

UBCO Department of Physics and Astronomy Future Directions

Prepared by the OUC Department of Physics and Astronomy - October 26, 2004

Introduction

In April of 2004, following the government's announcement of the creation of two new institutions, the department met and generated a vision document in which it outlined the research interest of its members, a proposal for the development of the undergraduate Physics and Astronomy program at both the New Okanagan College (NOC) and UBC Okanagan (UBCO) and a proposal for the development of graduate programs at UBCO.

Now that the development of UBCO and the NOC has been underway for six months the department decided to update its earlier document. This document is limited to the consideration of the future development of the UBCO Physics Department.

Research Interests

The department of Physics and Astronomy is a relatively small department comprising members who have a wide variety of research interests. Broadly speaking these interests can be grouped into two multi-disciplinary, collaborative research clusters¹.

Research Cluster 1 – Applied Electromagnetic Wave Interactions with Matter

- Health Physics
- RF Engineering and Propagation
- Nanotechnology
- Digital Signal Processing
- Biophotonics
- Material Science

Research Cluster 2 – Cosmology, Astronomy, and General Relativity

- General Relativity, Cosmology and Quantum Field Theory in Curved Space-time
- Radio Astronomy
- Particle Physics

Undergraduate Physics Program

It is expected that the UBCO Physics major and honours programs will continue to evolve. The entire core of third and fourth year courses are currently offered every other year, and very few fourth year options are offered. A priority for the department is that Core upper division courses should be annualized and that other fourth year courses should be expanded and offered at least every other year. The department also proposes that upper division service courses for other departments be annualized as well.

Applied Science Undergraduate Programs at UBCO

It has long been the position of the department that OUC should re-institute the first and second year of the engineering transfer program and that the department would provide the required Physics courses for this program.

With the announcement that UBCO will in fact have an Applied Science program starting in 2005 the department is excited to play a role in its development. In particular, the

¹ Details of ongoing and proposed research are presented at the end of this paper

department's research interests (listed above) would mesh very well with, and support the development of, an Engineering Physics program at UBCO. Specific thematic options within the Engineering Physics program logically evolve from these research interests.

Graduate Programs in Physics and Astronomy and Applied Science

The UBCO Physics & Astronomy Department should introduce Master's and Doctoral degrees in Physics and Astronomy and in Applied Science. As we already have strong research interests in the area of *Applied Electromagnetic Wave Interactions with Matter* and *General Relativity* these areas would seem to be natural for graduate programs in Physics and Astronomy. Applied Science graduate programs at UBCO could be introduced immediately in areas where there is currently expertise.

To increase the graduate research opportunities open to students, co-supervision across disciplines, campuses (UBCV) and in collaboration with external agencies such as the Dominion Radio Astrophysical Observatory (DRAO), the Cancer Clinic of the Southern Interior and Pacific Argi-Foods Research Centre (PARC) is supported by the department.

New Faculty Required for Physics & Astronomy at UBCO

From the published figures, student FTE growth is expected to be 150% at UBCO. We estimate that by 2009-10 UBCO Physics & Astronomy will require 11 professorial faculty and 1 laboratory supervisor. We are assuming that the current use of Teaching Assistants and Laboratory Demonstrators will expand. It is anticipated that this will require the hiring of at least 6 additional professorial faculty members into the UBCO Physics and Astronomy department by 2010.

The department would like to see hiring start this year by having one or more Physicist hired into the *Optimization and Image Processing* research cluster. This area of research is a particularly good fit with the department's current research interests. The *Optimization and Image Processing* research cluster is found within competition H-3 *Aging and Health Science* of the proposed *Health and Wellness* thematic option at UBCO.

RESEARCH CLUSTER 1

APPLIED ELECTROMAGNETIC WAVE INTERACTIONS WITH MATTER

Research Area One

Health Physics

In collaboration with the Cancer Clinic of the Southern Interior

- Radiation dosimetry
- Inverse planning of radiation treatments
- Image processing for tracking accuracy of beam delivery
- Development of photonic methods for imaging, diagnosis and treatment?

Research Area Two

RF Propagation and Engineering

- Propagation Channel Modeling
 - Development of propagation channel models for RF signals in complex environments
 - wireless communications signals in buildings
 - GPS satellite signals received indoors
- Wireless Location
 - building material effects on spread spectrum signals used for positioning
 - high sensitivity and assisted GPS receiver design and testing for indoor and urban environments
- RF Interference
 - RF interference effects on modernized GPS and Galileo (European satellite positioning and navigation system)
- Ultrawideband Communications
 - UWB transmitter and receiver implementation
 - use of UWB signals for location and navigation
- Current Collaboration with
 - Faculty of Engineering at University of Calgary
 - TR Labs
 - Department of National Defense
 - Nokia
 - Spirent Communications
- Future collaboration anticipated with Dominion Radio Astrophysical Observatory

Research Area Three

Nanotechnology

- Low frequency Raman scattering – inelastic visible light scattering (National Center for Scientific Research, France)
- Transmission electron microscopy for characterization of nanostructures – 200 kV – 0.19 nm point-point resolution (Academica Sinica, Taiwan)
- Femtosecond laser pulse pump probe (Sun Yat Sen University, Taiwan)
- Grazing incidence X-ray diffraction; 2 MeV ion beam deposition; Low-Frequency Raman (Indira Gandhi Center for Atomic Research, India)
- Incompressible neutron stars (Joint Institute for Nuclear Research, Russia)

Research Area Four

Digital Signal Processing

- Time series analysis (analytical continuation -DRAO aperture synthesis telescope signals)
- Deconvolution methods – motional deblurring, recursive inversion

Research Area Five

Biophotonics

- Image processing - multiply scattered light in biological tissue
- Microparticle photophysics – optical methods for analysis / physical separation of micron-sized particles into shape or size cohorts
- Equipment:
 - CW visible Laser (100 mW output) for Fourier optics)
 - Q-switched NdYag laser with KDP frequency doubler for time-resolved scattering

Physics Research Area Six

Material Science

- Create an imaging center that is multi-disciplinary and spans several departments at UBCO.
- Once the Imaging Center is established we propose to develop Electron Microscopy / X-ray Spectroscopy undergraduate / graduate course.
- The Imaging Center would allow us to focus part of our research on Material Science, particularly surface phenomena, using a Scanning Electron Microscope (SEM), and material structure using a Transmission Electron Microscope (TEM).

RESEARCH CLUSTER 2 ASTRONOMY, COSMOLOGY AND GENERAL RELATIVITY

Research Area One

General Relativity, Cosmology and Quantum Field Theory in Curved Space-time

- Curvature corrections to the action as the source of the cosmological acceleration.
- Dark matter as new gravitational physics.
- Higher dimensional physics and Brane-World scenarios.
- Exact cosmological solutions to Einstein's theory with nonlinear electromagnetic fields.
- The origin of black hole entropy and Hawking radiation.
- Generalizations of Einstein's theory to non-Riemannian manifolds.
- Wormholes in Einstein's theory and in string theory.
- Quantum inequalities in curved space-times and the constraints they impose on negative energy densities in quantum field theory.

Research Area Two

Radio Astronomy

In collaboration with the Dominion Radio Astrophysical Observatory (DRAO) potential research areas include:

- software engineering of signal processing algorithms for 2 and 3-D image data,
- electronic research and design for radio frequency propagation and antennae,
- correlator design and fabrication,
- astronomy research.

DRAO has about 45 staff, about 20 of whom are research scientists. This is equally split between radio astronomy and radio frequency (RF) engineering. In addition, there are one half dozen Post Doctoral students and Research Associates working at DRAO. Many research scientists from around the world come to DRAO for extended periods to engage in research there. DRAO is an excellent environment for graduate students.

DRAO has had many graduate students complete their research there. At any one time one-half dozen graduate students are working in co-operation with DRAO staff. There are an equal number of undergraduate students working at DRAO during the course of the year.