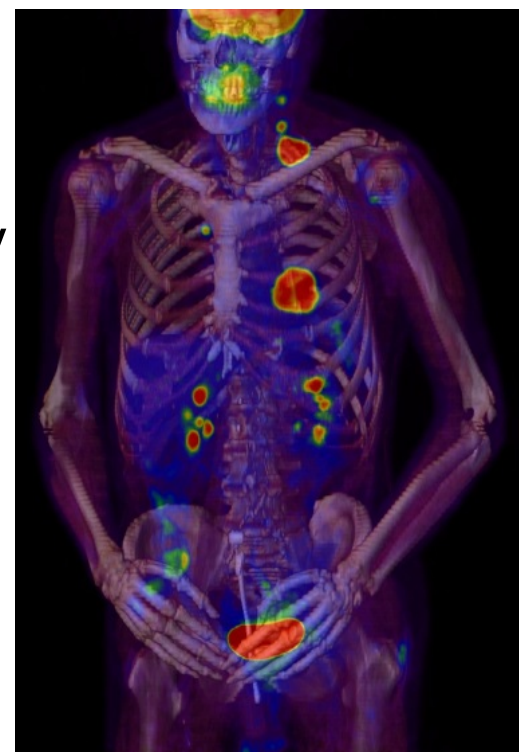
BLACK CARBON

- Addressing needs for traceable measurement to improve emission inventory and control
- Recognized global leadership in Black Carbon mass instrument calibration
- Informing policy and regulators for civil aviation, marine, and road transportation



BIOLOGICAL METROLOGY

- Launching effort in nanoscale biometrology
- Addressing needs for real-time measurement tools for Antibody-Drug Conjugates (ADCs)
- Characterization methods for vaccine delivery
- Developing quantified methods and certified reference materials for clinically-relevant amino acids and peptides



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Merci !

Obrigado !

Thank you !

