2002 CONGRESS PLENARY SESSION ABSTRACTS
RÉSUMÉS DES SESSIONS PLÉNIÈRES - CONGRÈS 2002

[SU-PLEN-1] ***PLENARY SESSION / SESSION PLÉNIÈRE*** ***SUNDAY, JUNE 2***
BROCKHOUSE MEDAL WINNER / GAGNANT DE LA MÉDAILLE BROCKHOUSE ***DIMANCHE LE 2 JUIN***

ROOM / SALLE 2000 A ***Chair: B. Joós, U. Ottawa***

SU-PLEN-1 **13h30**

PAWEL HAWRYLAK, National Research Council of Canada

Quantum Dots

Semiconductor quantum dots are a natural extension of the current micro-electronic technology to nano-technology. I will attempt to review the theoretical and experimental work in this field over the last decade. In particular, I will demonstrate that the significant progress that has been achieved in the control over the composition of a solid in all three dimensions leads directly to control over electron numbers and their interactions on a single electron and single spin level. Hence one can view quantum dots as laboratories for correlated electron systems whose electronic and optical properties can be designed on a many-particle level. Several examples of nontrivial electronic behavior will be given, including quantum Hall droplets, unusual spin depolarisation events, Luttinger liquid, magic states, and hidden symmetries and exciton condensation in excitonic artificial atoms. I will conclude by summarising the possible impact of quantum dots on nano-spintronics, nano-photonics, and quantum information.

[SU-KEY] ***HERZBERG MEMORIAL LECTURE / LECTURE COMMÉMORATIVE HERZBERG, PUBLIC SESSION PUBLIQUE*** ***SUNDAY, JUNE 2 DIMANCHE LE 2 JUIN***

ROOM / SALLE 2000 A ***Chair: M. Thewalt, SFU***

SU-KEY **19h00**

ERIC CORNELL

'Bose-Einstein Condensation Experiments in an Ultracold Atomic Gas'

At temperatures under one millionth of a degree from absolute zero, a dilute vapor of ultra-cold atoms may undergo Bose-Einstein condensation. The resulting substance is an ideal environment for a host of experiments in quantum mechanics at the interface between condensed-matter and atomic physics. I will present a representative sample of past and current work.

[MO-PLEN-1A] ***PLENARY SESSIONS / SESSIONS PLÉNIÈRES*** ***MONDAY, JUNE 3***
CAP/INO MEDAL WINNER / GAGNANT DE LA MÉDAILLE ACP/INO ***LUNDI LE 3 JUIN***

ROOM / SALLE 2000 A ***Chair: R.A. Lessard, U. Laval***

MO-PLEN-1A **08 h 30**

ALLAN CARSWELL, Optech Incorporated and Department of Physics and Astronomy, York University

Lidar Applications: From the Depths of the Ocean to the Surface of Mars

Laser radar (lidar) technology has been advancing rapidly in recent years and lidar is now not only the sensor of choice in many applications but is also providing in a number of situations capabilities unmatched by other techniques. Lidars transmit optical radiation with highly controlled coherence, polarization, wavelength, spectral purity and, if needed, at very high intensity. This radiation interacts with lidar-illuminated media via a host of scattering, fluorescence and absorption processes. The backscattered signal is collected and analyzed with an array of optical, temporal and spatial measurements to derive precise, quantitative information on the illuminated region. Since it was founded as a “spin-off” from the Department of Physics and Astronomy at York in 1974 Optech has pioneered the development and application of pulsed, time-of-flight laser ranging systems. These are now used worldwide for terrestrial and marine airborne surveying, 3D laser imaging, industrial process control measurements and atmospheric monitoring. This presentation provides an overview of these applications including recent work on satellite-borne lidars for terrestrial atmospheric measurements and lidars for spacecraft docking, landing and atmospheric measurements on the surface of Mars.

[MO-PLEN-1B] PLENARY SESSIONS / SESSIONS PLÉNIÈRES — MONDAY, JUNE 3 / LUNDI LE 3 JUIN
CAP/CRM PRIZE WINNER / GAGNANT DU PRIX ACP/CRM

ROOM / SALLE 2000 D — **Chair: G.W.F. Drake, U.Windsor**

MO-PLEN-1B **08 h 30**

PAVEL WINTERNITZ, Centre de recherches Montreal

Continuous Symmetries of Discrete Equations

Lie group theory has been used for over a century to obtain exact analytical solutions of differential equations, specially nonlinear ones. Virtually all known solutions of the Einstein equations, the Yang-Mills equations, and the Navier-Stokes equations and many others were obtained in this manner. Many phenomena in physics are discrete and are described by difference equations. The purpose of this talk is to review the results of an ongoing research program, the aim of which is to turn Lie group theory into an efficient tool for classifying and solving difference equations.

[MO-PLEN-2] PLENARY SESSION / SESSION PLÉNIÈRE — MONDAY, JUNE 3 / LUNDI LE 3 JUIN
CAP-PN

ROOM / SALLE 2000 A — **Chair: G. Schinn, EXFO Inc.**

MO-PLEN-2 **09h15**

NICOLAS GISIN, Université de Genèvre

Quantum Cryptography Below Lake Geneva

Quantum mechanics is well known for being counter-intuitive or even bizarre. Now, it can also be useful for practical applications. Quantum cryptography could be the first application of quantum mechanics at the individual quanta level. It takes advantage of the Heisenberg uncertainties to provide an absolutely secure communication scheme. This way of turning an apparent limitation, like the uncertainty relations, into a potentially useful process, like secure communication, is an example of the new field of quantum information technology. After a basic introduction to quantum cryptography and a presentation of some experimental results, the continuous dialog between fundamental and applied issues will be further illustrated by showing that the most efficient implementation of quantum cryptography is closely related to the experimental arrangement used to violate Bell inequality, thus to demonstrate quantum non-locality. Finally, a recent demonstration of quantum cryptography using a commercial prototype between the cities of Lausanne and Geneva, via a 67 km underlake telcom cable, will be presented.

[MO-PLEN-3] PLENARY SESSION / SESSION PLÉNIÈRE — MONDAY, JUNE 3 / LUNDI LE 3 JUIN
CAP HERZBERG MEDAL WINNER / GAGNANT DE LA MÉDAILLE HERZBERG DE L'ACP

ROOM / SALLE 2000 A — **Chair: M. Thewalt, SFU**

MO-PLEN-3 **13h30**

ERIC HESSELS, York University

*The n=2 Triplet States of Helium: Determining the Fine-Structure Constant**

The n=2 triplet P J=1-to-J=2 and J=0-to-J=1 fine-structure intervals in atomic helium have been measured to be 2291174.0(1.4) and 29616950.9(0.9) kHz, respectively. The measurements are made in a thermal beam of metastable n=2 triplet S helium atoms which are excited up to the n=2 triplet P state using a 1.083-micron diode laser. The fine-structure transitions are driven using microwave fields. When sufficiently-precise theoretical calculations of the energy interval is available, the measured 29.6-GHz J=0-to-J=1 interval will allow for a 15-part-per-billion determination of the fine-structure constant. Improvements to the experiment (including laser focussing of the metastable helium thermal beam and narrowing of the resonance to a subnatural linewidth) are now being implemented and will lead to a factor of five improvement in the precision of the measurements. These improved measurements, along with improved theory, will allow for a 3-part-per-billion determination of the fine-structure constant, which will be the most accurate determination of this constant.

* This work is supported by the Natural Sciences and Engineering Research Council of Canada, by a Premier's Research Excellence Award, by the Canada Research Chair Program, by the Canadian Institute for Photonic Innovations, by the Canadian Foundation for Innovation and by the Ontario Innovation Trust.

[MO-LUM] CAP/GSI-LUMONICS BEST STUDENT PAPER COMPETITION / COMPÉTITION ACP/GSI-LUMONICS POUR LE MEILLEUR PRÉSENTATION — MONDAY, JUNE 3 / LUNDI LE 3 JUIN

ROOM / SALLE 205 B — **Chair: R.A. Lessard, U. Laval**

17h15 **J-F. BRIÈRE**, Calculs *ab initio* sur polymères à basé de carbazole (see abstract MO-A4-6)

17h30 **G. MELKONYAN**, Phonon Deficit Effect and Refrigeration by Superconducting Tunnel Junctions (see abstract WE-A1-4)

17h45 **M. GAUTHIER**, Calcul exact de la mobilité pour des systèmes avec des conditions frontières périodiques en présence d'un champ externe (see abstract TU-P1-4)

18h00 **L.Y. BEAULIEU**, Atomic Force Microscopy Studies of Electrode Materials for Li-Ion Batteries (see abstract WE-A3-5)
18h15 **D. CÔTÉ**, Time-Resolved Rectification and Shift Currents in GaAs (see abstract TU-A8-2)
18h30 **C.A. MURRAY**, Self-Assembled Microencapsulation and Reorganization of Morphology in Freely-Standing Polymer Trilayer Films (see abstract TU-A1-6)
18h45 **M. BOLDUC**, Oxygen Plasma Source Ion Implantation (OPSII) and Chemically Driven Radiation-Enhanced Diffusion and Segregation (see abstract MO-A6-2)
19h00 **M. KORKUSINSKI**, Exchange and Correlation in a Few-Electron Quantum Dot (see abstract WE-A3-6)

[TU-PLEN-1] PLENARY SESSION / SESSION PLÉNIÈRE

TUESDAY, JUNE 4
MARDI LE 4 JUIN

ROOM / SALLE 2000 A ***Chair: T. Mattison, UBC***

TU-PLEN-1 **08h30**

L.M. KRAUSS

Life, The Universe, and Nothing: Life and Death in an Ever-Expanding Universe

In this talk, I will ruminate on the future of the Universe itself, and also on the future of life within it, using as my starting point recent observations in cosmology. I will first discuss why the Universe we appear to inhabit is the worst of all possible universes, as far as considerations of the quality and quantity of life is concerned. Then, I will describe how fundamental aspects of the way in which we teach cosmology, in particular the relation between geometry and destiny, have been altered by the recognition that the cosmological constant may not be zero. Finally, I will address the fascinating question of whether life might be eternal in an eternally expanding universe. The answer to this question appears to hinge on issues of basic physics, in particular on issues of quantum mechanics and computation, which may determine whether life is ultimately analogue or digital.

[TU-PLEN-2] PLENARY SESSION / SESSION PLÉNIÈRE
CAP TEACHING MEDAL WINNER / GAGNANT DE LA MÉDAILLE D'ENSEIGNEMENT DE L'ACP

TUESDAY, JUNE 4
MARDI LE 4 JUIN

ROOM / SALLE 2000 A ***Chair: H. Van Driel, U. Toronto***

TU-PLEN-2 **09h15**

JAYMIE M. MATTHEWS, University of British Columbia

Bringing Astrophysics Down to Earth

Stars, planets and galaxies serve as wonderful laboratories to explore physics that can't be reproduced on Earth. On the other hand, they can also be used to excite students and the public about fundamental physics relevant to their everyday lives. I will discuss strategies to use research in fields such as extrasolar planet hunting and stellar seismology as a springboard to convey principles like centre-of-mass, Doppler Effect, inverse square law and others to a non-scientific audience.

[TU-PLEN-3] PLENARY SESSION / SESSION PLÉNIÈRE
CAP MEDAL OF ACHIEVEMENT WINNER / GAGNANT DE LA MÉDAILLE DE L'ACP

TUESDAY, JUNE 5
MARDI LE 5 JUIN

ROOM / SALLE 2000 A ***Chair: M. Thewalt, SFU***

TU-PLEN-3 **13h30**

ALAN ASTBURY, University of Victoria/TRIUMF

The W and Z Revisited

The particle physics community anticipated the discovery of W and Z bosons, the force carriers of the weak interaction, for many years. The advent and refinement of the Standard Model produced a set of predictions which urgently needed confirmation. The situation was not unlike that which currently surrounds the Higgs boson. In the late seventies CERN embarked on a very ambitious experiment in accelerator physics, which made use of the negative charge and stability of the antiproton, to produce counter rotating beams in a proton accelerator. The antimatter aspects of antiprotons were accommodated by production, cooling, and accumulation in vacuo. Today Fermilab uses these techniques to produce the world's highest energy collisions. The underground area experiment, UA1 and UA2, were the first serious attempts to cover a solid angle of 4B at a hadron collider. Techniques have improved greatly over time, but the principles of particle identification remain the same, and form the basis for the LHC experiments. The talk will try to convey the enjoyment of discovery, and the lessons learned.

[WE-PLEN-1] PLENARY SESSION / SESSION PLÉNIÈRE

WEDNESDAY, JUNE 5
MERCREDI LE 5 JUIN

ROOM / SALLE 2000 A ***Chair: M. Freeman, U. Alberta***

WE-PLEN-1 **08h30**

M. ROUKES, Caltech

Nanomechanical Systems - Mechanical Devices for Single-Molecule and Single-Quantum Nanoscience

Advanced nanofabrication techniques now enable the creation of ultrasmall mechanical devices. These nanoelectromechanical systems (NEMS) offer unprecedented opportunities for sensitive chemical, biological, and physical measurements. In my talk, I will describe three specific applications of NEMS that

we are currently pursuing: vacuum-based magnetic resonance force microscopy (MRFM), vacuum-based mass spectrometry (NEMS-MS), and fluid-based biochemical force assays (BioNEMS). In all three of these arenas ultraminiature mechanical devices offer functionality down to the single-molecule limit. Their reduced size yields extremely high fundamental vibrational frequencies while simultaneously preserving very high mechanical responsivity. For vacuum-based applications, this powerful combination of attributes translates directly into high force and mass sensitivity, ultimately at the attonewton and single-Dalton level respectively. In fluidic media, even though the high quality factors attainable in vacuum become precipitously damped, the small device size and high compliance still yields response at the piconewton level - the force required to break individual hydrogen bonds within a macromolecule. Ultimately NEMS will enable us to access the regime where mesoscopic mechanics becomes dominated by quantum, rather than thermal, fluctuations, and force detection approaches, or even exceeds, the standard quantum limit. I will discuss the intriguing prospects of this realm – and the practical obstacles to be surmounted along the path toward its attainment.

M.L. Roukes, "Plenty of Room, Indeed", *Scientific American* **285**, 48-57 (Sept. 2001)
M.L. Roukes, "Nanomechanical Systems Face the Future", *Physics World*, **14**, 25-31 (Feb. 2001)

[WE-PLEN-2] PLENARY SESSION / SESSION PLÉNIÈRE

WEDNESDAY, JUNE 5 / MERCREDI LE 5 JUIN

ROOM / SALLE 2000 A — *Chair: W. Whelan, Ryerson*

WE-PLEN-2 **09h15**

E. PODGORSAK, Department of Medical Physics, McGill University

The Physics of Medical Physics

Medical physics is a branch of physics concerned with the application of physics to medicine. It deals mainly, but not exclusively, with the use of indirectly ionizing radiation in diagnosis of human disease through diagnostic imaging with x rays and radio-isotopes and with the use of directly and indirectly ionizing radiation in treatment of cancer. The study and use of ionizing radiation started with three important discoveries: x rays by Roentgen in 1895, natural radioactivity by Becquerel in 1896, and radium by Pierre and Marie Curie in 1898. Since then, ionizing radiation has played an important role in atomic and nuclear physics, and provided an impetus for development of medical physics as a subspecialty of physics. Initially most technological advances in medical use of ionizing radiation were related to improvements in efficient x-ray beam delivery, development of analog imaging techniques, optimization of image quality with concurrent minimization of delivered dose, and an increase in beam energies for radiotherapy. During the past two decades, however, most developments in radiation medicine were related to integration of computers in imaging, development of digital diagnostic imaging techniques, and incorporation of computers into therapeutic dose delivery with high-energy linear accelerators. Radiation dosimetry and treatment planning have also undergone tremendous advances in recent years; through development of new absolute and relative dosimetry techniques, through improved theoretical understanding of basic radiation interactions with human tissues, and through introduction of Monte Carlo techniques I dose distribution calculations. Medical physicists are generally involved in three areas of activities: clinical service and consultation; research and development; and teaching. Academic training alone does not make a medical physicist. In addition to academic training, practical experience with medical problems and equipment is essential, and this may be acquired through on-the-job training or, preferably, through a structured two-year traineeship (residency) program in a hospital after graduation with a M.Sc. or Ph.D. degree in medical physics.

[WE-PLEN-3] PLENARY SESSION / SESSION PLÉNIÈRE
CAP/COMP KIRKBY MEDAL WINNER / GAGNANT DU MÉDAILLE KIRKBY DE L' ACP/OCPM

WEDNESDAY, JUNE 5 / MERCREDI LE 5 JUIN

ROOM / SALLE 2000 A — *Chair: M. Lord, CNSC*

WE-PLEN-3 **13h30**

J.R. CUNNINGHAM, Camrose, AB

Evolution of a Good Application of Physics (Treatment of Cancer by Ionizing Radiation)

The use of ionizing radiation for the treatment of Cancer is an example of an appropriate application of Physics to Medicine. Radiation has about the same success rate as surgery, and each have their advantages. A physical quantity, Radiation Absorbed Dose is, under controllable conditions, quantitatively related to biological effect. Careful clinical trials, involving large numbers of patients, have indicated that a deviation of more than about ±0.5% in the delivery of the planned dose to the patient can be detected. This includes the repeated positioning of the patient for treatment so the accuracy requirement on dose prediction is tighter. Prediction of the dose pattern involves repeated solutions of a non-linear superposition integral, which even with the assumption of tissue homogeneity, has no solution in closed form. Approximate solutions must be accepted, and part of the "evolution" of the application has been the search for better approximations. Early versions were remarkably crude, but with the availability of Monte Carlo methods, the problem has been substantially solved. Another stage in this process is the solution of the "inverse problem", which is the determination of the radiation parameters that will produce the optimum dosage pattern for each individual patient. The evolution will not be complete until the detailed biological response can be related to the local radiation dose in a more general way. Although numerous bio-mathematical models have been proposed, and some progress has been made, none are yet particularly successful in clarifying the details of the bio-physical process.