

# The Winnipeg Institute for Theoretical Physics<sup>1</sup> Annual Report

September 2004 - August 2005

<sup>1</sup>Web site: <http://www.physics.umanitoba.ca/research/witp.html>

# 1 Director's Narrative Report

The Winnipeg Institute for Theoretical Physics was created to support theoretical physics research in Manitoba. It has carried out this mandate by encouraging collaboration between members of the Institute and by financially supporting workshops, visiting colloquium speakers, and short and long term visits by research collaborators of international standing. The permanent members of this Institute are drawn from Brandon University, the University of Manitoba, and the University of Winnipeg.

The past year was the 14<sup>th</sup> year of the Institute's existence. As usual the Institute sponsored a series research colloquia by out-of-province visitors as well as Institute members. Associated with the Permanent Members were research associates, postdoctoral fellows, and graduate students.

For the 2004–2005 academic year, the list of invited speakers is found in section 4.1. Visiting scientists whose stay lasted longer than one week are listed in section 4.2. The cumulative list of graduate degrees awarded appears in section 4.3, and the published research work of associate members/graduate students and of members are found, respectively, in sections 4.4 and 4.5. The total number of refereed publications by full members listed in section 4.5 is 43 for years 2003 and 2004. These numbers do not count twice those that are collaborative publications among members of the Institute. The research associates and postdoc members published 13 refereed papers. Section 5.1 contains a summary of income and expenditures for the period September 1, 2004 to August 31, 2005. The plans for the coming year include a program of invited speakers, visiting research collaborations, and the promotion of postgraduate and postdoctoral research.

Essentially all of the funds available to the Institute are spent for workshop and colloquium activities and for travel expenses of visiting scientists. The Institute has no technical support staff or administrative staff. All the administrative work is done on a volunteer basis by the members of the Institute. The Institute's funding is substantially supplemented by contributions from the NSERC grants of individual members in pursuing the Institute's mandate.

During the past academic year, the Institute's Executive Committee has consisted of T. A. Osborn, Past-Director (Manitoba) and R. Kobes, Director (Winnipeg).

## 2 Current List of Members (September, 2005)

### 2.1 Permanent Members

- B. Bhakar<sup>1</sup>, *Ph.D. (Delhi)* [Director, Jan. - June 00]
- P.G. Blunden<sup>1</sup>, *Ph.D (Queen's)* [Director, 93-94]
- M.E. Carrington<sup>3</sup>, *Ph.D. (SUNY, Stony Brook)*
- T. Chakraborty<sup>1</sup>, *Ph.D. (Dilbrugarh University, India)*
- J. D. Fiege<sup>1</sup>, *Ph.D. (McMaster)*
- T.D. Fugleberg<sup>3</sup>, *Ph.D. (UBC)*
- R.L. Kobes<sup>2</sup>, *Ph.D. (Alberta)* [Director, 97-98]
- G. Kunstatter<sup>2</sup>, *Ph.D. (Toronto)* [Director, 91-92]
- P.D. Loly<sup>1</sup>, *Ph.D. (London)* [Director, Fall 99]
- T.A. Osborn<sup>1</sup>, *Ph.D. (Stanford)* [Director, 92-93, 02-04]
- B.W. Southern<sup>1</sup>, *Ph.D. (McMaster)* [Director, 90-91]
- J.P. Svenne<sup>1</sup>, *Ph.D. (M.I.T.)* [Director, 95-96]
- G.C. Tabisz<sup>1</sup>, *Ph.D. (Toronto)*
- J.M. Vail<sup>1</sup>, *Ph.D. (Brandeis)* [Director, 98-99]
- D.W. Vincent<sup>2</sup>, *Ph.D. (Toronto)* [Director, 94-95]
- J.G. Williams<sup>3</sup>, *Ph.D. (Birmingham)* [Director, 96-97]
- M. Whitmore<sup>1</sup>, *Ph.D. (McMaster)*

---

<sup>1</sup>University of Manitoba

<sup>2</sup>University of Winnipeg

<sup>3</sup>Brandon University

## 2.2 Associate Members

### *Research Associates*

- A. Borodich (Whitmore) July '04– present
- R. E. Cameron (Tabisz) 1995– present

### *Postdoctoral Fellows*

- Jose Martinez-Resco (Carrington) August 2004 - August 2005.
- Daria Ahrensmeier (Carrington, Kobes, Kunstatter) Feb. '02– present
- Marco Califano (Chakraborty) July '04 – present
- Weixing Qu (Tabisz) 2001– present

## 2.3 Graduate Students

- Miraseed Zelli (M.Sc.) (Southern)
- Aleksandrs Alexsejevs (Ph.D.) (Blunden)
- Svetlana Barkanova (Ph.D.) (Blunden) GRADUATED 2004
- Jason Bland (Ph.D.) (Kunstatter)
- Edward Kavalchuk (Ph.D.) (Carrington/Kobes)
- Amra Peles (Ph.D.) (Southern) GRADUATED 2004
- A. J. Penner (M.Sc.) (Kobes) GRADUATED 2004
- Andrew Senchuk (M.Sc.) (Tabisz)
- J. Medved (Ph.D.) (Kunstatter) GRADUATED 2000
- T. Melde (Ph.D.) (Svenne) GRADUATED 2001
- Slaven Peles (Ph.D.) (Kobes) GRADUATED 2001

## 2.4 Undergraduate Research Students 2004-2005

- D. K. Chevrier (*J.M. Vail*)
- Chris Wyenberg. (*Southern*)
- Jason Wyenberg. (*Southern*)
- Todd Kruk, May - August 2005 (NSERC summer undergraduate research award) [Carrington / Fugleberg].
- Kai Choy, May - August 2005 (NSERC summer undergraduate research award) [Carrington / Fugleberg].
- Vince Bagnulo (*Kunstatler*)
- Dave Ostapchiuk (*Kunstatler*)
- Gina Passante (*Kobes*)

## 3 Research Interests of Permanent Members

### B. Bhakar

Present activities are directed towards the understanding of completely integrable and nonintegrable field theories in low [(1+1) and (2+1)] dimensions. Therefore, investigations are being carried out to study the behaviour of spin chain models on a lattice in (1+1) dimensions with nearest neighbour interactions only. These models are closely related to nonlinear sigma models.

### P.G. Blunden

Electromagnetic interactions in complex and few-nucleon systems are being studied. I am particularly interested in the description of electron scattering at large energy and momentum transfers, the so-called quasi-elastic region, in which one or more constituents are knocked out of the nucleus. In this kinematical regime one can explore different aspects of the nuclear response to learn about two-nucleon correlations, two-body electromagnetic currents, the role of nucleon substructure, and the momentum distribution of the initial struck nucleon.

Another area of interest is in a quantum field theory of mesons and hadrons (QHD). Some recent work includes: Dirac-Hartree-Fock calculations for the properties of finite nuclei; hadronic and electromagnetic reactions; a relativistic treatment of mesonic currents; the exact numerical evaluation of one-loop quantum corrections to solitons in 3+1 dimensions; a quark-meson coupling model that treats the nucleon as a collection of confined relativistic quarks embedded in the nuclear medium; and a relativistic mean-field treatment of finite nuclei using light front coordinates.

I have a collaboration with colleagues at Jefferson Lab looking at two-photon exchange corrections in elastic electron-proton scattering. This explanation is a key to resolving a discrepancy between two experimental techniques for extracting the electric and magnetic form factors of the proton at high momentum transfer, and has important implications for our understanding of the structure of the proton.

M.E. Carrington

Finite temperature field theory has applications in many areas. It can be used to study phase transitions like the QCD phase transition in the quark-gluon plasma and the electro-weak phase transition in the early universe. It can also be used to study collective behaviour in many body systems, like the production of thermal masses and the propagation of damped plasma oscillations.

It is also of interest to develop calculational techniques to study systems that are not at equilibrium. For example, the lifetime of the quark-gluon plasma is extremely short and it is not clear that there is time to reach equilibrium before the plasma state dissolves. It is likely that an accurate mathematical description of the quark-gluon plasma will involve the use of non-equilibrium methods. Conventional field theoretic techniques assume equilibration, and thus do not apply to unequilibrated systems. There are several methods that can be used to study unequilibrated systems. I am working with transport theory and NPI effective theories.

T. Chakraborty

Spin Transport in a Quantum Dot

It has long been recognized that a two-dimensional electron gas (2DEG) in narrow-gap semiconductors, particularly in InAs-based systems with its high values of the  $g$ -factor, exhibit zero-field splitting due to the spin-orbit (SO) coupling. This coupling is also the driving mechanism for making futuristic devices based on controlled spin transport, such as a spin transistor, where the electron spins would precess (due to the SO coupling) while being transported through the 2DEG channel. Tuning of this precession in the proposed spin transistor would provide an additional control that is not available in conventional devices, but may be crucial for the rapidly emerging field of semiconductor spintronics. We have developed a theoretical approach where the SO interaction is treated via exact diagonalization of the Hamiltonian for interacting electrons confined in a parabolic QD. Coulomb interaction causes energy levels to cross and at the crossing point magnetization shows a jump. In an magnetic field the strength of the SO coupling is proportional to the field (in addition to the coupling parameter and the angular momentum). Hence, the effect of the coupling is more prominent for slopes of the higher angular momenta energy curves. As a consequence, an increase in the SO coupling strength causes the energy level crossings to move to weaker fields and the jump in magnetization shows a large shift to weaker magnetic fields. This result can be exploited to tune the SO coupling strength that might be useful for spin transport.

## Electron Dynamics in a DNA Molecule

The unique properties of DNA, self-assembly and molecular recognition, has rendered the 'molecule of life' a promising candidate in the rapidly emerging field of molecular nano-electronics. A recent report of a field-effect transistor based on DNA molecules, that was preceded by a series of seminal experiments on the electron conduction in DNA, has sparked a lot of interest on the electronic properties of the DNA. A thorough understanding of the electronic properties of DNA is crucial in the development of the future DNA-based nanoscale devices. In addition, charge transfer through DNA also plays an important role in radiation damage and repair and therefore important for biological processes. We have performed theoretical calculations of the electron energy spectrum, based on a two-leg charge ladder model for the poly(dA)-poly(dT) DNA and poly(dG)-poly(dC) DNA molecules. We take the electron-electron interactions and the electron spin degree of freedom fully into account in our model. The energy spectra for the G-C and the A-T base pairs show a large gap and the interaction was found to enhance the gap. The effect of interaction is less pronounced for the G-C base pairs than that of the A-T pairs. The spin-flip excitations are not the lowest energy excitations. We also analyze the charge distribution for the ground state as well as for the excitations.

J.D. Fiege

This research program explores topics in submillimetre astronomy, planetary science and the interstellar media of other galaxies. The common thread connecting these projects is that they all use computational techniques based on advanced genetic algorithms to explore and test theoretical models using large astronomical data sets. Genetic algorithms are computational techniques for parameter search and optimization that operate in analogy to biological evolution. The author of this proposal previously developed a genetic algorithm called "Ferret" with features designed for difficult data-modeling problems in astrophysics and other physical sciences.

Stars form in dense cores and filaments within molecular clouds. These clouds emit partially polarized submillimetre radiation from dust grains that are aligned perpendicular to the magnetic field, on average. The total intensity is an indicator of the column depth of the gas. However, the direction of linear polarization and the polarization percentage provide constraints on the structure of the magnetic field, which plays a crucial role in the support of molecular clouds against self-gravity, their internal turbulence, and star formation processes. One project uses Ferret to fit theoretical models of magnetized cores and filaments to continuum intensity and polarization data, in order to understand the physics of these objects.

Another project couples Ferret to a planetary structure code to model the internal structure of the moons of Jupiter and Saturn, using constraints from NASA's Galileo Orbiter and the Cassini mission. Three of Jupiter's moons, namely Europa, Callisto and Ganymede, are particularly interesting because they harbour electrically conducting oceans of liquid saltwater beneath a crust of water ice, which interact with Jupiter's magnetosphere to generate magnetic fields. This work is expected to provide improved constraints on the physical conditions within these satellites.

A third project applies Ferret to the task of building global, empirical models of the neutral atomic hydrogen (HI) present in disk galaxies. This phase of the interstellar medium is distributed in a thin disk. We determine the global density, velocity and temperature structure of HI disks, and compare the results for a selection of galaxies.

### T.D. Fugleberg

My current research interests have to do with matter and quantum fields under extreme conditions.

I am studying a new state of matter - the colour superconducting state - which may be present in neutron and/or quark stars with consequences detectable in astronomical observations. The colour superconducting state arises in the theory of the strong nuclear force, Quantum Chromodynamics, (QCD). My research involves refining models used in this analysis to include the physical masses of the quarks and other degrees of freedom in as complete a way as possible in order to make definitive quantitative predictions for observation. This research involves free colour charge and is thus related to the main unsolved problem of QCD - colour confinement.

I am also doing research in the areas of non-equilibrium and thermal field theory. Both of these topics have important applications in the physics of the early universe and in heavy ion collisions. I am developing techniques for simplifying calculations in the real time formalism of thermal field theory. Non-equilibrium field theory is still in its infancy but has important implications in the search for the quark gluon plasma and the evolution of the universe immediately following the big bang. I am performing numerical studies of  $\phi^4$  theory in the 2PPI model in order to understand how quantum fields evolve for arbitrary non-equilibrium initial conditions.

### R.L. Kobes

I have three main areas of research interests: quantum field theory, especially at finite temperature and density, classical theories which exhibit chaotic and fractal behaviour, and quantum computing and quantum information theory. Many of the problems we study in these areas involve numerical studies.

### G. Kunstatter

Gauge theories provide the theoretical basis for virtually all phenomenological descriptions of the fundamental interactions. They are also playing an increasingly important role in our understanding of certain condensed matter systems. The quantization of gauge theories is, however, complicated by the presence of unphysical modes in the classical description, which must be factored out in order to expose the true physical content of the theory. My research uses geometrical techniques to investigate questions concerning gauge dependence in quantized gauge theories such as Quantum Chromodynamics, Chern-Simons theory and Quantum Gravity, both at zero and finite temperature. Most recently, I have been examining the quantum mechanical behaviour of black holes via simplified field theoretic models in two spacetime dimensions. These models are ideal theoretical



laboratories for the study of fundamental issues surrounding black hole evaporation, such as the statistical mechanical source of entropy and the endpoint of gravitational collapse.

P.D. Loly

In my continuing study of the scientific properties of magical squares a couple of surprising developments have been made recently regarding extensions to my paper with Wayne Chan on compounding magic squares. In essence compounding is an old Chinese idea (before 1275 CE) wherein a base square is incremented and placed in the positions of elements of a frame square. Identical squares may be said to generate "fractal" squares, i.e. self-similar on different scales. Chan and Loly developed a computer implementation of this idea and demonstrated its utility in forging a new world record for large magic squares (order 12,544). In retrospect, perhaps the most important conclusion is that compounding preserves pandiagonality. Now, during the course of preparing a manuscript based on his 2003 summer work, Matt Rempel has developed a remarkable proof of the preservation of the multimagic property (remaining magic after all their elements are raised to a power of 2 or 3 or more, as suggested by Wayne Chan in 2003) of certain magic squares after compounding. Adam Rogers has now been able to show which eigenvalues of compounded magic squares are non-zero on the basis of the eigenvalues of their constituents. He is collaborating with Dan Schindel on these eigenproperties. Studies of the eigenproperties of magic squares have matured to encompass all in fourth order, and to begin to classify the 275 million in fifth order. My study with Daniel Schindel on singular associative (regular) magic squares, the most complete study of eigenproperties of any class of magic squares, is almost finished and we have enlisted the collaboration of Walter Trump (Nuremberg) to incorporate all singular ultramagic squares in seventh order. Schindel, Rempel and I have recently succeeded in counting the number of Benjamin Franklin's bent diagonal squares in eighth order, for which a recent study had given a very large upper bound. This is highly topical with respect to polyhedral cone counting methods, and may well lead to some involvement with the 2006 Franklin anniversary celebrations.

T.A. Osborn

My research program aims to achieve a unification of classical and quantum mechanics in a common mathematical framework. The theory that emerges (quantum phase space, QPS) is an altered version of classical phase space in which the usual commutative product of functions is deformed (as Planck's constant varies away from zero) into a noncommutative (star) product. With this one structural modification it is possible to state the full content of quantum mechanics as a noncommutative phase space theory. In this setting, the Schrödinger wave function never arises. Hilbert space operators are represented by phase space (Wigner) distributions, and quantum expectation values are given by integrals over phase space. This unification via QPS provides an alternate, autonomous statement of quantum mechanics that clarifies its content and interpretation and at the same provides a new computational platform that has many parallels to that of classical mechanics.

Two active projects are: 1) In recent work on charged particle systems in electromagnetic fields we have developed a QPS representation (called a perfect quantization) that is both gauge and geometrically covariant and has an exact star product determined by

a symplectic area phase. Perfect quantization provides an ideal platform for studying the semiclassical charged particle dynamics. We aim to extend this perfect quantization to general non-Abelian gauge theories, i.e., to include Riemannian manifolds and arbitrary spin structure. 2) Develop effective methods to treat long time dynamics in QPS. Rigorously define quantum chaos and the quantum Lyapunov exponent. Investigate the role of the Heisenberg uncertainty principle in the suppression of quantum chaos effects.

## B.W. Southern

### Statistical Physics

Cooperative phenomena in systems with competing interactions and disorder is a topic of active study. Disorder can arise in many ways such as the dilution of nonmagnetic materials with magnetic impurities or from the loss of perfect translational order in a solid. In particular, in magnetic systems, this competition can arise from the fact that the exchange interaction between magnetic atoms oscillates with distance. If the atoms are located at the sites of a regular lattice, a state of long ranged magnetic order often occurs. However, if there is some disorder in the positions of the atoms, conflicting messages from neighbouring atoms can destroy or weaken this order. In some cases, even if the atoms are arranged so that they lie at the sites of a regular lattice and the interactions are all of the same sign but negative, the order can be weakened to such an extent that the directions of the magnetic moments at zero temperature become completely random. Such systems are said to be frustrated because of the competing interactions and, in this latter case, we refer to the system as geometrically frustrated. Frustration can lead to novel ground states and can change the nature of the excitations in the system. In particular, it can change the nature of topological defects present in the system. These topological defects can interact and exhibit nontrivial unbinding transitions as the temperature increases. Our understanding of these effects is far from complete. A variety of theoretical techniques are employed to study these systems including renormalization group methods, low temperature series methods and numerical Monte Carlo methods.

## J. P. Svenne

Our current work has two main themes. The first, and currently most active one, involves work with a multi-channel algebraic system (MCAS) to study scattering of nucleons from light nuclei, and reactions initiated by such. This is a three-continent collaboration with Drs. L. Canton, G. Pisent (Padova University, Italy) and K. Amos, S. Karataglidis and D. van der Knijff (Melbourne University, Australia). The theory uses expansions in Sturmian functions of the channel-coupling interactions, leading to an algebraic solution of the coupled integral equations of the multichannel problem. This enables us to allow for the Pauli principle in the context of a collective model description of the target nucleus, by the use of orthogonalizing pseudo-potentials. The algebraic solution provides us a method of locating all resonances, no matter how narrow, as well as all bound states of the compound system, without the use of an excessively fine energy step sizes. Satisfying the Pauli principle is an essential aspect of the theory, as it removes any spuriousity, in both bound states and resonances and thus provides a theoretical formulation of the scattering

problem that has predictive power. The results of the calculations can also be used to give accurate interpretation of the nuclear structure of the target nucleus and the compound system. Our first work was on the well-studied, both theoretically and experimentally, nucleus  $^{12}\text{C}$ , with scattering by both neutrons and protons, with inclusion of the Coulomb force. The results compare very well with experiment. We are now working on other light and medium mass nuclear systems including systems well away from the valley of stability. Some very exciting new results near the proton drip line have already been obtained and are submitted for publication.

The second theme, in collaboration with L. Canton and G. Pisent at Padua University, focuses on pion absorption on very light nuclei. We have been carrying out practical calculations on  $^3\text{H}$  and  $^3\text{He}$ , initially with two-cluster final states; later three-nucleon final states will also be included. This uses various mechanisms and input on  $\pi N$ ,  $NN$  and  $\pi N\Delta$  interactions. The three-nucleon system is treated exactly in a Faddeev-based theory. Final-state interactions are correctly taken into account. In addition to the dominant  $\Delta$  rescattering contribution to pion production, various other mechanisms, important especially near threshold, are also included. We are able to calculate, along with differential and total cross sections, all possible spin observables, measured or, as yet, not. Comparison with data, where available, is now very good. This work is continuing, and a large paper collecting our main results to date is in preparation.

J.M. Vail

My research is concerned with developing and applying methods to simulate the properties of solid materials. Reliable simulation is an important complement to experiment in studying material properties where subtle variations of chemical composition, crystal structure, electronic configuration, and disorder are crucial, or where time scales, and temperature and pressure regimes are experimentally inaccessible. In 1984, with collaborators, we made a major advance in the atomistic simulation of point defects in ionic materials by combining accurate electronic structure methods for the defect with total energy analysis of the crystal. The method includes physically consistent boundary conditions, the quantum-mechanical ion-size effect, and lattice distortion and polarization, and is embodied in an automated user-friendly program. The method has been applied to charge state and structural stability of defect complexes, optical and spin resonance properties of color centers and impurities, local modification of valence and conduction band edges by impurities, derivation of effective interatomic forces, hole trapping and electron loss by impurities in oxides, local phonon mode frequencies, and classical and quantum diffusion.

Two research projects are current: (1) optical transitions between the electronic state localized at the angstrom level and a state localized at the nanometer level; (2) point-defect properties of group III nitrides.

D.W. Vincent

My general research interests lie in gravitation theory and early universe cosmology. I am currently involved with calculations on multidimensional cosmology solutions of Einstein's

equations, which have relevance to the cosmological constant problem, the Anthropic Principle, and the Many-Worlds approach to quantum cosmology .

### J.G. Williams

One of the developing trends in general relativity has been the interest in global, as opposed to local, properties of spacetime. My current research is concerned with spacetimes admitting gravity kinks, i.e. light cone configurations for which the cones tip over an integral number of times. Progress to date includes a kink classification for noncompact product spacetimes in both 3+1 and 2+1 dimensions and the construction of a covariant kink counting number formula in 1+1 dimensions that is related to the Gauss-Bonnet theorem and Morse's Law of Vector Fields. The problem of geodesic incompleteness in spherically symmetric kink spacetimes has been studied in relation to the weak and strong energy conditions, and null geodesics in a number of such spacetimes have been completed using the Kruskal technique. In 2+1 dimensions, a kink solution has been found for the Einstein equations with a perfect fluid source. The mass density, pressure and curvature are all well behaved and the vorticity is nonzero. Future effort will be directed towards introducing time-dependence and to studying the properties of scalar fields in such non-globally hyperbolic spacetimes.

### M. Whitmore

My research group does theoretical studies of soft condensed matter systems, in particular inhomogeneous copolymer systems and phospholipid membranes. Both these classes of molecules have relatively high molecular weights, have chemically distinct sections, and are chain-like in structure. They can self-assemble to form complex nano-scale structures, and undergo subtle phase transitions. A related system is the end-tethered polymer layer, which consists of polymers with one end anchored to a surface, all immersed in solvent. These systems are of wide interest in materials science and biological systems. Our primary goal is to understand them at a fundamental level, primarily using computer-intensive numerical simulations, augmented by relatively simple theories to highlight the underlying physics.

In the area of polymers, our primary focus is on the self-assembly of copolymers, the structures that form, the effects of additives, and the structure of end-tethered polymers. For example, we use numerical self-consistent field (NSCF) theory to calculate the phase diagrams of copolymers and copolymer/solvent blends. Recently, we have been working with chemists at the University of Toronto to understand detailed structural properties of copolymer/homopolymer blends that are observed there. The end-tethered polymer system illustrates the advantages of the NSCF approach. At high molecular weight and tethering density, the molecules become highly stretched, and the system reaches a limit known as the "polymer brush". There exist theories that describe this limit, but it has not been known at what point it is reached. In fact, it is now becoming clear that most systems that are created in the laboratory fall outside this limit. The NSCF theory gives results that are in excellent agreement with recent systematic experiments, identify the onset of the brush limit, and provide a new physical picture of the laboratory systems. Because the NSCF theory is a mean field theory, we have also done Monte Carlo simulations of

many of these systems. They can also be used to construct visual pictures and movies which can provide considerable physical insight. Very recently, we have begun to extend the NSCF theory to incorporate fluctuation effects, in an attempt to understand a long-standing disagreement between theory and experiment near a mean-field critical point in the phase diagram of block copolymers.

My colleague John Whitehead and I have developed an NSCF theory of phospholipid membranes. It provides a detailed picture of these systems, including a range of their structural and thermodynamic properties and their phase behaviour. It is the first theory of its kind to predict effects of pressure which are in good agreement with experiment. In particular, it predicts that the application of hydrostatic pressure causes the layer thickness to increase, rather than decrease as one might expect. We are currently extending this work to mixtures of lipids of different lengths.

## 4 Research Activities

### 4.1 Seminars

Date	Speaker	Institution	Title
September 17, 2004	Ken Amos	University of Melbourne, Australia	On new developments in analyses
Jan. 22, 2004	Prof. T. Chakraborty	University of Manitoba	Spintronics: Quantum Mechanics Spin Transistor
April 15, 2004	Dr. A. Barvinsky	Lebedev Physical Institute	Cosmological Constant Problem and Distance Modifications of Einstein
Sept. 27, 2004	Prof. V. Mandelzweig	Racah Institute of Physics	Quasilinearization Method and its Application to Physical Problems

### 4.2 Visiting Scientists

Dates	Visitor	Institution
Sept. 16-21, 2004	Ken Amos	University of Melbourne, Australia
July 8 - Aug. 1, 2005	Luciano Canton	Padova, Italy

### 4.3 Graduate Degrees Supervised

1. J. Medved (2000). "Thermodynamics of Charged Black Holes in Two-Dimensional Gravity". Ph.D. thesis, University of Manitoba, 2001. (University Microfilms), (Kunstatter).
2. S. Peles (2001). "Nonlinear Phenomena and Chaos in Periodically Driven Classical Systems". Ph.D. thesis, University of Manitoba, 2001. (University Microfilms), (Kobes).
3. T. Melde (2001). "The Three Nucleon System including one Dynamical Pion: A one dimensional test case". Ph.D. thesis. University of Manitoba, May 2001. (University Microfilms), (Svenne).
4. A. Peles (2004). "Frustrated Magnets: A Monte Carlo Study of Stiffness, Vorticity and Topological Excitations". Ph.D. thesis. University of Manitoba, 2004. (University Microfilms), (Southern).
5. A. J. Penner (2004). "Nonlinear Analysis of Complicated Physical Systems", MSc thesis. (Kobes).
6. S. Barkanova (2004). "The Electroweak Radiative Corrections and Parity-Violating Electron-Nucleon Scattering". PhD thesis, (Blunden).

### 4.4 Publications of Associate Members/Graduate Students

#### S. Bekhechi

1. S. Bekhechi and B.W. Southern, "Chiral mixed phase in disordered 3d Heisenberg models", *Phys. Rev. B* **70**, 020405(R) (2004).
2. N. Moussa and S. Bekhechi. 'Surface Critical Behavior of Thin Ising Films at the "Special Point" ', *Physica A* **320**, 435 (2003).
3. S. Bekhechi and B.W. Southern, 'Damage Spreading in Two-Dimensional geometrically frustrated lattices: the triangular and kagome anisotropic Heisenberg model'. *J. Phys. A: Math. Gen.* **36**, 8549 (2003).
4. S. Bekhechi and B. W. Southern. 'Off-equilibrium study of the fluctuation-dissipation relation in the easy-axis Heisenberg antiferromagnet on the kagome lattice'. *Phys. Rev. B* **67**, 212406 (2003).
5. S. Bekhechi and B.W. Southern, 'Low Temperature Static and Dynamic Behaviour of the Easy-Axis Heisenberg Antiferromagnet on the Kagome Lattice'. *Phys. Rev. B* **67**, 144403 (2003).

## A. Borodich

1. A.I. Borodich and G.M. Ullmann. Internal hydration of protein cavities: studies on BPTI. *Physical Chemistry Chemical Physics*. 6:1906-1911 (2004).
2. A. Borodich, I. Rojdestvenski, M.G. Cottam, J. Anderson, and G. Oquist. Segregation of the photosystems in higher plant thylakoids and short-term and long-term regulations by a mesoscopic approach. *Journal of Theoretical Biology*. 225:431-441 (2003).
3. A. Borodich, I. Rojdestvenski, M.G. Cottam, and G. Oquist. Segregation of photosystems in thylakoids depends on their size. *Biochimica et Biophysica Acta (Bioenergetics)* 1606:73-82 (2003).
4. A. Borodich, I. Rojdestvenski, and M.G. Cottam. Lateral heterogeneity of photosystems in thylakoid membranes studied by Brownian Dynamics simulations. *Biophysical Journal*. 85:774-789 (2003).
5. I. Rojdestvenski, A.G. Ivanov, M.G. Cottam, A. Borodich, N.P.A. Huner, and G. Oquist. Segregation of photosystems in thylakoid membranes as a critical phenomenon. *Biophysical Journal*. 82:1719-1730 (2002).

## Conference Proceedings

6. A. Borodich, I. Rojdestvenski, J. Anderson, and G. Oquist. Segregation of the Photosystems and Short-Term and Long-Term Regulations in Higher Plant Thylakoids. *The Sixth Nordic Congress on Photosynthesis*. Umea, Sweden. p.14. (2002).
7. A. Borodich, I. Rojdestvenski. Segregation of Photosystems in Photosynthetic Membrane of Green Plants. *EURESCO conference Computational Biophysics: Integrating Theoretical Physics and Biology*. San Feliu de Guixols, Spain. p. 58. (2002).
8. A.I. Borodich. Transverse Nonlinear Focusing of Nonstationary Space Charge Dominated Beams. *Proceedings Of The 1999 Particle Accelerator Conference*. N.Y. p. 1869-1871. (1999).
9. A.I. Borodich, I.A. Volkov. Optimal Transport of Nonstationary High Intensity Beams. *Proceedings Of The 1999 Particle Accelerator Conference*. N.Y. p 1872-1874. (1999).

## M. Califano

1. M. Califano, G. Bester and A. Zunger. "Prediction of a shape-induced enhancement in the hole relaxation in nanocrystals." *Nano Lett.* 3. 1197 (2003).
2. M. Califano and P. Harrison, "Composition, volume and aspect ratio dependence of the strain distribution, band lineups and electron effective masses in self-assembled pyramidal  $\text{In}_{1-x}\text{Ga}_x\text{As}/\text{GaAs}$  and  $\text{SixGe}_{1-x}/\text{Si}$  quantum dots." *J. Appl. Phys.* 91, 389 (2002).

3. M. Califano and P. Harrison. "Quantum box energies as a route to the ground state levels of self-assembled InAs pyramidal dots." *J. Appl. Phys.* 88, 5870 (2000).
4. M. Califano and P. Harrison. "Presentation and experimental validation of a single-band, constant-potential model for self-assembled InAs/GaAs quantum dots." *Phys. Rev. B* 61, 10959 (2000).
5. M. Califano and P. Harrison. "Approximate methods for the solution of quantum wires and dots: Connection rules between pyramidal, cuboidal and cubic dots." *J. Appl. Phys.* 86, 5054 (1999).

#### Conference Proceedings

6. M. Califano and A. Zunger. "Pseudopotential theory of electronic processes in colloidal CdSe quantum dots." Proceedings of the American Chemical Society Meeting 2003, March 23-27, 2003, New Orleans, LA (USA).
7. M. Califano, A. Zunger and A. Franceschetti, "Impact ionization in CdSe dots." Proceedings of the 27th International Conference on the Physics of Semiconductors (ICPS2004), July 26-30, 2004, Flagstaff, AZ (USA).
8. M. Califano, A. Zunger and A. Franceschetti, "Efficient inverse Auger recombination at threshold in CdSe nanocrystals." Proceedings of APS Meeting 2004, March 22-26, 2004, Montreal, QC (Canada).
9. M. Califano and A. Zunger. "Existence of an internal band gap within the valence band in CdSe nanocrystals." Proceedings of APS Meeting 2003, March 3-7, 2003, Austin, TX (USA).
10. M. Califano and A. Zunger. "Electronic structure calculations on quantum wires made of III-V compounds." Proceedings of APS March Meeting 2002, March 18-22 2002, Indianapolis, IN (USA).
11. M. Califano and P. Harrison. "A single-band constant-confining-potential model for self-assembled InAs/GaAs quantum dots." Proceedings of the 25th International Conference on the Physics of Semiconductors, September 2000, Osaka (Japan).
12. M. Califano and P. Harrison, "A single-band constant-confining-potential model for self-assembled InAs/GaAs quantum dots." Proceedings of the MRS 2000 Fall Meeting, Boston, MA (USA).
13. M. Califano and P. Harrison. "Composition, volume and aspect ratio dependence of the strain distribution, band lineups and electron effective masses in self-assembled pyramidal  $\text{In}_{1-x}\text{Ga}_x\text{As}/\text{GaAs}$  and  $\text{SixGe}_{1-x}/\text{Si}$  quantum dots." IoP Condensed Matter and Materials Physics Conference, University of Bristol (UK) 2000.
14. M. Califano and P. Harrison, "A single-band, constant-potential model for self-assembled InAs/GaAs quantum dots." IoP Condensed Matter and Material Physics Conference, University of Leicester (UK) 1999.



## T. Melde

1. L. Canton, T. Melde, and J.P. Svenne, Practical Approximation Scheme for the Pion Dynamics in the Three-Nucleon System, *Physical Review C*, **63**, 034004-1-10 (2001)

### Conference Proceedings and Talks

2. Juris P. Svenne, Thomas Melde and Luciano Canton, Pion Dynamics in the Three-Nucleon System, , contributed paper to the 2nd World Congress of Latvian Scientists, Riga, Latvia, August 14-15, 2001 (paper delivered orally in Latvian).
3. L. Canton, T. Melde and J.P. Svenne. Meson Dynamics and the resulting "3-Nucleon Force" diagrams: Results from a simplified test case. contributed paper to "Mesons and Light Nuclei" conference, Prague, Czech Republic, July 2-6. 2001. Proceedings to be published.
4. L. Canton, G. Pisent. W. Schadow. T. Melde. and J.P. Svenne, Three-Nucleon Portrait with Pion. contributed paper to the "VIII Convengo su problemi di fisica teorica", Cortona, Italy, October 18-20, 2000. Proceedings: *Theoretical Nuclear Physics in Italy*, G. Pisent, S. Boffi, L. Canton, A. Covello, A. Fabriocini, and S. Rosati, eds. (World Scientific, Singapore, 2001) pp. 249-256.
5. L. Canton, T. Melde and J.P. Svenne. Practical scheme for approximate treatment of the pion dynamics in three-nucleon systems (poster), Few Body XVI conference at Taipei, Taiwan, March 6-10. 2000.
6. T. Melde, J.P. Svenne and L. Canton, Pion Dynamics and Three-Nucleon Forces. contributed paper to the DNP-2000 Conference of the APS. October 4-7, 2000, Williamsburg, VA, U.S.A. (oral presentation by Svenne)
7. L. Canton, T. Melde and J.P. Svenne, "Interpreting the 3-nucleon force diagrams" (oral presentation by Melde), CAP-2000, York University.
8. T. Melde and J.P. Svenne. The piNNN scattering problem revisited (oral presentation by Melde), CAP-1999. University of New Brunswick, Fredricton.

## A. Peles

1. A. Peles. B.W. Southern. B. Delamotte. D. Mouhanna and M. Tissier, "Critical properties of a continuous family of XY noncollinear magnets". *Phys. Rev.* **B69**, 220408(R) (2004).
2. A. Peles and B.W. Southern, "Frustrated Heisenberg Antiferromagnets between  $d=2$  and  $d=3$ ", *Phys. Rev.* **B68**, 081403(R) (2004).
3. A. Peles and B.W. Southern. "Spin Stiffness of Stacked Triangular Antiferromagnets", *Phys. Rev.* **B67**, 184407 (2003).

## 4.5 Publications of Permanent Members

### P.G. Blunden

1. P.G. Blunden, W. Melnitchouk, and J.A. Tjon, Two-photon exchange and elastic electron-proton scattering. *Phys. Rev. Lett.* 91. 142304 (2003).
2. S. Barkanova, A. Aleksejevs, and P.G. Blunden, 2002, Radiative corrections and parity-violating electron-nucleon scattering. nucl-th/0212105. Submitted to *Physical Review C*.
3. P.G. Blunden, M. Burkardt, and G.A. Miller 2000, Light-front nuclear physics: Toy models, static sources, and tilted light-front coordinates, *Phys. Rev. C*61. 025206. nucl-th/9908067
4. P.G. Blunden, M. Burkardt and G.A. Miller. 1999, Light-front nuclear physics: Mean field theory for finite nuclei, To appear in *Phys. Rev. C*, nucl-th/9906012.
5. P.G. Blunden, M. Burkardt and G.A. Miller, 1999, Rotational invariance in nuclear light-front mean field theory, *Phys. Rev. C*59, R2998 (1999).

### Conference Proceedings and Talks

1. Two-photon exchange and elastic electron-proton scattering, Invited talk at Workshop on Electron-Nucleus Scattering VIII, Elba, Italy, June 2004.
2. Two-photon exchange effects in electron-proton scattering, Colloquium at Argonne National Laboratory, April 2004.
3. Two-photon exchange effects in electron-proton scattering, Colloquium at University of Manitoba, November 2003.
4. Two-photon exchange and elastic electron-proton scattering, Talk presented at Fall Meeting of APS Division of Nuclear Physics. Tuscon. AZ, October 2003.
5. P.G. Blunden and A. Aleksejevs, Radiative corrections and parity-violating electron scattering, Workshop on Fundamental Symmetries and Weak Interactions. Institute for Nuclear Theory, Seattle, WA November 26, 2002 (presented by A. Aleksejevs, Ph.D. student).
6. P.G. Blunden, Parity violating effects in the deuteron, Workshop on Fundamental Symmetries and Weak Interactions. Institute for Nuclear Theory. Seattle, WA December 3, 2002.
7. P.G. Blunden. Light-front nuclear physics: Mean field theory for finite nuclei, International Workshop on Relativistic Dynamics and Few-Hadron Systems. ECT Trento. November 6-17, 2000.

M. E. Carrington

1. "Transport Theory Beyond Binary Collisions," M.E. Carrington, S. Mrowczynski. Phys. Rev. D71, 065007 (2005).
2. "2PI Effective Action and Gauge Invariance Problems," M.E. Carrington, G. Kunstatter and H. Zaraket, Eur. Phys. J. C42, 253 (2005).
3. "The 4PI Effective Action for  $\phi^4$  Theory," M.E. Carrington. Eur. Phys. J. C35 383 (2004).
4. "Dielectric Functions and Dispersion Relations of Ultra-Relativistic Plasmas with Collisions," M.E. Carrington, T. Fugleberg, D. Pickering and M.H. Thoma, Can. J. Phys. 82, 671 (2004).
5. "Dileptons from Hot, Heavy, Static Photons," P. Aurenche. M.E. Carrington and N. Marchal, Phys. Rev. D68. 056001 (2003).
6. "Scattering Amplitudes at Finite Temperature," M.E. Carrington. Hou Defu and R. Kobes, Phys. Rev. D67 025021 (2003).
7. "Infrared behaviour of the pressure in  $\phi^3$  theory in 6 dimensions," M.E. Carrington. T.J. Hammond and R. Kobes. Phys. Rev. D65 067703 (2002).
8. "Equilibration in an Interacting Field Theory," M.E. Carrington, R. Kobes, G. Kunstatter, D. Pickering and E. Vaz, Can. J. Phys. 80 987 (2002).
9. "A General expression for Symmetry Factors of Feynman Diagrams." C.D Palmer and M.E. Carrington, Can. J. Phys. 80 847 (2002).
10. "Covariant approach to equilibration in effective field theories," Mark Burgess. M.E. Carrington and G. Kunstatter. Can. J. Phys. 80 97 (2002).
11. "A Diagrammatic Interpretation of the Boltzmann Equation," M.E. Carrington, Hou Defu, R. Kobes, Phys. Lett. B523 221 (2001).
12. "Nonlinear Response from Transport Theory and Quantum Field Theory at Finite Temperature," M.E. Carrington. Hou Defu, R. Kobes, Phys. Rev. D64 025001 (2001).
13. "Spontaneous Symmetry Breaking for Scalar QED with Nonminimal Chern-Simons Coupling," D.S. Irvine. M.E. Carrington, G. Kunstatter and D. Pickering, Phys. Rev. 64 045015 (2001).
14. "Spontaneous Scale Symmetry Breaking in 2+1 Dimensional QED at Both Zero and Finite Temperature," M.E. Carrington, WF Chen and R. Kobes. Eur. Phys. J C18 757 (2001).
15. "Approach to Equilibrium in the Micromaser," D. Leary, S. Yau. M.E. Carrington, R. Kobes and G. Kunstatter, Can. J. Phys. 79 783 (2001).

16. "KMS conditions for 4-point green functions at finite temperature," M.E. Carrington, Hou Defu and J.C. Sowiak, Phys. Rev. D62 065003 (2000).
17. "Shear Viscosity in  $\phi^4$  Theory from an Extended Ladder Resummation," M.E. Carrington, Hou Defu and R. Kobes, Phys. Rev. D62 085013 (2000).
18. "Four-Point Spectral Functions and Ward Identities in Hot QED," Hou Defu, M.E. Carrington, R. Kobes and U. Heinz, Phys. Rev. D61 085013 (2000).
19. "A New Formulation of a 1+1 Dimensional Field Theory Constrained to a Box, M.E. Carrington, R. Kobes and G. Kunstatter, Phys. Rev. D61 125008 (2000).
20. "Evaluating Real Time Finite Temperature Feynman Amplitudes," M.E. Carrington, Hou Defu, A. Hachkowski, D. Pickering and J.C. Sowiak, Phys. Rev. D61 25011 (2000).
21. "Two-Loop Quantum Corrections of Scalar QED with non-Minimal Chern-Simons Coupling," M.E. Carrington, W.F. Chen, G. Kunstatter and J. Mottershead, Phys. Rev. D60 125018 (1999).
22. "Equilibrium and Non-Equilibrium Hard Thermal Loop Resummation in the Real Time Formalism." M.E. Carrington, Hou Defu and Markus Thoma, Eur. Phys. J. C7 347 (1999).

#### Papers in Refereed Proceedings

23. "Chapman-Enskog Expansion of the Boltzmann equation and its Diagrammatic Interpretation". M.E. Carrington, Hou Defu, R. Kobes, refereed paper published electronically in the proceedings of the XXXI International Symposium of Multiparticle Dynamics, Sept 1-7, 2001, Datong, China.
24. "Contributions to Transport Theory from Multi-particle Interactions and Production Processes", M.E. Carrington, refereed paper published in the proceedings of 'Strong and Electroweak Matter 2004' June 16-19, Helsinki, Finland.

#### T. Chakraborty

1. T. Chakraborty and P. Pietilinen, "Correlation effects on Rashba precession in a two-dimensional electron gas" (to be published)
2. C. Schiller, K.-B. Broocks, P. Schrtter, Ch. Heyn, D.Heitmann, M. Bichler, W. Wegscheidier, T. Chakraborty, and V.M. Apalkov, "How to probe a fractionally-charged quasihole?", Physica E 22, 131-134 (2004).
3. Schüller, C., Broocks, K.-B., Schröter, P., Heyn, Ch., Heitmann, D., Bichler, M., Wegscheidier, W., Chakraborty, T., and Apalkov, V. M., "Optical Probing of a Fractionally Charged Quasihole in an Incompressible Liquid," Phys. Rev. Lett. 91, 116403 (2003).

4. T. Chakraborty and V. M. Apalkov, "Quantum cascade transitions in nanostructures", *Advances in Physics* 52, 455-521 (2003).
5. T. Chakraborty and V.M. Apalkov, "Magnetic field effects on intersubband transitions in a quantum nanostructure", *Physica E* 16, 253-258 (2003).
6. D. Smirnov, O. Drachenko, J. Leotin, H. Page, C. Becker, C. Sirtori, V. Apalkov and T. Chakraborty, "Intersubband magnetophonon resonance in quantum cascade structures", *Int. J. Mod. Phys. B* 16, 2952-2955 (2002).
7. V.M. Apalkov and T. Chakraborty, "Interaction of a quantum dot with an incompressible two-dimensional electron gas", *Physica E* 14, 289-293 (2002).
8. V. M. Apalkov and T. Chakraborty, "Optical properties of quantum-dot cascade structure". *Physica E* 14, 294-298 (2002).
9. V. M. Apalkov and T. Chakraborty, "Influence of Disorder and a Parallel Magnetic Field on a Quantum Cascade Laser", *Appl. Phys. Lett.* 78, 697-699 (2001).
10. V. M. Apalkov and T. Chakraborty, "Magnetic Field induced Luminescence Spectra in a Quantum Cascade Laser". *Appl. Phys. Lett.* 78, 1973-1975 (2001). [This article has been selected for *Virtual Journal of Nanoscale Science & Technology* 3 (April 9,2001)].
11. V. M. Apalkov and T. Chakraborty, "Luminescence Spectra of a Quantum-Dot Cascade Laser", *Appl. Phys. Lett.* 78, 1820-1822 (2001). [This article has been selected for *Virtual Journal of Nanoscale Science & Technology* 3 (April 2, 2001)].
12. T. Chakraborty, K. Niemeel, and P. Pietilinen, "Spin polarization of quantum Hall states", in *150 Years of Quantum Many-body Theory*, Eds. R.F. Bishop, K.A.Gernoth, and N. R. Walet (World Scientific, 2001). p. 295.
13. V. M. Apalkov, T. Chakraborty, P. Pietilinen and K. Niemeel, "Half-Polarized Quantum Hall States", *Phys. Rev. Lett.* 86, 1311- 1314 (2001).
14. V. M. Apalkov, T. Chakraborty, P. Pietilinen and K. Niemeel, "Comment on Composite Fermion Hofstadter Problem: Partially Polarized Density Wave States in the  $\nu = 2/5$ ", *condmat/0007043*.
15. K. Niemeel, P. Pietilinen and T. Chakraborty, "Spin transitions in the fractional quantum Hall systems", *Physica B* 284-288, 1716-1717 (2000).
16. T. Chakraborty and P. Pietilinen, "Temperature dependence of spin polarizations at higher Landau levels". *Phys. Rev. Lett.* 83, 5559-5562 (1999).
17. S. Conti and T. Chakraborty, "Dynamical Correlations in a Half-Filled Landau Level", *Phys. Rev. B* 59, 2867-2870 (1999).
18. T. Chakraborty, "Interacting Electrons in a Narrow Quantum Hall System", *Festkörperprobleme/Advances in Solid State Physics*, 38, 397-496 (1999).

## Other Refereed Publications

19. Tapash Chakraborty, F. M. Peeters, and U. Sivan (Eds.), "Nano-Physics & Bio-Electronics: A New Odyssey", 1st ed. (Elsevier, 2002).
20. Tapash Chakraborty, "Quantum Dots - A survey of the properties of artificial atoms", 1st ed. (Elsevier, 1999).

## T. D. Fugleberg

1. T. Fugleberg, *General Quasiparticle Propagator and Mass Dependence in Degenerate Color Superconductivity*, Phys.Rev. D67 (2003) 034013 [hep-ph/0206033] (35 pages).
2. T. Fugleberg, *Color Superconductivity with Non-Degenerate Quarks*, hep-ph/0112162.
3. K. Buckley, T. Fugleberg and A. Zhitnitsky, *Induced theta-vacuum states in heavy ion collisions: a possible signature*, Phys. Rev. C63 (2001) 034602-1 to 034602-9.
4. K. Buckley, T. Fugleberg and A. Zhitnitsky, *Can Induced Theta Vacua be created in Heavy Ion Collisions?*, Phys.Rev.Lett. 84 (2000) 4814-4817.
5. T. Fugleberg, *False Vacuum Decay in QCD within an Effective Lagrangian Approach*, hep-ph/9906430.
6. T. Fugleberg, I. Halperin and A. Zhitnitsky, *Domain Walls and Theta Dependence in QCD with an Effective Lagrangian Approach*, Phys. Rev. D59 (1999) 074023-1 to 074023-20.

## Conference Proceedings and Talks

7. T. Fugleberg, *Color Superconductivity with 2+1 Flavors*, published in Proc. International Symposium on Statistical QCD, Bielefeld (Germany), 26 August 2001, Nucl. Phys. A702 (1-4) (2002) pp. 196-200.
8. T. Fugleberg, *Can Induced Theta Vacua be created in Heavy Ion Collisions?*, published in From Particles to the Universe, Proceedings of the 15th Lake Louise Winter Institute, Lake Louise, Alberta, Canada 20-26 February 2000, World Scientific Pub. Co. (2001) (4 pages).

## J. Fiege

1. Aburihan M., Fiege J.D., Henriksen R. H., & Lery T., 2001, Protostellar Evolution During Time Dependent Anisotropic Collapse. MNRAS, 326, 1217-1227
2. Feldman, P. A., Redman, R. O., Avery, L. W., Di Francesco, J., Fiege, J. D., Carey, S. J., & Wyrowski, F., 2004, "Search for the Chemical Signature of Outflows from Bright, Compact Sources in MSX IRDCs", Can. J. Chem., 82, 740

3. Fiege J. D., Johnstone D., Redman R. O., Feldman P. A., Carey S. J.. Magnetic Models of the G11.11-0.12 Infra-Red Dark Cloud, *Ap.J.*, 2004, in press. accepted 10 Aug. 2004, 17 pages
4. Johnstone D., Fiege J. D., Redman R. O., Feldman P. A., Carey S. J.. The G11.11-0.12 Infrared-Dark Cloud: Anomalous Dust and a Non-Magnetic Isothermal Model. 2003, *Ap.J. Letters*, 588, 37-40
5. Vallee J. P., Greaves J. S. & Fiege J. D., Magnetic Structure of a Dark Bok Globule. 2003, *Ap.J.*, 588. 910-917
6. Matthews B. C., Fiege J. D. & Moriarty-Schieven G. H., 2001. Magnetic Fields in Star-Forming Molecular Clouds. III. Submillimetre Polarimetry of Intermediate Mass Cores and Filaments in Orion B. *Ap.J.*, 569, 304-321
7. Matthews B. C., Wilson C. D. & Fiege J. D., 2001, Magnetic Fields in Star-Forming Molecular Clouds II. The Depolarization Effect in the OMC-3 Filament of Orion A, *Ap.J.*, 562, 400-423
8. Fiege J. D. & Pudritz R. E., 2000d, Polarized Sub-Millimetre Emission from Filamentary Molecular Clouds, *Ap.J.*, 544. 830-837
9. Fiege J. D. & Pudritz R. E., 2000c, Prolate Cores in Filamentary Molecular Clouds. *Ap.J.* 534, 291-308
10. Fiege J. D. & Pudritz R. E., 2000b, Helical Fields and Filamentary Molecular Clouds II - Axisymmetric Stability and Fragmentation, *MNRAS*, 311, 105-119
11. Fiege J. D. & Pudritz R. E., 2000a, Helical Fields and Filamentary Molecular Clouds I. *MNRAS*, 311. 85-104
12. Lery T., Henriksen R. H. & Fiege J. D., 1999, Magnetised protostellar bipolar outflows. I. Self-similar model with Poynting flux, *A&A*, 350, 254-274
13. Lery T., Henriksen R. N., Fiege J. D., Ray T. P., Frank A., Bacciotti F., 2002. A global jet/circulation model for young stars, *A&A*, 387, 187-200

#### Other Refereed Publications

14. Fiege J. D., 2002, The Structure and Dynamics of Filamentary Molecular Clouds, 30 page invited and refereed book chapter, "Simulations of Magnetohydrodynamic Turbulence in Astrophysics: Recent Achievements and Perspectives", Springer Lecture Notes in Physics. 2003, conference 2-6. page 299-328. July 2001, Paris, France; editors: Falgarone E. & Passot T.

## Conference Proceedings

15. Fiege J. D., 2004. Computational Intelligence Techniques for Submillimetre Polarization Modeling, in "Astronomical Polarimetry - Current Status and Future Directions", held March 15-19. 2004. Waikoloa, HI
16. Pudritz R. E. & Fiege J. D.. 2000. Star Formation and Topology: The Physics of Magnetized Molecular Clouds. Proc. 33rd ESLAB Symp. "Star Formation from the Small to the Large Scale". ESA SP-445, Editors: Favata, F., Kaas, A.A., and Wilson, A., p.171
17. Lery T., Frank A., Henriksen R. N. & Fiege J. D.. 1999. Protostellar Bipolar Outflows and Propagation of MHD Jets, in "Star Formation 1999, Proceedings of Star Formation 1999". held June 21 - 25. 1999, Nagoya. Japan. Editor: Nakamoto T.. Nobeyama Radio Observatory. p. 291-292
18. Matthews, B. C., Wilson. C. D., Fiege. J. D., Magnetic Fields in Star-Forming Clouds: How Can FIRST Contribute?, in "The Promise of the Herschel Space Observatory". Eds. G.L. Pilbratt. J. Cernicharo, A.M. Heras, T. Prusti. & R. Harris. ESA-SP 460. p. 461-463
19. Pudritz R. E. & Fiege J. D.. 1999, Cluster Formation and the ISM, in "New Perspectives on the Interstellar Medium". held August 22-28, Naramata, B.C., ASP Conference Series 168, Edited by Taylor A.R., Landecker T.L., & Joncas G. Astronomical Society of the Pacific (San Francisco), ISBN: 1-886733-89-9 (1999).. p.235-247
20. Mitchell G. et al. 1999, Large SCUBA Images of the Rho Ophiuchus and Orion B Molecular Clouds, in "Imaging at Radio Through Submillimeter Wavelengths". held June 6-9, 1999. Tucson. AZ. Edited by Jeff Mangum. 1999
21. Fiege J. D. & Pudritz R. E., 1999, Helical Fields and Filamentary Molecular Clouds, in "New Perspectives on the Interstellar Medium", held August 22-28, Naramata. B.C., ASP Conference Series 168. Edited by Taylor A.R., Landecker T.L.. & Joncas G. Astronomical Society of the Pacific (San Francisco), ISBN: 1-886733-89-9 (1999), p.248-251

## R.L. Kobes

1. R. Kobes and A. J. Penner. 2005, "Nonlinear fractal interpolating functions of one and two variables". Fractals 13, 179.
2. S. Hamieh, R. Kobes, and H. Zaraket. 2005, "POVM optimization of classical correlations", Phys. Rev. A, to appear.
3. Saurya Das, Randy Kobes, Gabor Kunstatter, 2003, "Energy and efficiency of adiabatic quantum search algorithms", J. Phys. A: Math. Gen. 36, 1 .
4. M. Carrington, H. Defu. and R. Kobes, 2003, "Scattering amplitudes at finite temperature", Phys. Rev. D67. 025021 .



5. S. Das, R. Kobes, and G. Kunstatter, 2002, "Adiabatic quantum computation and Deutsch's algorithm". *Phys. Rev. A* **65**, 062310.
6. M. Carrington, T. J. Hammond, and R. Kobes, 2002, "Infrared behaviour of the pressure in  $g\phi^3$  theory". *Phys. Rev. D* **65**, 067703.
7. M. Carrington, R. Kobes, G. Kunstatter, D. Pickering, and E. Vaz, 2002, "Equilibration in an interacting field theory", *Can. J. Phys.* **80**, 987.
8. R. Kobes and H. Letkeman, 2002, "Non-linear fractal interpolating functions". *Visual Mathematics* **4**, No. 1.
9. M. E. Carrington, Hou Defu, and R. Kobes, 2001, "A diagrammatic interpretation of the Boltzmann equation". *Phys. Lett.* **B523**, 221.
10. M. E. Carrington, Hou Defu, and R. Kobes, 2001, "Nonlinear response from transport theory and quantum field theory at finite temperature". *Phys. Rev.* **D64**, 025001.
11. R. Kobes, J. -X. Liu, and S. Peles, 2001, "Analysis of a parametrically driven pendulum", *Phys. Rev.* **E63**, 036219.
12. M. E. Carrington, W. F. Chen, and R. Kobes, 2001, "Spontaneous Scale Symmetry Breaking in 2+1-Dimensional QED at Both Zero and Finite Temperature". *Eur. Phys. J.* **C18**, 757.
13. D. Leary, S. Yau, M. Carrington, R. Kobes, G. Kunstatter, 2001, "Approach to equilibrium in the micromaser". *Can. J. Phys.* **79**, 783.
14. M. E. Carrington, Hou Defu, and R. Kobes, 2000, "Shear viscosity in  $\phi^4$  theory from an extended ladder resummation", *Phys. Rev.* **D62**, 025010.
15. Hou Defu, M. E. Carrington, R. Kobes, and U. Heinz, 2000, "Four-point spectral functions and Ward identities in hot QED", *Phys. Rev.* **D61**, 085013.
16. M. Carrington, R. Kobes and G. Kunstatter, 2000, "A new formulation of a 1+1 dimensional field theory constrained to a box", *Phys. Rev.* **D61**, 125008.
17. P. Aurenche, F. Gelis, R. Kobes, and H. Zaraket, 1999, "Two-loop Compton and annihilation processes in thermal QCD". *Phys. Rev.* **D60:076002** (24 pages).

#### Refereed conference proceedings

1. Daria Ahrensmeier, Saurya Das, Randy Kobes, Gabor Kunstatter, and Haitham Zaraket, 2002, "Rapid data search using adiabatic quantum computation", to appear in proceedings of 6th International Conference on Quantum Communication, Measurement and Computing (M. I. T.).

2. M. E. Carrington, Hou Defu, and R. Kobes, 2002. "Chapman–Enskog expansion of the Boltzmann equation and its diagrammatic representation", (XXXI International Symposium on Multiparticle Dynamics, in press) .
3. R. Kobes, 2000. "Calculating the viscosity (the hard way)", in *The BNL workshop on Non-equilibrium and Equilibrium field theory*, edited by D. Boyanovsky, R. Pisarski, and H. de Vega (BNL publication) .

### G. Kunstatter

1. J. Gegenberg and G. Kunstatter "Using 3D Stringy Gravity to Understand the Thurston Conjecture", *Class. Qu. Gravity* 21, 1197-1208 (2004).
2. S. Das and G. Kunstatter. "Varying Fine Structure Constant and Black Holes Physics". *Class. Quant. Grav.* 20. 2015-2024 (2003).
3. G. Kunstatter. "d-dimensional Black Holes Entropy from Quasi-Normal Modes". *Phys. Rev. Lett.* 90 (2003) 161301.
4. S. Das, R. Kobes and G. Kunstatter, "Energy and Efficiency of Adiabatic Quantum Search Algorithms". *J. Phys. A: Math. Gen.* 36, 1-7 (2003) .
5. V. Husain, G. Kunstatter, B. Preston and M. Birukou, "Anti-deSitter Gravitational Collapse". *Class. Qu. Gravity (Letters)* 20. L23-L29 (2003).
6. Andrei Barvinsky, Saurya Das and Gabor Kunstatter, "Discrete Spectra of Charged Black Holes", to appear in a special issue of *Foundations of Physics in Honour of Prof. J. Bekenstein*.
7. S. Das, R. Kobes, and G. Kunstatter. "Adiabatic quantum computation and Deutsch's algorithm". *Phys. Rev. A* 65. (2002). 062310
8. M. Birukou, V. Husain, G. Kunstatter, M. Olivier and E. Vaz. "Scalar Field Collapse in d Spacetime Dimensions", *Phys.Rev. D* 65:104036, (2002).
9. M. Burgess, M.E. Carrington and G. Kunstatter, "Covariant approach to equilibration in effective field theories", *Can. J. Phys.* 80. 97-107 (2002).
10. M.E. Carrington, R. Kobes, G. Kunstatter, D. Pickering and E. Vaz. "Equilibration in an Interacting Field Theory." *Can. J. Phys.* 80 987 (2002).
11. A. Barvinsky, S. Das and G. Kunstatter. "Quantum Mechanics of Charged Black Holes", *Physics Lett.* B517. 415-420 (2001).
12. A. Barvinsky, S. Das and G. Kunstatter, "The Spectrum of Charged Black Holes—The Big Fix Mechanism Revisited", *Class. and Qu. Grav.* 18, 4845-4862 (2001) gr-qc/0012066

13. D.S. Irvine, M.E. Carrington, G. Kunstatter and D. Pickering, "Spontaneous Symmetry Breaking for Scalar QED with Non-minimal Chern-Simons Coupling". Phys. Rev. D64 045015, 2001.
14. A.J.M. Medved and G. Kunstatter. "One-Loop Corrected Thermodynamics of the Extremal and Non-Extremal BTZ Black Hole". Phys. Rev. D63, 104005 (2001); hep-th/0009050
15. W. Chen and G. Kunstatter, "Constraint from the Lamb shift and anomalous magnetic moment on radiatively induced Lorentz and CPT violation effects in quantum electrodynamics", Phys. Rev. D62 (2000) 105029: hep-ph/0002294
16. J. Gegenberg and G. Kunstatter, "Boundary Dynamics of Higher Dimensional AdS Spacetime", Phys. Lett. B478, 327-332 (2000); hep-th/9905228
17. D. Leary, S. Yau, M. Carrington, R. Kobes and G. Kunstatter, "Approach to Equilibrium in the Micromaser", Can. J. Phys. 79, 783-799 (2001) physics/9907010
18. M.E. Carrington, R. Kobes and G. Kunstatter. "A New Formulation of a 1+1 Dimensional Field Theory Constrained to a Box", Phys.Rev.D61:125008 (2000). hep-th/9906202.
19. M.E. Carrington, W.F. Chen and G. Kunstatter, "Two-Loop Quantum Corrections of Scalar QED with Non-Minimal Chern-Simons Coupling". Phys. Rev. D60 (1999) 125018; hep-th/9905172.
20. A.J.M. Medved and G. Kunstatter. "Quantum Corrections to the Thermodynamics of Charged 2-D Black Holes". Phys. Rev. D60,104029(1999). hep-th/9904070.
21. V. Frolov, D. Fursaev, J. Gegenberg and G. Kunstatter, "Thermodynamics and Statistical Mechanics of Induced Liouville Gravity" Phys.Rev. D60 (1999) 024016.
22. A.J.M. Medved and G. Kunstatter, "Hamiltonian Thermodynamics of Charged Black Holes". Phys. Rev. D59 (1999) 104005.
23. G. Kunstatter, "Quantum Corrections to the Thermodynamics of 2-D Charged Black Holes", Black Holes II, Val Morin, June 6-9, 1999. (Invited talk).

#### Papers presented at meetings

24. G. Kunstatter, "Critical Behaviour in Black Holes Formation: from 2-d to infinity" (Invited), Workshop on 2-D Gravity, Erwin Schrodinger Institute, Vienna, Oct. 2003.
25. G. Kunstatter. "From Quasi-normal Modes to Black Hole Microstates", Canadian Conference on General Relativity, Guelph, May. 2003.
26. G. Kunstatter, "From Quasi-normal Modes to Black Hole Microstates". (Invited). Black Holes IV, May, 2003.

## P.D. Loly

1. Adam Rogers and Peter Loly. "The electric multipole expansion for a magic cube". *European Journal of Physics* 26 (2005) 809-813. (C1)
2. P. D. Loly and Steeds. "A new class of pandiagonal squares". *International Journal of Mathematical Education in Science and Technology*. vol. 36. No. 4. 2005. 375-3881. (C1)<sub>ij</sub>
3. Adam Rogers and Peter Loly. "Rotational sorcery - The inertial properties of magic squares and cubes", *Canadian Undergraduate Physics Journal*. III(2), 25. 2005. (C1)
4. P. D. Loly and M. Steeds, "A New Class of Pandiagonal Squares", to be published in the *International Journal of Mathematical Education in Science and Technology*, (2004).
5. Adam Rogers and Peter Loly. "The Inertia Tensor of Magic Cubes", *American J. Physics*, 72(6), 786-9, (2004).
6. P.D.Loly, "The Invariance of the Moment of Inertia of Magic Squares", *The Mathematical Gazette*, 88(511), 151-3, (2004).
7. W. Chan and P. D. Loly. "Iterative Compounding of Square Matrices to Generate Large-Order Magic Squares", *Mathematics Today*, 38(4), 113-118. (2002).
8. P. D. Loly, "A purely pandiagonal 4\*4 square and the Myers-Briggs Type Table". *J. Rec. Math.*, 31(1), 29-31. 2000/2001 (2002).
9. P. D. Loly, "A Logical Way of Ordering the Trigrams and Hexagrams of the Yijing". *The Oracle - The Journal of Yijing Studies*, vol. 2, no. 12. p.2-13). (2002)
10. W. Chan and P. D. Loly, "Magic Square Record!", *ManACE Journal*, p.7. (2001)
11. P. D. Loly, "Type Wheels and Square Bagels", *Bull. Psych. Type*. 24:4. 33-34. (1999).

## Conference proceedings

12. P.D. Loly, "Scientific Studies of Magic Squares", *Seventh International Conference on History, Philosophy and Science Teaching (IHPST-7)*, 553-563, (2003). Contributed paper .

## T.A. Osborn

1. M. V. Karasev and T. A. Osborn, "Cotangent bundle quantization: entangling of metric and magnetic field". *J. Phys. A*. 38 8549-8578 (2005).

2. M. V. Karasev and T. A. Osborn, "Quantum Magnetic Algebra and Magnetic Curvature", *J. Phys. A*, 35, 2345-2363 (2004).
3. T.A. Osborn, M.F. Kondratieva. "Heisenberg Evolution WKB and Symplectic Area Phases" , *J. Phys A: Math. and Gen.*, 35, 5279-5303 (2002).
4. M. V. Karasev, T. A. Osborn. "Symplectic Areas, Quantization, and Dynamics in Electromagnetic Fields", *J. Math. Phys.*, 43, 756-788 (2002).
5. T.A. Osborn, M.F. Kondratieva, G.C. Tabisz, B.R. McQuarrie. "Mixed Weyl symbol calculus and spectral line shape theory", *J. Phys. A: Math and Gen.*, 32 4149-4169 (1999).

#### Conference Proceedings and Invited Talks

6. "On the notion of the Lyapunov exponent", M. F. Kondratieva and T. A. Osborn, Petroskii Conference, Moscow, May 25-30, 11 pages, (2004).
7. "Quantum Phase Space and its Magnetic Curvature". International Conference Mathematics and Its Applications, Hong Kong, May 28 - 31, (2004) (invited talk).
8. M. V. Karasev and T. A. Osborn. "Magnetic Curvature of Quantum Phase Space", *Proceedings of the Third International Sakharov Conference on Physics*, vol. 1, 153-162 (2003).
9. T. A. Osborn, "Magnetic Curvature of Quantum Phase Space", 8<sup>th</sup> International Wigner Symposium, New York, May 27-30, (2003) (invited talk).
10. M.F. Kondratieva, T. A. Osborn "Time dependent Wigner function in semiclassical approximation", in: *Proceedings of XIII International Summer School-Seminar "Recent Problems in Field Theory"*, edited by A.B. Aminova, Kazan State University, 236-243 (2002).
11. T. A. Osborn, "Symplectic Areas, quantization, and dynamics in electromagnetic fields". International Conference on Quantization, Gauge Theory and Strings, Moscow, June 5-10, (2000) (invited talk).
12. B. R. McQuarrie, T. A. Osborn, M. F. Kondrat'eva and G. C. Tabisz, "Moyal Quantum Dynamics: Atomic Scattering and Line Shapes", in *Spectral Line Shapes*, Vol. 10, edited by R. M. Herman (AIP, New York, 1999), pp. 332-335.

## B.W. Southern

1. S. Bekhechi, B.W. Southern, A. Peles and D. Mouhanna. "Short-time dynamics of a family of XY noncollinear magnets", submitted to PRL (cond-mat/0511640) [2005]
2. B.W. Southern and A. Peles, "Topological Phase Transitions in Frustrated Magnets", in Proceedings of Theory I Conference, (to appear in Can. J. Phys.) [2005]
3. S. Bekhechi and B.W. Southern, "Chiral mixed phase in disordered 3d Heisenberg models". *Phys. Rev. B* **70**, 020405(R) [2004]. [C1]
4. A. Peles, B.W. Southern, B. Delamotte, D. Mouhanna and M. Tissier. "Critical properties of a continuous family of XY noncollinear magnets", *Phys. Rev. B* **69**, 220408(R) [2004]. [C1]
5. A. Peles and B.W. Southern, "Frustrated Heisenberg Antiferromagnets between  $d=2$  and  $d=3$ ". *Phys. Rev. B* **68**, 081403(R) [2004]. [C1]
6. Z.F. Wang and B.W. Southern, "Three-state Potts model on the Maple Leaf lattice". *Phys. Rev. B* **68**, 094419 (2003). [C1]
7. S. Bekhechi and B.W. Southern. "Damage Spreading in Two-Dimensional geometrically frustrated lattices: the triangular and kagome anisotropic Heisenberg model", *J. Phys. A: Math. Gen.* **36**, 8549 (2003). (C1)
8. V. Levashov, M.F. Thorpe and B.W. Southern. "Charged lattice gas with a neutralizing background" ,*Phys. Rev. B* **67**, 224109 (2003). (C1)
9. S. Bekhechi. and B. W. Southern. "Off-equilibrium study of the fluctuation-dissipation relation in the easy-axis Heisenberg antiferromagnet on the kagome lattice". *Phys. Rev. B* **67**, 212406 (2003). (C1)
10. A. Peles and B.W. Southern. "Spin Stiffness of Stacked Triangular Antiferromagnets", *Phys. Rev. B* **67**, 184407 (2003). (C1)
11. S. Bekhechi and B.W. Southern, "Low Temperature Static and Dynamic Behaviour of the Easy-Axis Heisenberg Antiferromagnet on the Kagome Lattice". *Phys. Rev. B* **67**, 144403 (2003). (C1)
12. Z.F. Wang, B.W. Southern and D.A. Lavis, "Monte Carlo Study of an Extended 3-State Potts Model on the Triangular Lattice", *Phys. Rev. B* **67**, 054415 (2003). (C1)
13. W. Stephan and B.W. Southern, "Is There a Phase Transition in the Isotropic Heisenberg Antiferromagnet on the Triangular Lattice?", *Canadian Journal Of Physics* **79**, 1459-61 (2001). (C1)

This paper was awarded the "Best Paper Award" from the condensed matter and materials physics division of the CAP and an invited talk was given at the Congress in June 2002.

14. W. Stephan and B.W. Southern, "Monte Carlo Study of the Anisotropic Heisenberg Antiferromagnet on the Triangular Lattice", *Phys. Rev. B* **61**, 11514-11520. (2000). (C1)
15. B.W. Southern and J.L. Martínez Cuéllar, "Multi-Magnon Excitations in Alternating Spin/Bond Chains", *Phys. Rev. B* **58**, 9156-9165, (1998). (C1)

#### J.P. Svenne

1. Comparison between two methods of solution of coupled equations for low-energy scattering, K. Amos, S. Karataglidis, D. van der Knijff, L. Canton, G. Pisent, and J.P. Svenne, (6 pp.) *Physical Review C*, 2005; in press: arXiv: nucl-th/0510085
2. Compound and quasi-compound states in low-energy scattering of nucleons from  $^{12}\text{C}$ , G. Pisent, J. P. Svenne, L. Canton, K. Amos, S. Karataglidis, and D. van der Knijff. *Physical Review C* **72**, 014601 (2005); arXiv: nucl-th/0502016
3. Role of the Pauli principle in collective-model coupled-channel calculations, L. Canton, G. Pisent, J.P. Svenne, D. van der Knijff, K. Amos, and S. Karataglidis.; *Physical Review Letters* **94**, 122503 (2005); arXiv: nucl-th/0409050
4. An algebraic solution of the multichannel problem applied to low energy nucleon-nucleus scattering, K. Amos, L. Canton, G. Pisent, J.P. Svenne, and D. van der Knijff; *Nuclear Physics A* **728**, 65-95 (2003)
5. Three-Body Dynamics in One Dimension: A Test Model for the Three-Nucleon System with Irreducible Pionic Diagrams, T. Melde, L. Canton, and J.P. Svenne, *Few-Body Systems*, **32**, 143-168 (2002) .
6. Practical Approximation Scheme for the Pion Dynamics in the Three-Nucleon System, L. Canton, T. Melde, and J.P. Svenne. *Physical Review C*. **63**. 034004-1-10 (2001).

#### Refereed conference proceedings

7. Solution of multi-channel problems using MCAS for spectra and scattering cross sections, K. Amos, S. Karataglidis, P. Fraser, D. van der Knijff, J. P. Svenne, L. Canton, G. Pisent. invited paper (Amos) to the Workshop on Perspectives for Nuclear Data for the Next Decade, Bruyeres-le-Chatel, France, Sept. 2005; arXiv: nucl-th/0510030
8. Low energy nuclear scattering and sub-threshold spectra from a multi-channel algebraic scattering theory, K. Amos, P. Fraser, S. Karataglidis, D. van der Knijff, J. P. Svenne, L. Canton, G. Pisent. invited paper (Amos), to the FINUSTAR conference, Kos, Greece, Sept. 2005; arXiv: nucl-th/0510029

9. Structure of light nuclei from a multichannel algebraic scattering theory, J. P. Svenne, G. Pisent, L. Canton, K. Amos, S. Karataglidis, and D. van der Knijff. contributed paper (Svenne) to the CAP2005 Congress. UBC, Vancouver, June 5-8, 2005; abstract in *Physics in Canada*, 61, no. 3, May/June 2005, p.59
10. Compound and quasi-compound states in the low energy scattering of neutrons and protons by the  $^{12}\text{C}$  nucleus. G. Pisent. L. Canton. J.P. Svenne, K. Amos. S. Karataglidis. and D. van der Knijff. invited paper (Pisent), to the 10th Conference on Problems in Theoretical Nuclear Physics, Cortona, Italy, October 6-9, 2004. Proceedings: *Theoretical Nuclear Physics in Italy*, S. Boffi, A. Ciofi degli Atti, M. Di Toro, A. Fabrocini, G. Pisent. and S. Rosati, eds. (World Scientific, Singapore,2005) pp.301-308.
11. MCAS: A Multichannel Algebraic Scattering theory of low energy nucleon-nucleus reactions, J.P. Svenne, K. Amos, D. van der Knijff, L. Canton and G. Pisent. poster contributed paper (Svenne), to ND2004: International Conference on Nuclear Data for Science & Technology. Sept. 26 - Oct. 1, 2004, Santa Fe, NM, USA. AIP Conference Proceedings, vol. 769, pp.1096-1099.
12. MCAS: a Multi-channel Algebraic Scattering Program to Predict Low Energy Nucleon-nucleus Scattering. D van der Kniff, K Amos, L Canton, G Pisent, J P Svenne. (contributed paper: D. van der Knijff), APAC'03: Conference of the Australian Partnership for Advanced Computing. Sept. 29 - Oct. 2, 2003. Royal Pines Resort Gold Coast, Queensland Australia (John O'Callaghan, Bill Appelbe, editors)
13. Analysis of the N-C12 Low-Energy resonances by Sturm's expansion of the multichannel potential, G. Pisent. L. Canton, K. Amos, D. van der Knijff, J.P. Svenne, (Invited paper: G. Pisent). Conference on Time Asymmetric Quantum Theory: the Theory of Resonances, August. 23-26, 2003, Lisbon, Portugal (L. Ferreira, editor)
14. Properties of the  $pd \rightarrow (A = 3) + \pi^0$  reaction from threshold up to the  $\Delta$  resonance. L. Canton. L.G. Levchuk, G. Pisent. W. Schadow. A.V. Shebeko, and J.P. Svenne, contributed paper (L.C., poster) FB17 International Conference on Few-Body Problems in Physics. June 5-10, 2003, Durham, NC. U.S.A. Proceedings to be published.
15. Production mechanisms and polarization observables for  $p + d \rightarrow {}^3\text{He} + \pi^0$  near threshold, L. Canton, G. Pisent, W. Schadow, and J.P. Svenne. invited paper to the 16th International Baldin Seminar on High-Energy Physics Problems: Relativistic Nuclear Physics and Quantum Chromodynamics (ISHEPP 16). Dubna, Russia, 10-15 June, 2002. Proceedings to be published. preprint: DFPD-02-TH-24. Oct.2002, 7pp: arXiv:nucl-th/0210078.
16. Compound and quasi-compound resonances from a fully algebraic multichannel scattering model, J.P. Svenne, L. Canton. G. Pisent, K. Amos. and D. van der Knijff. contributed paper (JPS) to the DNP2002 Conference of the APS, October 9-12, 2002, East Lansing, Mich., U.S.A. Abstract in *Bull. Am. Phys. Soc.* 47, No.6. Oct. 2002. p.36



17. Three-Body Dynamics in One Dimension. T. Melde, L. Canton, and J.P. Svenne, contributed paper to the XVIII European Conference on Few-Body Problems in Physics, Sept. 9-14, 2002. Bled, Slovenia. Proceedings in: Few-Body Systems, Suppl. 14, 233-236 (2003).
18. Pion Dynamics in the Three-Nucleon System, Juris P. Svenne, Thomas Melde and Luciano Canton, contributed paper to the 2nd World Congress of Latvian Scientists, Riga, Latvia, August 14-15, 2001 (paper delivered orally in Latvian).
19. Meson Dynamics and the resulting "3-Nucleon Force" diagrams: Results from a simplified test case. L. Canton, T. Melde and J.P. Svenne, contributed paper to "Mesons and Light Nuclei" conference. Prague, Czech Republic. July 2-6, 2001. Proceedings: AIP Conference Proceedings, Vol. 603, 287 (2001).
20. Three-Nucleon Portrait with Pion, L. Canton, G. Pisent, W. Schadow, T. Melde, and J.P. Svenne, invited paper to the "VIII Convegno su problemi di fisica teorica". Cortona, Italy, October 18-20, 2000. Proceedings: *Theoretical Nuclear Physics in Italy*, G. Pisent, S. Boffi, L. Canton, A. Coviello, A. Fabrocini, and S. Rosati, eds. (World Scientific, Singapore, 2001) pp.249-256.
21. L. Canton, G. Pisent, W. Schadow, and J.P. Svenne, Spin observables for pion production from pd collisions (oral presentation by Canton), Few Body XVI conference at Taipei, Taiwan, March 6-10, 2000. Nuclear Physics, A684, 417c-419c (2001)
22. L. Canton, T. Melde and J.P. Svenne. Practical scheme for approximate treatment of the pion dynamics in three-nucleon systems (poster). Few Body XVI conference at Taipei, Taiwan, March 6-10, 2000.
23. Pion Dynamics and Three-Nucleon Forces, T. Melde, J.P. Svenne, and L. Canton, contributed paper to the DNP-2000 Conference of the APS, October 4-7, 2000, Williamsburg, VA, U.S.A. (oral presentation by Svenne)
24. T. Melde and J.P. Svenne, The  $\pi$ NNN scattering problem revisited (oral presentation by Melde), CAP-1999. University of New Brunswick, Fredericton.

#### G.C. Tabisz

1. R. Cameron and G. C. Tabisz. "Study of Intensity - Dependent Optical Rotation Phenomena in Chiral Molecules". Submitted to J. of Chemical Physics, (2004).
2. Wexing Qu and G.C. Tabisz. "Ab Initio Calculations of Linear and Non-Linear Optical Rotation by Several Small Chiral Molecules and by Uridine and its Diastereomers". Submitted to J. of Chemical Physics, (2004).
3. W. Glaz and G. C. Tabisz, "Modelling the Far Wings of Collision-Induced Translational Spectral Profiles", Can. J. Phys. 59, 801-811 (2001)

4. T. A. Osborn, M. F. Kondrat'eva, G. C. Tabisz and B. R. McQuarrie, "Mixed Weyl Symbol Calculus and Spectral Line Shape Theory", *J. Phys. A: Math. Gen.* 32, 4149-4169 (1999).
5. S. M. El-Sheikh, G. C. Tabisz and A. D. Buckingham, "Collision-Induced Light Scattering by Isotropic Molecules: The Role of the Quadrupole Polarizability", *Chem. Phys.* 247, 407-412 (1999).
6. B. R. McQuarrie, T. A. Osborn and G. C. Tabisz, "Semiclassical Moyal Quantum Mechanics for Atomic Systems". *Phys. Rev. A* 58, 2944-2961 (1999).

#### Refereed conference proceedings

1. Tabisz, G. C., "Interference Effects in the Infrared Spectrum of HD; Atmospheric Implications." in *Weakly Interacting Molecular Pairs: Unconventional Absorbers of Radiation in the Atmosphere*, C. Camy-Peyret and A. A. Vigasin, eds. (Kluwer Academic, Dordrecht, 2003), pp. 83-92.
2. Wang, X, Senchuk, A., and Tabisz, G. C., "The Far-Infrared Continuum in the Spectrum of Water Vapor," in *Weakly Interacting Molecular Pairs: Unconventional Absorbers of Radiation in the Atmosphere*, C. Camy-Peyret and A. A. Vigasin, eds. (Kluwer Academic, Dordrecht, 2003), pp. 233-237.
3. G. C. Tabisz, "Interference Effects in the Infrared Spectrum HD; Atmospheric Implications". *Proceedings of the NATO Advanced Research Workshop: Weakly Interacting Molecular Pairs: Unconventional Absorbers of Radiation in the Atmosphere*. edited by C. Camy-Peyret and A. Vigasin (Kluwer, 2003), 7 book pages.
4. X. Wang, A. Senchuk and G. C. Tabisz, "The Far-Infrared Continuum in the Spectrum of Water Vapour". *Proceedings of the NATO Advanced Research Workshop: Weakly Interacting Molecular Pairs: Unconventional Absorbers of Radiation in the Atmosphere*. edited by C. Camy-Peyret and A. Vigasin (Kluwer, 2003). 4 book pages.
5. W. Glaz and G. C. Tabisz, "Modelling the Far Wings of Collision-Induced Spectral Profiles", in *Spectral Line Shapes*, Vol. 11, edited by J. Seidel (AIP, New York, 2001), pp. 422-424.
6. S. M. El-Sheikh, G. C. Tabisz and A. D. Buckingham, "Collision-Induced Light Scattering by Isotropic Molecules". in *Spectral Line Shapes*, Vol. 11, edited by J. Seidel (AIP, New York, 2001), pp. 419-421.
7. B. R. McQuarrie, T. A. Osborn, M. F. Kondrat'eva and G. C. Tabisz, "Moyal Quantum Dynamics: Atomic Scattering and Line Shapes", in *Spectral Line Shapes*, Vol. 10, edited by R. M. Herman (AIP, New York, 1999), pp. 332-335.

J.M. Vail

1. J. M. Vail, D. Schindel, A. Yang, O. Penner, R. Pandey, H. Jiang, M. A. Blanco, A. Costales, Q. C. Qiu, and Y. Xu. "Effect of Dielectric Polarization on the Properties of Charged Point Defects in Insulating Crystals: the Nitrogen Vacancy in AlN", *J. Phys.: Condens. Matter* 16. 3371-3378 (2004).
2. J.M. Vail, *Topics in the Theory of Solid Materials* (Institute of Physics Publishing, Bristol, 2003), 368+xvi pages.
3. J.M. Vail, W.A. Coish, H. He and A. Yang (2002), "F Center in BaF<sub>2</sub>: Diffuse Excited State", *Physical Review B* 66. 01409-1-01409-8.
4. J.M. Vail (2001), "Electronic Localization for Point Defect Computations". *Radiation Effects and Defects in Solids* 154, 211-215.
5. J. M. Vail (1999), "Quantum Mechanics for Materials Science Curricula", *Journal of Materials Education*, 20. 237-242 (1999).

Abstracts

6. A. Yang, O. Penner, Q. Qiu, Y. Xu, and J.M. Vail, "A Computational Approach to Point Defects in Group III Nitrides". 38<sup>th</sup> Annual Canadian Undergraduate Physics Conference, Halifax, NS, Oct. 23-26, (2002).
7. Y. Xu, Q.C. Qiu and J.M. Vail. "A Computational Approach for Point Defects in Aluminum Nitride", 14th Canadian Materials Science Conference, Winnipeg MB, June 8-11. (2002)
8. J.M. Vail, A. Yang and R. Pandey. "Computation of Electronic Properties of Point Defects in Gallium Nitride", Materials Research Society, Boston MA, November 26-30, abstract 16.21. p. 189. (2001)
9. J.M. Vail, M.A. Blanco, A. Costales, H. Jaing, R. Pandey, O. Penner, Q. C. Qiu, Y. Xu and A. Yang. "Embedded Molecular Clusters: Group III Nitrides", 2003 Canadian Association of Physicists, Charlottetown, PEI, June 8-11, 2003, abstract MO-PoS52, *Physics in Canada* May/June, 59, 106 (2003)
10. J.M. Vail, Q.C. Qiu, Y. Xu, R. Pandey, H. Jiang, A. Costales and M.A. Blanco, "Local Properties of AlN: a Computational Approach", Materials Research Society, Boston MA, De. 2-6, 2002, Abstract L3.53. p. 264. (2002)
11. J.M. Vail, "The F Center in BaF<sub>2</sub>: Diffuse Excited State", International Conference on Radiation Effects in Insulators-REI-11, Lisbon, Portugal, Sept. 3-7, 2001, abstract P-A 16. p. 90. (2001)
12. J. M. Vail, "Electronic Localization for Point Defect Computations, ICDIM 2000, Johannesburg, South Africa, April 3-7, 2000, abstract O Mo A6, p. 16 (2000)

13. J. M. Vail, "Local Electronic Properties of Solids: The Molecular Cluster Fock Operator", 1999 Canadian Association of Physicists Congress, Fredericton NB, June 6-9, 1999, abstract MO-P10-8, *Physics in Canada*, May/June 1999. p.62. (1999)

#### D. E. Vincent

1. D. Topper and D. E. Vincent. "An analysis of Newton's projectile diagram". *Eur. J. Phys.* 20, 59-66 (1999)

#### J.G. Williams

1. T.A. Harriott and J.G. Williams, "Degree of mapping for general relativistic kinks," *Nuovo Cimento B* 120, 915-930 (2005) (C1).
2. T.A. Harriott and J.G. Williams, "Rotating kink spacetime," *Gen. Rel. Grav.* 35, 341-357 (2003)
3. J.G. Williams, "Whittaker functions as solutions for dust," (with T.A. Harriott), in *Proceedings of the 9th Marcel Grossmann Meeting on General Relativity*, edited by R.T. Jantzen, V. Gurzadyan and R. Ruffini (World Scientific, Singapore), pp. 1069-1070 (2002).
4. J.G. Williams, "Godel kink spacetime." (with T.A. Harriott), *Gen. Rel. Grav.* 33, 1753-1766 (2001)
5. J.G. Williams, "Solution of the Klein-Gordon equation in a 2+1 curved spacetime," (with T.A. Harriott), *Mod. Phys. Lett. A* 16, 1151-1156 (2001)

#### M. Whitmore

1. M. D. Whitmore and R. Baranowski. *End-Anchored Polymers: Compression by Different Mechanisms, and Interpenetration of Apposing Layers*, *Macromolecules* (submitted)
2. M. D. Whitmore. *End-Anchored Polymers and the Polymer Brush*, *Physics in Canada* 59, 103-110 (2003)
3. Y. Rharbi, J.-X. Zhang, J. G. Spiro, L. Chen, M. A. Winnik, J. D. Vavasour, M. D. Whitmore and R. Jérôme, *An Energy Transfer Study of Homopolymer Localization in Block Copolymers*, *Macromolecules* 36, 1241-1252 (2003)
4. J. R. de Bruyn, J. K. C. Lewis, M. R. Morrow, S. Norris, N. H. Rich, J. P. Whitehead and M. D. Whitmore, *Expanding the Role of Computers in Physics Education: A Computer-based First-Year Physics Course on Computational Physics and Data Analysis*, *Can. J. Phys.* 80, 855-865 (2002)
5. M. Kenward and M. D. Whitmore, *A Systematic Monte Carlo Study of Self-Assembling Amphiphiles in Solution*, *J. Chem. Phys.* 116, 3455-3470 (2002)

6. J. D. Vavasour and M. D. Whitmore. *Effects of Solubilized Homopolymer on Lamellar Block Copolymer Structures*. *Macromolecules* 34. 3471-3483 (2001)
7. M. Pépin and M. D. Whitmore, *Monte Carlo and Numerical Self-Consistent Field Study of Systems with End-Grafted and Free Polymers in Good Solvent*, *J. Chem. Phys.* 114, 8181-8195 (2001)
8. M. Pépin and M. D. Whitmore, *Monte Carlo and Mean Field Study of Diblock Copolymer Micelles*, *Macromolecules* 33. 8644-8653 (2000)
9. M. Pépin and M. D. Whitmore, *Homopolymer Solubilization Limits in Copolymer Micelles: a Monte Carlo Study*, *Macromolecules* 33, 8654-8662 (2000)
10. M. Pépin and M. D. Whitmore, *Monte Carlo and Numerical SCF Study of End-tethered Polymers in Good Solvent at Commonly Observed Densities*. *J. Chem. Phys.* 111, 10381-10388 (1999)
11. M. D. Whitmore and J. P. Whitehead, *Self-consistent Field Theory of Compressible Phospholipid Membranes at Finite Pressure*, *Can. J. Phys.* 76, 883-898 (1998)
12. M. D. Whitmore, J. P. Whitehead and A. Roberge, *Self-consistent Field Theory of Compressible Phospholipid Membranes at Ambient Pressure*. *Can. J. Phys.* 76, 831-881 (1998)
13. R. Baranowski and M. D. Whitmore, *Numerical Self-consistent Field Study of End-Tethered Polymers in  $\Theta$  Solvent*, *J. Chem. Phys.* 108, 9885-9892 (1998)

Refereed Symposium Proceedings and Presentations

14. M. Kenward and M. D. Whitmore, *Monte Carlo Studies of the Self-Assembly of Amphiphilic Molecules*. in *High Performance Computing Systems and Applications (HPCS'99)*, pages 481-495, Ed: A. Pollard, D. J. K. Mewhort and D. F. Weaver. Kluwer Academic(2000). Presented at HPCS'99, Kingston. ON (1999).
15. M. Pépin, M. D. Whitmore and G. Slater, *Monte Carlo Simulations of Polymers in Solution*, Presented at High Performance Computing Symposium. (HPCS'99), Kingston, ON (2000).
16. M. Pépin and M.D. Whitmore, *Optimizing Monte Carlo Simulations of Polymer Systems*. Presented at High Performance Computing Symposium (HPCS'98). Edmonton, AB (1998).

Book Chapters

17. M. D. Whitmore, *Block Copolymer Phase Behavior*, in *Encyclopedia of Materials: Science and Technology*. T. P. Lodge. section editor. Elsevier Science Ltd., 657-667 (2001)
18. M. D. Whitmore. *Theory of Block Copolymers*, to appear in *Supramolecular Polymers*, 2nd edition. A. Ciferri, editor, Marcel Dekker.

### Invited Presentations

19. M. D. Whitmore, *Modelling and Simulations of Self-Assembly of Block Copolymers*. High Performance Computing Systems and Applications (HPCS '02), Moncton, New Brunswick (2002).
20. M. D. Whitmore, *Self-Consistent Field Theory of Phospholipid Membranes*, Canadian Association of Physicists Congress, Toronto. (June. 2000).
21. M. D. Whitmore. *ACEnet: Transforming Research in Atlantic Canada*, High Performance Computing Systems and Applications (HPCS '04), Winnipeg, Manitoba. (May. 2004).
22. M. D. Whitmore, *High Performance Computing: The New and Growing Environment in Canada*, Canadian Association of Physicists Congress. Winnipeg. Manitoba (June, 2004).

### Contributed Presentations

23. I. Mahmoud Abu-Amajieh and M. D. Whitmore, *An Examination of the Surface-Pressure Isotherms in End-Tethered Polymer Layers*, C.A.P. Congress, Charlottetown, PEI (2003).
24. M.D. Whitmore, *Experimental and Theoretical Behaviour of End-tethered Polymers from the Mushroom to the Brush Limits*, Frontis Symposium on Chain Molecules at Interfaces: SCF Theory and Experiments, Wageningen, the Netherlands (2002).
25. M. Pépin and M. D. Whitmore, *Characterization of the Surface Density of End-tethered Polymers from the Mushroom to the Brush Limits*, Pacificchem 2000 Meeting, Hawaii, (2000).
26. M. S. Kent, M. Pépin, J. Douglas and M. D. Whitmore. *Experimental and Theoretical Study of End-tethered Polymers in Good and  $\Theta$  Solvents: Crossover Between the "Mushroom" and "Brush" Limits*, A.P.S. March Meeting, Minneapolis, MN (2000).
27. M. Pépin and M.D. Whitmore, *Relaxation Times and Phase Behaviour in Dilute Copolymer/Homopolymer/Solvent Blends*. C.A.P. Congress, Waterloo, ON (1998).

## 5 Financial

### 5.1 Statement of Income and Expenditures

#### Income

Income Source	Amount
Carry over from Aug. 31, 2003	\$4910.00
<b>Total Funds Available</b>	<b>\$4910.00</b>

#### Expenditures

Activity	Particulars	Amount Spent
Seminars	M. Karasev, Oct. 2003	\$1,000.00
	V. Vorobiev, Nov. 2003	\$541.08
	A. Barvinsky, April 2004	\$825.41
	Total Visitor Costs	\$2366.49
Miscellaneous	FAX, mail, printing, supplies	\$69.18
<b>Total Expenditures (2003-2004)</b>		<b>\$2,366.49</b>

In relation to the supporting funds indicated above, it should be pointed out that the members of the Institute use their individual NSERC grants to subsidize Institute activities. Currently the members from the three universities draw upon more than \$250,000 (update) of individual NSERC Research Grants. These funds have a significant fortifying effect on the level of activities in which we are able to engage. The financial contribution of the members associated with the expenses of visiting guest theorists, supports the activities and goals of the Institute, but does not appear in the budget data shown above.

The Institute has neither endowment nor trust fund support. The Institute has no significant space requirements. The occasional long term visitor requires a desk, but these needs have been accommodated by the space available to the physics departments at the member Universities. The host departments also supply occasional secretarial support such as that required for the preparation of seminar notices and research papers.

### 5.2 Financial Stability and Growth

The Institute has no substantial fixed costs and for this reason it is intrinsically stable. It can operate in a productive fashion at a variety of funding levels. All of the funds that the Institute receives are transformed directly into its research enhancing activities. The funds allocated to the Institute by supportive administrative bodies such as the Faculties of Science and Graduate Studies at the University of Manitoba are fortified

by the individual NSERC research grants of members. This is a strong commitment to the Institute by the Institute members. In view of its overall research productivity, in terms of published papers and supervised graduate students, its capacity for running very successful conferences and workshops, and the demonstrated ability to attract excellent short-term and long-term visiting scientists, the Institute is achieving its goals. The Institute membership includes all of the theoretical physicists in the province. Hence its growth relies solely upon the associate members that it can attract (i.e. graduate students, postdoctoral fellows and research associates). The number and quality of these associate members is dependent on the Institute being able to create a positive research atmosphere. This in turn depends strongly upon the level of funding that the Institute receives. In comparison with its first half dozen years, in the past six years there has been a marked decrease in the funds made available to the Institute by the three Manitoba universities. This has meant we have not been able to sponsor any costly conferences during this period of time.

The report guidelines suggest that some indication be given of the percentage of time that members spend on Institute research. Since the Institute's programs enhance the ongoing research interests of its members, there is no distinction between individual research and Institute research. The director has spent less than 5% of his time with the administrative aspects of the Institute.