THE UNIVERSITY OF BRITISH COLUMBIA

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MEMORANDUM

April 8, 2010

To: Senate, Vancouver
c/o Lisa Collins, Associate Registrar, Senate and Curriculum Services

From: David H. Farrar
Provost and Vice President Academic

Re: **Establishment of the Quantum Matter Institute within the Faculty of Science**

Recommendation:

I recommend that Senate approve the establishment of the Quantum Matter Institute, within the Faculty of Science, effective May 1, 2010.

Background:

The Quantum Matter Institute will be a single-Faculty academic research facility, within the Faculty of Science, part of an emerging vision for UBC to house a world-renowned centre for quantum matter research. Building on the international reputation of leading research in correlated electron systems and especially transition metal oxides (TMO), George Sawatzky (Physics and Astronomy/Chemistry) and Douglas Bonn (Physics and Astronomy) are leading current initiatives in the new field of transition metal oxide (TMO) interfaces and heterostructures. This is being done in consultation with members of the Advanced Materials Process Engineering Laboratory (AMPEL) as well as the Pacific Institute for Theoretical Physics (PITP) at UBC. The University's strength in the area of quantum matter research is built on a decade of theoretical and experimental work by internationally recognized leaders and rising stars, now ideally placed to establish a core research facility of international renown. The goal is to take this research to the next level of preparing new classes of materials and devices based on physical atom-by-atom preparation methods and theoretical insight into the properties of TMO materials and their interfaces. These engineered TMO films and heterostructures are expected to transcend the current limitations of today's nanostructured sensors, memory devices, solar cells and other electronics-based devices.

Attachment: Quantum Matter Institute – Executive Summary, by Drs. George Sawatzky and Douglas Bonn, March, 2010.

Quantum Matter Institute – Executive Summary

Mission: The Quantum Matter Institute will provide a platform for development of new materials and devices, based mainly on the huge diversity of properties of strongly correlated electron systems evolving from quantum mechanical concepts. The specific intent of the Quantum Matter Institute (QMI) is to facilitate translation of the theoretical and experimental understanding of these systems to enhanced technological capabilities in nanostructure quantum material devices. In this wide range of new materials, the transition metal oxides (TMO) and transition metal oxide interfaces and heterostructures play a special role. The first step towards this goal is to improve our knowledge of these TMO systems such that they can be prepared with predictable and high-quality interfaces that exhibit unique properties. Establishment of QMI is an essential mechanism for building UBC's research capacity and leading the way into a new era of materials research with applications in the electronics and information fields, the automotive industry, the health care sector and sustainable energy systems.

Rationale: The University has demonstrated strategic commitment to materials research and has already created a solid base of researchers, facilities and infrastructure in support of the QMI; for example, through the allocation of CRCs. On a global scale, the QMI will ensure that UBC and Canada play a leading role in major materials research discoveries and resulting strategic enabling technologies. This will enhance Canadian innovation and competitiveness, and generate social and economic benefits to improve Canadians' standard of living and quality of life.

The Quantum Matter Institute will build on the success of an existing quantum materials research focus, established in the Department of Physics & Astronomy at UBC, and physically located in the Advanced Materials Process and Engineering Laboratory (AMPEL), founded in 1996. AMPEL includes a range of globally-renowned theoretical and experimental physicists, chemists, and engineers, with shared infrastructure dedicated to materials and device development. AMPEL has extensive facilities for preparing, characterizing and researching new materials and structures, measuring their properties, and modelling new devices from them. QMI will bring together the new facilities for atom-by-atom growth of new materials, new methods for atomic imaging, and the theoretical expertise of Pacific Institute of Theoretical Physics (PITP) participants. QMI will also have the unique advantage of ready access to facilities, such as synchrotron-based spectroscopic beamlines at the Canadian Light Source (developed by some QMI researchers), and the TRIUMF-based facilities for condensed matter physics research, in close proximity. The outstanding opportunity to provide a focus for the existing and new facilities will put UBC in the best position to successfully recruit additional world-class investigators, to attract additional donor funding and to propel UBC and Canada to the leading edge of quantum matter research.

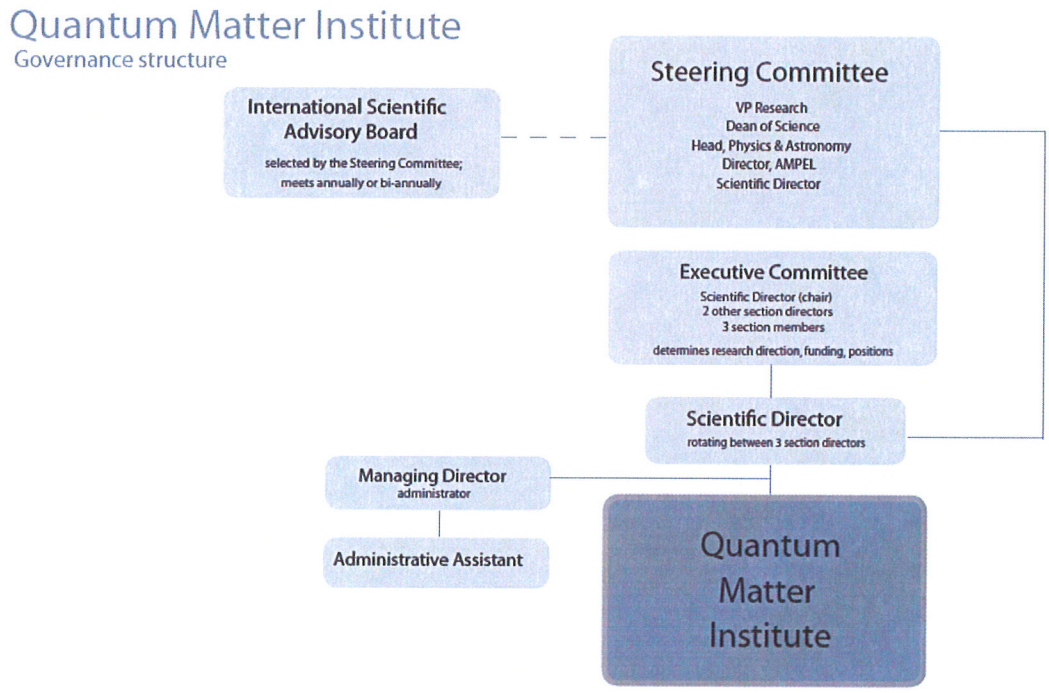
Research Background: A central goal of modern materials research and nanoscience is the control of materials and prediction of properties of materials and their interfaces all the way down to the atomic dimensions. In the search for ever-higher functionality in solid-state devices, transition metal oxides are fascinating and particularly promising systems. In addition to the more conventional semiconducting, dielectric, metallic, and magnetic properties, which can be tuned by varying the materials' composition, transition metal oxides display a vast array of unique phenomena. These include high temperature (and unconventional) superconductivity, 'colossal' magnetoresistance, all forms of magnetism and ferroelectricity, as well as (quantum) phase transitions and couplings between these states.

Our new focus is to develop the science and technology arising at the physical interface between different quantum materials. Using novel techniques we have developed for constructing thin film oxide heterostructures with atomic precision, new states of matter can be created at these interfaces. Between two nonmagnetic insulators, for example, metallic, superconducting, and magnetic states can be induced and actively controlled by external stimuli. In analogy to the rich physics and commercial devices that emerged from the development of semiconductor heterostructures, we will create novel low-dimensional

states inaccessible in bulk oxides, accessing the full versatility enabled by these strongly correlated quantum mechanics-based electron systems. The objectives include the development of new multifunctional interface systems, their fundamental understanding and control, and their application in device geometries.

There are profound strengths at UBC in the study of quantum materials by theory, bulk synthesis, microwave response, soft x-ray scattering, photoemission spectroscopy, muon spin resonance and beta nuclear magnetic resonance, and mesoscopic physics. Establishment of QMI will put UBC in an excellent position to attract world-class talent in related fields, thus bridging fundamental studies and applications of these novel materials, and to facilitate donor funding initiatives. Together with the existing expertise, formal establishment of the Quantum Matter Institute will provide a unique focal point in the science and technology of quantum materials at UBC, and Canada will be in an excellent position to play a leading role in this paradigm–shifting field of science and technology.

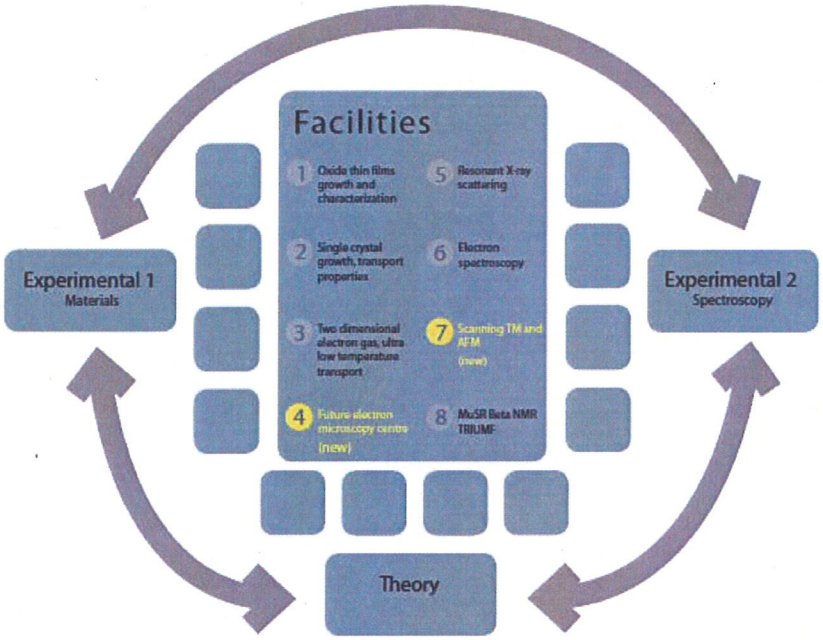
Governance Structure:



Funding Details:

The QMI budget (Budget Details Table, below) is based on the proposed structure of the QMI (See Scheme, below). The management part includes a managing director and an administrative assistant, in addition to already present committee members and faculty members. The research part of the QMI consists basically of 8 experimental research groups and 4 theoretical research groups, and a total of 8 central service groups as in the proposed structure in the figure below.

Quantum Matter Institute



The experimental groups will on average have 4 PhD students, 1 research associate, and 2 post doctoral fellows each. Each experimental research group will also be responsible for one of the central service groups utilizing the expertise of the research associates. The central service groups and the research associates will be aided by a total of 5 technical support staff.

The theoretical research groups will on average have 2 graduate students each and 2 post doctoral fellows.

The resulting costs of each of these categories are listed in the budget details table, below. The graduate students' income is rather low in that table because only the research part and not the teaching assistant part of their total income is considered as a cost to the QMI.

The management office costs are based on office supplies and the costs of the international scientific advisory committee meetings once every two years.

The expected income is based on 4 sources. Individual grants from Tri-council (mainly NSERC) and other Canadian funding agencies, donor funding, scholarships and international exchange agreements, and internal sources (consisting of combined Faculty of Science, Physics Department and VPRI office of UBC contributions). We do not include the equipment funds or the renovation costs here, as we are concentrating only on the operational costs.

The Canadian funding agencies support is estimated based on the current funding of 12 research groups in condensed matter physics at UBC. We expect this funding to increase considerably with the hiring of several new faculty members at the CRC level, with at least one at the full professor level.

The donor funding, shown as $1,590,000 yearly, is a portion of a total $13 million commitment that is available for the QMI.

Budget Details

	position/expense	number	yearly cost
QMI general costs	Manging director	1	80,000
	Administrative assistant	1	35,000
	Central QMI costs		30,000
Experimental personnel (8 groups)	Research associate (1x8)	8	720,000
	Technician (5 shared)	5	350,000
	Postdoctoral fellow (2x8)	16	1,040,000
	Graduate student (4x8)	32	480,000
Experimental operating budget (8 groups)	Consumables (He, solvents, etc.); travel, conferences, field work; publication costs: 8x80,000	8	640,000
Theory personnel (4 groups)	Research associate	0	0
	Technician	0	0
	Postdoctoral fellow (2x4)	8	520,000
	Graduate student (2x4)	8	120,000
Theory operating budget (4 groups)	Travel, conferences: publication costs: 4x10,000	4	40,000
TOTAL			**4,055,000**

YEARLY FUNDING		
Grants	NSERC	1,749,558
Donor	see table	1,590,000
Graduate scholarship	12	180,000
PD scholarship	6	390,000
Internal sources	QMI general	145,000
TOTAL		**4,054,558**

Personnel yearly slary	
Position	yearly cost
Manging director	80,000
Administrative assistant	35,000
Research associate	90,000
Technician	70,000
Postdoctoral fellow	65,000
Graduate student	15,000

Exp operating budget	80,000
Theory operating budget	10,000

DONOR funding
$2,160,000 6 @ $90,000/yr x 4 yrs
$2,080,000 8 @ 65,000/yr x 4 yrs
$720,000 12 @ $15,000/yr x 4 yrs
$1,400,000 5 @ $70,000/yr x 4 yrs
1,590,000