The Winnipeg Institute for Theoretical Physics[1] Annual Report

(Corrected Version)

September 1997 – August 1998

[1]**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, by financially supporting expert seminars in the research areas of concern, and by financially supporting the long term visits of internationally respected scientists to the Institute so as to facilitate collaboration of these scientists with Institute members. The 12 permanent members of this Institute are drawn from the University of Manitoba, the University of Winnipeg, and Brandon University.

The past year (1997–1998) was the eigth year of the Institute's existence. It saw a continuation of the activities of previous years with research seminars being given by seven out-of-province visitors. Other researchers connected with and taking part in the Institute activities were the following: one research associate, five postdoctoral fellows, and eight graduate students.

For the 1997–1998 academic year, the list of invited speakers is found in section 4.1 of the report. 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 publications by full members listed in section 4.5 is 27 for 1997-8 and totals 169 for 1991-97. These numbers do not count twice those that are collaborative publications among members of the Institute. Section 5.1 contains a summary of income and expenditures for the period September 1, 1997 to September 30, 1998. For the forthcoming year, the Institute intends to continue with its established programs. As in previous years, the seminar program of invited guest speakers aims to bring to Winnipeg a number of visiting physicists.

Essentially all of the funds available to the Institute are expended for the workshop and symposium activities and for the travel expenses needed to support visiting scientists. The Institute has no technical support staff or administrative staff. All the required administrative work is done on a volunteer basis by the members of the Institute. The Institute benefits substantially from the financial supplements of members using their individual NSERC Research Grants to defray part of the costs of visitors.

The Institute director for the past academic year has been R. Kobes (University of Winnipeg), who prepared this report. Other members of the Executive were the past director, J.G. Williams (Brandon University), and the incoming director, J. Vail (University of Manitoba). J. Vail begins his term on October 1, 1998. The Executive for the upcoming 1998–1999 year will consist of J. Vail, R. Kobes and a member yet to be chosen, who will become director in October 1999.

2 Current List of Members (September, 1998)

2.1 Permanent Members

- B. Bhakar[1], *Ph.D. (Delhi)*
- P.G. Blunden[1] , *Ph.D (Queen's)*
- M.E. Carrington[3] , *Ph.D. (SUNY, Stony Brook)*
- R.L. Kobes[2], *Ph.D. (Alberta)*
- G. Kunstatter[2] , *Ph.D. (Toronto)*
- P.D. Loly[1] , *Ph.D. (London)*
- T.A. Osborn[1] , *Ph.D. (Stanford)*
- B.W. Southern[1] , *Ph.D. (McMaster)*
- J.P. Svenne[1] , *Ph.D. (M.I.T.)*
- J.M. Vail[1] , *Ph.D. (Brandeis)*
- D.W. Vincent[2] , *Ph.D. (Toronto)*
- J.G. Williams[3], *Ph.D. (Birmingham)*

[1]University of Manitoba
[2]University of Winnipeg
[3]Brandon University

2.2 Associate Members

- W. Chen *(Postdoctoral Fellow)*
- S. Burnett *(Postdoctoral Fellow)*
- J.I. Johansson *(Research Associate)*
- M.F. Kondrat'eva *(Postdoctoral Fellow)*
- C. Sadov *(Postdoctoral Fellow)*
- C. Soo *(Postdoctoral Fellow)*
- W. Stephan *(Postdoctoral Fellow)*

2.3 Graduate Students

- B. McQuarrie (Ph.D.), *(Osborn and Tabisz)*
- J. Medved (Ph.D.), *(Kunstatter)*
- T. Melde (Ph.D.), *(Svenne)*
- Slaven Peles (M.Sc.), *(Kobes)*
- Zhinong Weng (M.Sc.), *(Vail)*

2.4 Summer Undergraduate Research Students

- D. Leary, *(Carrington, Kobes, Kunstatter)*, May–August, 1997
- S. Yau, *(Carrington, Kobes, Kunstatter)*, May–August, 1997

3 Research Interests of Permanent Members

B. Bhakar

Present activities are directed towards the understanding of completely integrable and non-integrable 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.

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 standard model. 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. Both the imaginary time and real time formalisms are commonly used. The real time formalism is usually considered to be more complicated, but it has the advantage that it produces real time Green functions directly, without involving analytic continuations. Currently I am working on the development of various techniques that can be used to reduce the complexity of finite temperature calculations in the real time formalism.

R.L. Kobes

The general area of research is quantum field theory at finite temperature and density, with applications particularly in particle physics. We are presently studying aspects of hot gauge theories such as the quark–gluon plasma, as well as general calculational methods in finite temperature field theory. We are also interested in classical theories which exhibit chaotic behaviour, and have begun a numerical study of some properties of a particular system similar to a forced pendulum.

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

Periodic Systems: I now operate two major themes, one with a nearly-free-electron flavour, and the other concerned with excitations in magnets which has more of a tight-binding flavour.

Quantum Well Spectra: Very recently, postdoctoral fellow Alex Mogilner and I have resolved the recurring question of zero-energy gaps in 1D bandstructures by using quite general analytical results for the eigenvalues of "oscillatory" matrices. This exciting development facilitates another paper, extending some explicit calculations of the energy bands of a number of earlier "exactly soluble" potentials. In 2D and 3D we will use analogues of the Kronig-Penney potential to study bandstructures of mesoscopic ultrasmall quantum box structures now etched routinely in AlGaAs in semiconductor heterostructures which caught our interest as an application of our multi-dimension nearly-free-electron code.

T.A. Osborn

A principal research interest is the investigation of quantum (and classical) evolution in a variety of gauge theories. Using the methods of mathematical physics, the goal is to describe the dynamics of these strongly interacting systems by the development of non-perturbative, analytically explicit approximate solutions. The usefulness of such an approximate dynamics is that it allows detailed physical insights into the fundamental structure of the system, as well as the computation of all observables of interest (such as the stress-energy tensor). For example, the large mass semi-classical expansion of the propagator for an N-body system coupled via the Lorentz force to an arbitrary external electromagnetic field has been recently shown to admit an asymptotic expansion in the reciprocal mass. This expansion is valid to infinite order in the external fields, is manifestly gauge and Lorentz invariant, possesses simple expansion coefficients, and has an a priori determined error bound. The extension of this type of semi-classical description to characterize relativistic quantum theories evolving on Riemannian and pseudo-Riemannian spacetime manifolds and interacting with Yang-Mills fields is currently underway.

B.W. Southern

The nature of excitations in both regular lattices and disordered systems is being investigated using scaling techniques. Quantum spin chains are being studied in an attempt to understand the differences between integer and half-integer spin systems. A study of the effects of disorder on the nature of phase transitions is also in progress. The disorder can be due to the fact that the degrees of freedom in the problem are not located at the sites of a perfect crystal or due to the fact that the interactions have a distribution of possible values. Both real space renormalization group methods and transfer matrix methods are used to study the relationship between the critical exponents of various models on these structures and the geometrical properties, and to explore questions about universality in these systems.

The study of frustrated systems is also an area of active research. Spin glasses are one example where frustration can either prevent a system from ordering or lead to a new type of glassy phase. Frustration can also lead to novel ground states where the symmetry of the ordered phase is no longer represented as a simple vector. The order parameter is more like a rigid body and hence the excitation spectrum is also different. The symmetry of the order parameter can change the nature of the topological defects present in the system and these defects can exhibit nontrivial unbinding transitions as the temperature increases. These problems are being studied using Monte Carlo methods.

J. P. Svenne

Our current work, in collaboration with a group at Padua University (L. Canton, G. Cattapan, G. Pisent), P.J. Dortmans at Melbourne University, and W. Schadow of Bonn University

(now a postdoc at Ohio University), focuses on pion absorption on very light nuclei. The work on pion absorption is proceding along two lines: One is on carrying out practical calculations on ^{3}H and ^{3}He, initially with two–cluster final states; later three–nucleon final states will also be included. This uses the same basic mechanisms and input on πN, NN and $\pi N\Delta$ interactions as in pion absorption on the deuteron. The three–nucleon system is treated exactly in a Faddeev–based theory. Final–state interactions are correctly taken into account. In addition, the S-wave mechanism important for absorption at low energies, that is normally credited to Koltun and Reitan, is being re-examined.

The second line of inquiry is further to develop the complete coupled three–body to four–body theory of the $\pi NNN - NNN$ system, on which extensive work has has already been done by members of the collaboration. This work elaborates the complicated set of coupled integral equations for this problem, which are not amenable to exact solution in the foreseeable future. Approximations and calculational techniques for the solution of these equations will be developed for a simplified, perhaps schematic, model. This could be useful in deriving methods for treating more realistic problems.

Finally, in a separate collaborationn with Drs. G. Pisent and P.J. Dortmans, we are studying the presence and behaviour of compound and quasi–compound resonances in complex nuclear systems.

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, and classical and quantum diffusion.

Three projects are currently in progress: (1) overlap and localization effects from the embedding region in the simulation of point defects by small clusters; (2) optical excitation of the F center and of oxygen in barium fluoride; (3) a formulation of the many-body problem in terms of two-body density functionals.

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.

4 Research Activities

4.1 Seminars

Date	Speaker	Institution	Title
Sept. 25, 1997	Dr. Mikhail Karasev	Moscow Institute of Electronics and Mathematics	Quantum Algebra, Coherent Transform and Approximate Eigenstates for the Zeeman Effect
Oct. 23, 1997	Dr. Y. Hosotani	School of Physics University of Minnesota	Spin Chains and Ladders and the Schwinger Model
Nov. 27, 1997	Dr. Y. Gusev	Department of Physics University of Alberta	Finite Temperature Field Theory on Homogeneous Backgrounds
Jan. 21, 1998	Dr. C. Soo	Physics Department University of Winnipeg	Anomalies, Chiral Fermions, and Invariant Pauli-Villars Regularization
May 14, 1998	Dr. R. Baier	Physics Department Universität Bielefeld	Radiative Energy Loss and p_T Broadening of Fast Partons Traversing Dense Media
May 15, 1998	Dr. W. Chen	Department of Physics University of Helsinki	Differential Regularization and Its Applications
July 2, 1998	Dr. S. Sadov	Department of Physics Keldysh Institute (Moscow)	Regularization of Integral Equations in Diffraction Theory via Asymptotics of Higher Harmonics

4.2 Visiting Scientists

Dates	Visitor	Institution
Aug–Sept, 1997	M.V. Karasev	MIEM, Moscow
Oct., 1997	Dr. Y. Hosotani	University of Minnesota
Nov., 1997	Dr. Y. Gusev	University of Alberta
May, 1998	Dr. R. Baier	Universität Bielefeld
May, 1998	Dr. W. Chen	University of Helsinki
July, 1998	Dr. S. Sadov	Keldysh Institute (Moscow)

4.3 Graduate Degrees Supervised

1. B. R. McQuarrie, Ph.D. December 1997 (*T.A. Osborn and G.C. Tabisz*), "Molecular Collisions: Effect on the HD Infrared Spectrum and the Development of a Moyal Quantum Mechanical Description"

2. J.L. Martinez-Cuellar, M.Sc., July 1997 *(B.W. Southern).* "Three Magnon Excitations in Alternating Quantum Spin/Bond Chains."

3. Yu.V. Gusev, Ph.D., October 1996 *(T.A. Osborn).* "Covariant Computation of Heat Kernels in Perturbation Theory."

4. Iain Stewart, M.Sc., March 1996 *(P.G. Blunden).* "Derivative Expansion Approximation of Vacuum Polarization Effects."

5. Ning Li, University of Manitoba M.Sc., February 1995 *(C.H. Woo).*

6. J. Chen, University of Manitoba, M.Sc., October 1994 *(R. Kobes).* "Proximity Effect and the Thermodynamic Properties of Superlattice Systems."

7. Sandra Cyr, M.Sc., October 1994 *(B.W. Southern).* "Multi-Magnon Excitations in One-Dimensional Quantum Spin Chains with NNN Interactions."

8. R. Epp, University of Manitoba Ph.D., September 1993 *(G. Kunstatter).* "Curved Space Quantization, and Dirac *vs.* Reduced Quantization of Poincare Invariant Gauge Theories."

9. Domingo Louis-Martinez, University of Manitoba Ph.D October 1994 *(G. Kunstatter).* "Dirac's Constrained Systems: Two Dimensional Gravity and Spinning Relativistic Particle."

10. K. Mak, University of Manitoba Ph.D., September 1993 *(R. Kobes, G. Kunstatter).* "Damping rates and hot gauge theories."

11. K. Mak, University of Manitoba M.Sc., September 1991 *(R. Kobes, G. Kunstatter).* "Hamiltonian analysis of Yang–Mills fields in a general class of linear gauges."

12. J. Wang, University of Manitoba M.Sc., September 1992 *(R. Kobes).* "Finite layers effect in metallic superlattices."

4.4 Publications of Associate Members/Graduate Students

S.S.C. Burnett

1. S.S.C. Burnett (1997),"Additive renormalization of the specific heat of O(n) symmetric systems in three loop order", submitted. (C1)

2. S.S.C. Burnett, M. Strösser and V. Dohm (1997), "Minimal renormalization without ϵ-expansion: Amplitude functions for O(n) symmetric systems in three dimensions below T_C", Nucl. Phys., in press. (C1)

3. S.S.C. Burnett, M. Strösser and V. Dohm (1996), "Superfluid density of ^{4}He near T_λ in two-loop order", Czech. J. Phys. **46** (S1), 169. (C1)

4. S.S.C. Burnett and S. Gartenhaus (1994), "Phenomenology, specific heat and corrections to scaling in copper ammonium bromide", Phys. Rev. B **49**, 1137. (C1)

5. S.S.C. Burnett and S. Gartenhaus (1993), "Zero-field susceptibility of the antiferromagnetic square Ising lattice", Phys. Rev. B **47**, 7944. (C1)

6. S.S.C. Burnett and S. Gartenhaus (1991), "Phenomenology and corrections to scaling in Heisenberg ferromagnets", Phys. Rev. B **43**, 591. (C1)

J.I. Johansson,

1. M. Hedayati-Poor, J.I. Johansson and H.S. Sherif (1995), "Relativistic Calculations for Photonuclear Reactions (II): Nonrelativistic Reductions and Nuclear Medium Effects", Nuc. Phys. **A593**, 377-398. (C1)
e-print archive: nucl-th/9507021.

2. J.I. Johansson, H.S. Sherif and G.M. Lotz (1996), "Relativistic Calculations for Photonuclear Reactions (III): A Consistent Relativistic Analysis of $(e, e'p)$ and (γ, p) Reactions", Nuc. Phys. **A605**, 517-530. (C1)
e-print archive: nucl-th/9603026.

3. J.I. Johansson, H.S. Sherif and G.M. Lotz (1996),=20 "Relativistic Analysis of $(e, e'p)$ and (γ, p) Reactions in a Consistent Model", Fourteenth Particle and Nuclei International Conference (PANIC96) Williamsburg, Virgina, USA, May 22-28, 1996. Poster presented by G.M. Lotz. (C3)

4. J.I. Johansson and H.S. Sherif (1996), "Spin Observables in Consistent Relativistic Models of $(e, e'p)$ and (γ, p) Reactions", 12^{th} International Symposium on High-Energy Spin Physics (SPIN96), Amsterdam, The Netherlands, September 10-14, 1996, to be published by World Scientific. Presented by J.I. Johansson. (C3)

T. Melde

1. M. Hawton and T. Melde (1995), "Photon number density operator $i\hat{E}\cdot\hat{A}$", Phys. Rev. A**51**, 4186-4190. (C1)

C. Soo

1. C. Soo and L.N. Chang (1997), "The Weyl theory of fundamental interactions: Is CPT violated?", hep-th/9702171, Nucl. Phys. B, submitted. (C1)

2. F.L. Lin and C. Soo (1997), "Quantum field theory with and without conical singularities: black holes with cosmological constant and the multihorizon scenario", gr-qc/9708049, Phys. Rev. D, submitted. (C1)

3. C. Soo and L.N. Chang (1996), "Invariant Regularization of Anomaly–Free Chiral Theories", Phys. Rev. D **55**, 2410. (C1)

4. C. Soo and L.N. Chang (1996), "Invariant Regularization of Local Lorentz Invariance and Neutrino Masses", VPI-IPPAP-96-5, *Proceedings of the 28th. International Conference on High Energy Physics*, Warsaw, Poland, 1996. (in press) (C3)

5. C. Soo and L.N. Chang (1996), "Chiral Fermions, Gravity, and GUTs", CGPG-94/9-3, *Proceedings of the 4th Drexel Symposium 1994*, (in press). (C3)

6. C. Soo and L.N. Chang (1996), "The Standard Model with Gravity Couplings", Phys. Rev. **D53**, 5682. (C1)

7. C. Soo (1995), "Self–Dual Variables, Positive Semidefinite Action, and Discrete Transformations in Four–Dimensional Quantum Gravity", Phys. Rev. D**52**, 3484. (C1)

8. C. Soo and Lee Smolin (1995), "The Chern–Simons Invariant as the Natural Time Variable for Classical and Quantum Cosmology", Nucl. Phys. **B449**, 289. (C1).

9. C. Soo and L.N. Chang (1994), "Superspace Dynamics and Perturbations around 'Emptiness' " Int. J. Mod. Phys. **D3**, 529. (C1).

10. C. Soo and L.N. Chang (1994), "Einstein Manifolds and SO(3) Instantons: Invariants and Phases", VPI-IHEP-93-4, in *Proceedings of the 5th. Asia Pacific Physics Conference*, Kuala Lumpur, Malaysia, 1992, eds. S. P. Chia et al (World Scientific). (C3).

11. C. Soo and L.N. Chang (1992), "BRST Cohomology and Invariants of Four–Dimensional Gravity in Ashtekar Variables", Phys. Rev. D46, 4257-4262. (C1)

12. C. Soo and L.N. Chang (1992), "BRST Invariants of 4D-Gravity in Ashtekar Variables", VPI-IHEP-92/8, in *Proceedings of the XXIst. International Conference on Differential Geometric Methods in Theoretical Physics*, Nankai, China. (C3)

13. C. Soo and L.N. Chang (1991), "Ashtekar's Variables and the Topological Phase of Quantum Gravity", VPI-IHEP-91-2, in *Proceedings of the XXth. Differential Geometric Methods Conference*, New York, N.Y., 1991, eds. S. Catto and A. Rocha (World Scientific, Singapore). (C3)

W. Stephan

1. R. Neudert, M. Knupfer, M. S. Golden, J. Fink, W. Stephan, K. Penc, N. Motoyama, H. Eisaki, and S. Uchida, "Manifestation of Spin–Charge Separation in the Dynamic Dielectric Response of One–Dimensional Sr_2CuO_3", Phys. Rev. Lett. **81**, 657 (1998). (C1)

2. C. M. Canali, W. Stephan, L. Y. Gorelik, R. I. Shekhter, and M. Jonson, "Coulomb correlations and coherent charge tunneling in mesoscopic coupled rings", Europhys. Lett. **40**, 67 (1997). (C1)

3. M. Capone, W. Stephan, and M. Grilli, "Small polaron formation and optical absorption in Su-Schrieffer-Heeger and Holstein models", Phys. Rev. B **56**, 4484 (1997). (C1)

4. W. Stephan, M. Capone, M. Grilli and C. Castellani, "Influence of electron–phonon interaction on superexchange", Phys. Lett. A 227, 120 (1997). (C1)

5. C. M. Canali, W. Stephan, L. Y. Gorelik, R. I. Shekhter, and M. Jonson, "Ordering effect of Coulomb interaction in ballistic double–ring systems", Solid State Comm. **104**, 75 (1997). (C1)

6. Walter Stephan and Karlo Penc, "Dynamical density-density correlations in one-dimensional Mott insulators", Phys. Rev. B **54**, R17269 (1996). (C1)

7. Walter Stephan, "Single-polaron band structure of the Holstein model", Phys. Rev. B **54**, 8981 (1996). (C1)

8. C. M. Canali, C. Basu, W. Stephan, and V. E. Kravtsov, "Distribution of level curvatures for the Anderson model at the localization-delocalization transition", Phys. Rev. B **54**, 1431 (1996). (C1)

9. Peter Horsch and Walter Stephan, "Drude weight and f-sum rule of the Hubbard model at strong coupling", in *The Hubbard Model*, Eds. D. Baeriswyl et al., Plenum Press, New York, 1995, pp. 193-200. (C3)

10. Henk Eskes, Andzrej Oles, Marcel Meinders and Walter Stephan, "Spectral properties of the Hubbard bands", Phys. Rev. B **50**, 17980 (1994). (C1)

11. J. H. Jefferson and W. Stephan, "A real-space finite cluster approach to the correlated electron problem", Physica C **235-240**, 2251 (1994). (C1)

12. Peter Horsch and Walter Stephan, "Frequency–dependent conductivity of the one–dimensional Hubbard Model at strong coupling", Phys. Rev. **B 48**, 10595 (1993). (C1)

13. Walter Stephan and Peter Horsch, "Single–particle and optical excitations in doped Mott–Hubbard insulators", Int. J. Mod. Phys. **B 6**, 589 (1992). (C1)

14. W. Stephan and J.P. Carbotte, "Conductance of a spin-glass with proximity induced superconductivity", Phys. Rev. **B46**, 317 (1992). (C1)

15. Peter Horsch and Walter Stephan, "One- and Two-Particle Excitations in Doped Mott-Hubbard Insulators", in *Electronic Properties of High Temperature Superconductors*, Eds. H. Kuzmany, M. Mehring and J. Fink (Springer, Berlin, 1993). (C3)

16. Peter Horsch and Walter Stephan, "Moderately doped Antiferromagnets: Spectral Functions and Fermi Surface", in *Electronic Properties and Mechanisms of Superconductivity*, eds. T. Oguchi, K. Kadowaki and T. Sasaki (North–Holland, Amsterdam, 1992). (C3)

4.5 Publications of Permanent Members

P.G. Blunden

1. I.W. Stewart and P.G. Blunden (1997), "Quantum solitons at strong coupling", Phys. Rev. D **55**, 3742. (C1)

2. P.G. Blunden and G.A. Miller (1996), "Quark-meson coupling model for finite nuclei", Phys. Rev. C**54**, 359. (C1)

3. P.G. Blunden and G.A. Miller (1996), "Quark-meson coupling model in finite nuclei", Oral presentation at PANIC96, Williamsburg, VA, May, 1996. To be published by World Scientific. (C3)

4. A.S. Raskin and P.G. Blunden (1994), Comment on "Collective Modes in Dense Neutrino Systems", Phys. Rev. D**50**, 7742. (C1)

5. J.P. Adams, P.G. Blunden, B. Castel and Y. Okuhara (1993), "Role of Nuclear Structure in the Spin-Isospin Nuclear Response Problem", Phys. Rev. **48C**, 1438. (C1)

6. P.G. Blunden (1993), "The Nuclear Current Operator: Where Do We Stand?", Workshop on Electron-Nucleus Scattering, Elba, Italy, eds. O. Benhar (World Scientific), in press. (C3)

7. K. Tsushima, D.O. Riska and P.G. Blunden (1992), "The Electromagnetic Exchange Current, the Nucleon-Nucleon Interaction, and Nuclear Magnetic Moments", Nucl. Phys. **A559**, 543. (C1)

8. P.G. Blunden and D.O. Riska (1992), "The Isoscalar Electromagnetic Current Operator and the Nucleon-Nucleon Interaction", Nucl. Phys. **A536**, 697. (C1)

9. P.G. Blunden and E.J. Kim (1991), "One-Pion Exchange Currents in the QHD Formalism", Nucl. Phys. **A531**, 461. (C1)

M.E. Carrington

1. M. Carrington and R. Kobes, 1998, "The general cancellation of ladder graphs at finite temperature", Phys. Rev. **D57**, 6372–6385. (C1)

2. M. Carrington, R. Kobes and E. Petitgirard, 1998, "Cancellation of ladder graphs in an effective expansion", Phys. Rev. **D57**, 2631–2634. (C1)

3. M.E. Carrington and U. Heinz (1996), "Three Point Functions at Finite Temperature", preprint hep-th/9606055, Z. Physik C, 1997, in press. (C1)

4. M.E. Carrington (1996), "The Bosonization of Theories with Pseudo-vector Interactions", Z. Physik C, **72**, 1531. (C1)

5. M. Burgess and M.E. Carrington (1995), "Boundaries and Junctions in=20 Two Parity Violating Models in 2+1 Dimensions", Phys. Rev. B**52**, 5052. (C1)

6. M.E. Carrington (1995), "The Meissner Effect in Scalar QED with Magnetic Moment Interactions", Phys. Rev. D**51**, 4451. (C1)

7. M.E. Carrington and G. Kunstatter (1995), "Maxwell-Chern-Simons Scalar QED with Magnetic Moment Interactions," Phys. Rev. D**51**, 1903. (C1)

8. M.E. Carrington and G. Kunstatter (1994), "Massless Scalar QED with Non-Minimal Chern-Simons Coupling", Phys. Rev. D**50**, 2830. (C1)

9. M.E. Carrington and G. Kunstatter (1994), "Phase Transitions in Massless Scalar QED with non-minimally coupled Chern-Simons Term", Phys. Lett. **B321**, 223. (C1)

10. M.E. Carrington (1993), "Self-Consistent Resummation Scheme in Scalar QED", Phys. Rev. D**48**, 3836. (C1)

11. M.E. Carrington and J.I. Kapusta (1993), "Dynamics of the Electroweak Phase Transition", Phys. Rev. D**47**, 5304. (C1)

12. M.E. Carrington (1993), "Ring Diagram Summations in the Finite Temperature Effective Potential", Can. J. Phys. **71**, 227. (C1)

13. M.E. Carrington (1992), "The Effective Potential at Finite Temperature in the Standard Model", Phys. Rev. D**45**, 2933. (C1)

14. J. Kapusta, M.E. Carrington, B. Bayman, D.Seibert and C.S. Song (1991), "Superconducting Phase Transition in a 2D Chern-Simons Theory", Phys. Rev. B**44**, 7519. (C1)

R.L. Kobes

1. M. Carrington and R. Kobes, 1998, "The general cancellation of ladder graphs at finite temperature", Phys. Rev. **D57**, 6372–6385. (C1)

2. M. Carrington, R. Kobes and E. Petitgirard, 1998, "Cancellation of ladder graphs in an effective expansion", Phys. Rev. **D57**, 2631–2634. (C1)

3. P. Aurenche, F. Gelis, R. Kobes, and H. Zaraket, 1998, "Bremsstrahlung and photon production in thermal QCD", (to appear in Z. Phys. **C**). (C1)

4. P. Aurenche, F. Gelis, R. Kobes and E. Petitgirard (1997), "Breakdown of the hard thermal loop expansion near the light–cone", Z. Phys. **C75**, 315–332. (C1)

5. P. Aurenche, F. Gelis, R. Kobes and E. Petitgirard (1996), "Enhanced photon production rate on the light cone", Phys. Rev. D **54**, 5274–5279. (C1)

6. R. Kobes (1996), "Hard thermal loop resummation methods in hot gauge theories", in *Thermal Field Theories and Their Applications*, edited by Y.X. Gui, F.C. Khanna and Z.B. Su (World Scientific, Singapore). (C3)

7. R. Kobes (guest editor), (1996), *Memorial issue for Professor Umezawa*, Physics Essays **9**, no. 4. (B)

8. J. Chen, R. Kobes and J. Wang (1995), "Finite layers effect in metallic superlattices", Can. J. Phys. **73**, 545–553. (C1)

9. P. Elmfors and R. Kobes (1995), "The thermal β–function in hot Yang–Mills theory", Phys. Rev. D**51**, 774–780. (C1)

10. P. Kelly, R. Kobes, and G. Kunstatter (1994),"Parameterization invariance and the resolution to the unitary gauge puzzle", Phys. Rev. D**50**, 7592–7602. (C1)

11. R. Baier and R. Kobes (1994), "Damping rate of a fast fermion in hot QED", Phys. Rev. D**50**, 5944–5950. (C1)

12. M. van Eijck, R. Kobes, and Ch. G. van Weert (1994), "Transformations of real time thermal Feynman rules", Phys. Rev. D**50**, 4097–4109. (C1)

13. F.C. Khanna, R. Kobes, G. Kunstatter, and H. Umezawa (editors) (1994), *Proceedings of the Banff/CAP School on Thermal Field Theories*, (World Scientific, Singapore). (B)

14. R. Kobes and K. Mak (1993), "Role of the Infrared Cutoff in Fermion Damping Rates", Phys. Rev. D**48**, 1868-1870. (C1)

15. R. Kobes and G. Kunstatter (editors) (1993), *The proceedings of the workshop on perturbative methods in hot gauge theories*, Can. J. Phys. **71**, pp. 205-305. (B)

16. R. Kobes, G. Kunstatter and K. Mak (1993), "Damping of Fermions in Hot Gauge Theories", in *The Proceedings of the Workshop on Perturbative Methods in Hot Gauge Theories*, Can. J. Phys. **71**, pp. 252-255. (C3)

17. R. Kobes, G. Kunstatter and K. Mak (1992), "Fermion Damping in Hot Gauge Theories", Phys. Rev. D**45**, 4632-4639. (C1)

18. R. Kobes (1992), "Feynman Rules for Response Functions at Thermal Equilibrium", Phys. Rev. B**45**, 3230-3235. (C1)

19. R. Kobes (1992), "Comment on: Causal Structure of the Thermal Propagator in Real Time Formalisms", Z. Phys. **C53**, 537. (C1)

20. R. Kobes (1992), "Gauge Independence of the Plasmon Pole", in *Hot Summer Daze: BNL Summer Study on QCD at Nonzero Temperature and Density*, eds. A. Gocksch and R.D. Pisarski (World Scientific, Singapore), pp. 78-84. (C3)

21. R. Kobes (1991), "Three-Point Function at Finite Temperature in the Real Time Formalism", Phys. Rev. Lett. **67**, 1384-1387. (C1)

22. R. Kobes, G. Kunstatter and A. Rebhan (1991), "Gauge Dependence Identities and Their Application at Finite Temperature", Nucl. Phys. **B355**, 1-37. (C1)

23. R. Kobes (1991), "Retarded Functions, Dispersion Relations, and Cutkosky Rules at Zero and Finite Temperature", Phys. Rev. D**43**, 1269-1282. (C1)

24. R. Kobes, G. Kunstatter and A. Rebhan (1991), "Gauge Independence at the Gluon Propagator Poles and QCD Plasma Parameters", in *Proceedings of the 25th International Conference on High Energy Physics*, Vol. I., eds. K.K. Phua and Y. Yamaguchi (World Scientific, Singapore), pp. 414-417. (C3)

25. R. Kobes (1991), "Comparing Graphs in the Imaginary Time and Real Time Formalisms", in *Thermal Field Theories: Proceedings of the 2nd Workshop on Thermal Field Theories and Their Applications*, eds. H. Ezawa, T. Arimitsu and Y. Hashimoto (Elsevier, Amsterdam), pp. 153-162. (C3)

G. Kunstatter

1. M. Burgess, M. Carrington and G. Kunstatter, "The Effective Action for a Generalized Jaynes-Cummings Model", Can. J. Phys. (in print, 1998). (C1)

2. G. Kunstatter, R. Petryk and S. Shelemy, " Hamiltonian Thermodynamics of Black Holes in Generic 2-D Dilaton Gravity", Phys. Rev. **D57**, 3537-3547 (1998).(C1)

3. G. Kunstatter, "From Black Holes to Sine-Gordon Solitons", Symmetry in Physics, U. of Edmonton, September, 1997 (Invited talk).

4. G. Kunstatter, "From Black Holes to Sine-Gordon Solitons", Soliton 97, Queen's University, July, 1997 (Invited talk).

5. G. Kunstatter, "Thermodynamics and Statistical Mechanics of Quantum Black Holes", CAP Congress, University of Calgary, June, 1997 (Invited talk) .

6. G. Kunstatter, "Hamiltonian Thermodynamics of Black Holes in Generic 2-D Dilaton Gravity", Blach Holes: Theory and Mathematical Aspects, Banff, May 31-June 4, 1997 (Invited talk).

7. A.O. Barvinsky and G. Kunstatter (1997), "Mass spectrum for black holes in generic 2-D dilaton gravity", Proceedings of the Second International A.D. Sakharov Conference on Physics, editors I.M. Dremin and A.M. Seminkhatov (World Scientific, Singapore), pp. 210–215. (C3)

8. J. Gegenberg, G. Kunstatter and T. Strobl (1997), "Statistical mechanical entropy of two-dimensional black holes", Proceedings of the Second International A.D. Sakharov Conference on Physics, editors I.M. Dremin and A.M. Seminkhatov (World Scientific, Singapore), pp. 254–257. (C3)

9. D. Louis-Martinez and G. Kunstatter (1997), "Charged black holes in generic 2-D dilaton gravity", Proceedings of the 6th Canadian Conference on General Relativity and Relativistics Astrophysics, Fredericton, Fields Institute Communications, Volume 15, Eds. S.P. Braham, J.D. Gegenberg and R.J. McKellar (American Mathematical Society, Providence, RI), pp. 81–93. (C3)

10. J. Gegenberg, G. Kunstatter and T. Strobl (1997), "Edge states and entropy of 2-D black holes", Phys. Rev. D **55**, 7651–7665. (C1)

11. A. Barvinsky and G. Kunstatter (1996), "Exact Physical Black Hole States in Generic 2-D Dilaton Gravity" Phys. Lett. **B389**, 231–237. (C1)

12. G. Kunstatter (1996), "Black Hole Entropy and Quantum Mechanics in Generic 2-D Dilaton Gravity", Proceedings of the Sixth Moscow Seminar on Quantum Gravity, Int. J. Theor. Phys. **5**, 665–678. (C3)

13. G. Kunstatter (1996), "Exact Quantum States in 2-D Dilaton Gravity" Regional Meeting on General Relativity, Fredericton, April, 1996. (E2)

14. G. Kunstatter (1996), "Exact Quantum Black Hole States in Generic 2-D Dilaton Gravity", Second International Sakharov Conference on Physics, Moscow, May 18-23, 1996. (Invited). (C3)

15. D. Louis-Martinez and G. Kunstatter (1995), "2-D Dilaton Gravity Coupled to an Abelian Gauge Field", Phys. Rev. D**52**, 3494-3505. (C1)

16. M. Carrington and G. Kunstatter, (1995) "Maxwell Chern Simons Theory with Magnetic Moment Interactions", Phys. Rev. D**51**, 1903-1905. (C1)

17. R. Epp and G. Kunstatter (1995), "Dirac vs. Reduced Quantization of the Poincare Symmetry in Scalar Electrodynamics", Phys. Rev. D**51**, 781-789. (C1)

18. J. Gegenberg, G. Kunstatter and D. Louis-Martinez (1995), "Observables for 2-D Black Holes", Phys. Rev. D**51**, 1781-1786. (C1)

19. G. Kunstatter and Domingo Louis-Martinez (1995), "Quantum Mechanics and Thermodynamics of Charged Black Holes in Generic 2-D Dilaton Gravity", Proceedings of the CAP Workshop on Mathematical Physics, Quebec, June, 1995 (in print). (C3)

20. J. Gegenberg, G. Kunstatter and Domingo Louis-Martinez, (1995), "Classical and Quantum Mechanics of Black Holes in Generic 2-D Dilaton Gravity", Proceedings of the Conference on Heat Kernels and Quantum Gravity, U. of Manitoba, 1994, Discourses in Mathematics and Its Applications, No. 4, 1995, Ed. S. Fulling (Texas A&M Press, College Station, 1995). (C3)

21. G. Kunstatter (1995), "Thermodynamics and Quantum Mechanics of Charged 2-D Black Holes", CAP Congress/CAM95, Quebec City, June 11-15, 1995 (Invited). (C3)

22. G. Kunstatter, "Quantum Wave Functionals for Charged Black Holes in 2-D Dilaton Gravity", Sixth Quantum Gravity Seminar, Moscow, June 12-19, 1995 (Invited). (C3)

23. G. Kunstatter, "Charged Black Holes in 2-D Dilaton Gravity" 6th Canadian Conference on General Relativity and Relativistic Astrophysics", Fredericton, May 25-27, 1995 (Invited). (C3)

24. P.F. Kelly, R.L. Kobes and G. Kunstatter (1994). "Parametrization Invariance and the Resolution to the Unitary Gauge Puzzle", Phys. Rev. **D50**, 7592–7602. (C1)

25. M.E. Carrington and G. Kunstatter (1994), "Massless Scalar QED with Non-Minimal Chern-Simons Coupling", Phys. Rev. **D50**, 2830. (C1)

26. D. Louis-Martinez, J. Gegenberg and G. Kunstatter (1994), "Exact Dirac quantization of all 2D dilaton gravity theories", Phys. Lett. **B321**, 193-198. (C1)

27. D. Louis-Martinez and G. Kunstatter (1994), "Birkhoff's theorem in two-dimensional dilaton gravity", Phys. Rev. **D49**, 5227-5230. (C1)

28. M.E. Carrington and G. Kunstatter (1994), "Phase Transitions in Massless Scalar QED with Non-Minimally Coupled Chern-Simons Term", Phys. Lett. **B321**, 253-257. (C1)

29. J. Gegenberg and G. Kunstatter (1994), "Partition Function for Topological Field Theories' , Annals of Physics **231**, 270-289. (C1)

30. F.C. Khanna, R. Kobes, G. Kunstatter, and H. Umezawa (editors) (1994), *Proceedings of the Banff/CAP School on Thermal Field Theories* (World Scientific, Singapore). (B)

31. J. Gegenberg and G. Kunstatter (1993), "Quantum Theory of Black Holes", Phys. Rev. (Rapid Comm.) **D47**, R4192-4195. (C1)

32. R. Epp, G. Kunstatter and D.J. Toms (1993), "Path Integral Quantization of Scalar QED", Phys. Rev. **D47**, 2474-2482. (C1)

33. J. Gegenberg and G. Kunstatter (1993), "Exact Quantum Wave-Functionals for Spherically Symmetric Black Holes", in *Proceedings of the 5th Canadian Conference on General Relativity and Relativistic Astrophysics*, eds. R.B. Mann and R.G. McLenaghan (World Scientific, Singapore), pp. 134–139. (C3)

34. R. Epp and G. Kunstatter (1993), "Dirac vs. Reduced Quantization of Poincaré Invariant Gauge Theories", in *Proceedings of the 5th Conference on General Relativity and Gravitation*, ed. R. Mclenaghan (World Scientific), pp. 307–311. (C3)

35. R. Baier, G. Kunstatter and D. Schiff (1993), "Gauge Fixing Dependence of Gluon and Quark Damping Rates in Hot QCD", in *Proceedings of the Winnipeg Workshop on Perturbative Methods in Hot Gauge Theories*, Can. J. Phys. **71**, 208-216. (C3)

36. R. Kobes, G. Kunstatter and K. Mak (1993), "Damping of Fermions in Hot Gauge Theories", in *Proceedings of the Winnipeg Workshop on Perturbative Methods in Hot Gauge Theories*, Can. J. Phys. **71**, 252-255. (C3)

37. G. Kunstatter (1993), "Transversality of the Re-Summed Thermal Gluon Self Energy", in *Proceedings of the Winnipeg Workshop on Perturbative Methods in Hot Gauge Theories*, Can. J. Phys. **71**, 256-261. (C3)

38. R. Kobes and G. Kunstatter (editors) (1993), *The proceedings of the workshop on perturbative methods in hot gauge theories*, Can. J. Phys. **71**, pp. 205-305. (B)

39. G. Kunstatter (1992), "Dirac vs. Reduced Quantization: A Geometrical Approach", Class. Qu. Grav. **9**, 1469-1485. (C1)

40. R. Kobes, G. Kunstatter and K. Mak (1992), "Fermion Damping in Hot Gauge Theories", Phys. Rev. D**45**, 4632. (C1)

41. R. Baier, G. Kunstatter and D. Schiff (1992), "High Temperature Fermion Damping Rate: Resummation and Gauge Independence", Phys. Rev. D**45**, R4381-R4384. (C1)

42. R. Baier, G. Kunstatter and D. Schiff (1992), "Gauge Dependence of the Thermal Gluon Self Energy", Nucl. Phys. **B388**, 287-314. (C1)

43. G. Kunstatter (1992), "Path Integral for Gauge Theories: A Geometrical Approach", in *Proceedings of les Journées Relativistes*, Class. Qu. Grav. **9**, S157-S168. (C3)

44. R. Kobes, G. Kunstatter and A. Rebhan (1991), "Gauge Dependence Identities and their Application at Finite Temperature", Nucl. Phys. **B355**, 1-37. (C1)

45. P. Ellicott, G. Kunstatter and D.J. Toms (1991), "Geometrical Interpretation of the Functional Measure for supersymmetric Gauge Theories and of the Gauge Invariant Effective Action", Annals of Physics **205**, 70-109. (C1)

46. J. Gegenberg, G. Kunstatter and H.P. Leivo (1991), "A Solvable Theory of Topological Matter Coupled to Gravity in 2+1 Dimensions", in *Proceedings of the 25th Rochester Meeting on High Energy Physics*, eds. K.K. Phua and Y. Yamaguchi (World Scientific, Singapore), pp. 707-710. (C3)

47. R. Kobes, G. Kunstatter and A. Rebhan (1991), "Gauge (In)-Dependence of the Gluon Propagator Poles and QCD Plasma Parameters", in *Proceedings of the 25th Rochester Meeting on High Energy Physics*, eds. K.K. Phua and Y. Yamaguchi (World Scientific, Singapore), pp. 414-417. (C3)

48. G. Kunstatter (1991), "Geometrical Approach to the Effective Action", in *Proceedings of the Banff CAP Summer School on Gravitation*, eds. R. Mann and P. Wesson (World Scientific, Singapore), pp. 356-400. (C3)

49. J. Gegenberg, G. Kunstatter and H.P. Leivo (1991), "The Gravitational Interaction in 2+1 Dimensions", in *Proceedings of the Banff CAP Summer School on Gravitation*, eds. R. Mann and P. Wesson (World Scientific, Singapore), pp. 233-245. (C3)

50. G. Kunstatter (1991), "The Great Plasmon Puzzle Resolved", in *Proceedings of the Workshop on Heavy Ion Physics*, Budapest, eds. T. Csorgo, S. Hegyi, B. Lukacs and J. Zimanyi, pp. 108-114. (C3)

P.D. Loly

1. P.D. Loly (1997), "Quarto Plus!", Bulletin of the Association for Psychological Type, **20**, 45. (C2).

2. C. Bunio, E.G. Emberly and P.D. Loly (1997), "Bagels: triangular, square,...", Physics in Canada, **53**. (C2).

3. E.G. Emberly, A. Kung and P.D. Loly (1996), "Vibrations of NaCl: A simple model for lattice dynamics", Mathematica in Education and Research, **5**, 5–10. (C1).

4. E.G. Emberly and P.D. Loly (1995), "Fermi Surfaces Coloured with the Group Speed to Reveal Critical Points for Singularities of the Density of States", Mathematica in Education and Research **4.1**, 8-13. (C1)
(with electronic supplement "Fermi.ma" on Mathsource)

5. P.D. Loly (1994), "Vector Notation: $\vec{r}$ versus **r**", American Journal of Physics **62**, 105. (C1)

6. A.I. Mogilner and P.D. Loly (1992), "Vanishing Gaps in 1D Bandstructures", J. Phys. A: Math. Gen. **25**, L855-860. (C1)

7. X.H. Qu and P.D. Loly (1992), "Two-Magnon Excitations in the Heisenberg Ferromagnet on the Triangular Lattice", J. Phys.: Condensed Matter **4**, 5419-5432. (C1)

8. P.D. Loly (1992), "Computers, Technology and Innovative Literature for Undergraduate Physics", Physics in Canada **48**, 82-90. (C2)

T.A. Osborn

1. T. A. Osborn, M. F. Kondrat'eva, C. Tabisz and B. R. McQuarrie (1998), "A Mixed Weyl Symbol Calculus and Spectral Line Shape Theory", submitted to J. Phys. A, 32 pages. (C1)

2. B. R. McQuarrie, T. A. Osborn, M. F. Kondrat'eva and G. C. Tabisz (1998), "Moyal Quantum Dynamics: Atomic Scattering and Line Shapes" AIP Proceedings: 14th International Conference on Spectral Line Shapes, State College, PA, June 22-26, 4 pages (C3)

3. B. R. McQuarrie, T. A. Osborn and G. C. Tabisz (1998), "Semiclassical Moyal Quantum Mechanics for Atomic Systems", in press, Phys. Rev. A, 45 pages. (C1)

4. T. A. Osborn and F. H. Molzahn (1997), "Moyal Quantum Mechanics: The Semiclassical Content", Edited by D. H. Feng and B. L. Hu (Proceedings of the 4th Drexel Symposium on Quantum Nonintegrability: Quantum Classical Correspondence, International Press, 1997), 253-266. (C3)

5. A.O. Barvinsky, T.A. Osborn and Yu.V. Gusev (1995), "Phase-space Technique for the Perturbation Expansion of Schrödinger Propagators", J. Math. Phys. **36**, 30–61. (C1)

6. T. A. Osborn and F. H. Molzahn, "Cluster WKB" (1995), in Mathematical Quantum Theory: Schrödinger Operators, Edited by J. Feldman, R. Froese and L. Rosen (CRM Proceedings and Lecture Notes Series, American Mathematical Society) Vol. 8, 227-241. (C3)

7. T.A. Osborn and F.H. Molzahn (1994), "Moyal Quantum Mechanics: The Semiclassical Heisenberg Dynamics", Annals of Physics (NY), **241**, 79-127. (C1)

8. F.H. Molzahn and T.A. Osborn (1994), "A Phase Space Fluctuation Method for Quantum Dynamics", Annals of Physics **230**, 343-394. (C1)

9. F.H. Molzahn, T.A. Osborn and S.A. Fulling (1992), "Multi-Scale Semiclassical Approximation for Schrödinger Propagators on Manifold", Annals of Physics **214**, 102-142. (C1)

10. A. Saksena, T.A. Osborn and F.H. Molzahn (1991), "An Asymptotic Analysis of Quantum Evolution with Electromagnetic Fields", J. Math. Phys. **32**, 938-955. (C1)

11. T.A. Osborn and F.H. Molzahn (1991), "The Wigner-Weyl Transform on Tori and Connected Graph Propagator Representations", in Forty More Years of Ramifications: Spectral Asymptotics and Its Applications, Edited by S.A. Fulling and F.J. Narcowich, Discourses in Mathematics and Its Applications, No. 1, (Department of Mathematics, Texas A & M University, College Station, Texas, 1991), pp. 199-236. (B)

B.W. Southern

1. B.W. Southern and J.L. Martínez Cuéllar, "Multi-Magnon Excitations in Alternating Spin/Bond Chains", Phys. Rev. B (to appear Oct 1 1998). (C1)

2. D. A. Lavis, B. W. Southern, and I F Wilde " The Inverse of a Semi-infinite Symmetric Banded Matrix", J. Phys. A: Math. Gen. **30** 7229-7241 (1997). (C1)

3. D.A. Lavis, B.W. Southern and I.F. Wilde (1997), "The Inverse of a Semi-infinite Symmetric Banded Matrix", J. Phys. A, in press. (C1)

4. D.A. Lavis and B.W. Southern (1997), "The Inverse of a Symmetric Banded Toeplitz Matrix", Rep. Math. Phys. **39**, 137–146. (C1)

5. S.L.M. Cyr, B.W. Southern and D.A. Lavis (1996), "Multi-magnon excitations in Heisenberg spin S chains with next-nearest-neighbour interactions" , J. Phys: Condens. Matter **8**, 4781-4795. (C1)

6. H-J. Xu and B.W. Southern (1996), "Phase Transitions in the 2D XY Antiferromagnet on the Triangular Lattice", J. Phys. A: Math. Gen. **29** L133-L139. (C1)

7. B.W. Southern and H-J. Xu (1995), "Monte Carlo Study of the Heisenberg Antiferromagnet on the Triangular Lattice", Phys. Rev. B**52**, R3836-R3839. (C1)

8. B.W. Southern, R.J. Lee and D.A. Lavis (1994), "Three-Magnon Excitations in Ferromagnetic Spin-S Chains", J. Phys. Condensed Matter **6**, 10075-10092. (C1)

9. B.W. Southern and A.P. Young (1993), "Spin Stiffness in Frustrated Antiferromagnets", Phys. Rev. B**48**, 13170-13173. (C1)

10. P. Katbamna, L.J. Dunne, W. Ford, D.A. Lavis and B.W. Southern (1993), "Continuous Phase Transitions and Orientational Ordering in Monolayers of Zwitterionic Amphiphilic Molecules at Fluid Interfaces", Phys. Stat. Sol. **B178**, 335-342. (C1)

11. B.W. Southern and Y. Achiam (1993), "Critical Dynamics of the D =3D 1 Kinetic Ising Model," J. Phys. A.: Math. Gen. **26**, 2505-2517. (C1)

12. B.W. Southern and Y. Achiam (1993), "Critical Dynamics and Universality in Kinetic Ising Models Without Translational Invariance." J. Phys. A.: Math. Gen. **26**, 2519-2533. (C1)

13. S. Masui, A.E. Jacobs, C. Wicentowich and B.W. Southern (1993), "Metastable States of the Random-Field Ising Chain." J. Phys. A: Math. Gen. **26**, 25-37. (C1)

14. Y. Achiam and B.W. Southern (1992), "Critical Dynamics of the Alternating Bond Kinetic Ising Model", J. Phys. A: Math. Gen. **25**, L769-773. (C1)

15. V.B. Cherepanov, S.L.M. Cyr and B.W. Southern (1992), "Metastable States of the Potts Glass", J. Phys. A: Math. Gen. **25**, 4347-4358. (C1)

16. A.J.M. Medved, B.W. Southern and D.A. Lavis (1991), "Two-Magnon States the Alternating-Bond Ferrimagnetic Chain", Phys. Rev. B**43**, 816-824. (C1)

J.P. Svenne

1. L. Canton, G. Cattapan, G. Pisent, W. Schadow, and J.P. Svenne, *Spin observables for the* $pd \leftrightarrow \pi^+ t$ *reaction around the* Δ *resonance*, Phys. Rev. C **57**, 1588-1594 (1998) (C1)

2. L. Canton, G. Cattapan, P.J. Dortmans, G. Pisent, and J.P. Svenne (1996), "A Meson-Exchange Isobar Model for the $\pi^+ d \leftrightarrow pp$ Reaction", Can.J.Phys., **74**, 209-225 (1996). (C1)

3. L. Canton G. Cattapan, P.J. Dortmans, G. Pisent, W. Schadow, and J.P. Svenne (1995), "The $\pi^+ d \leftrightarrow pp$ and $\pi^+ t \leftrightarrow pd$ Reactions with the Rescattering Model". Invited paper in the Proceedings of the "VI Convengo su problemi di fisica teorica", Cortona, Italy, October 12-14, 1995. Proceedings published as *Perspectives on Theoretical Nuclear Physics* I. Bombaci, A. Bonaccorso, A. Fabrocini, A. Kievsky, S. Rosati, and M. Viviani, eds (ETS, Pisa, 1996). (C3)

4. G. Pisent and J.P. Svenne (1995), "Analysis of compound and quasicompound resonances in a multichannel, finite-rank model", Phys. Rev. C **51**, 3211-3221. (C1)

5. P.J. Dortmans, L. Canton, G. Cattapan, G. Pisent and J.P. Svenne (1994), "Pion absorption by the deuteron with meson-exchange isobar models", *14th International IUPAP Conference on Few-Body Problems in Physics*, Williamsburg, VA, pp. 254-257. Contributed paper, poster and oral presentation. (C3)

6. L. Canton, G. Cattapan and J.P. Svenne (1993), "Pion Absorption on ^{3}He. II: Antisymmetrization and Angular Decomposition of the Faddeev-based Amplitude", Phys. Rev. C **48**, 1562-1572 (1993). (C1)

7. G. Cattapan, L. Canton and J.P. Svenne (1993), "Re-Examination of the πNNN-NNN Problem", Nuovo Cimento **106A**, 1229-1246 (1993). (C1)

J.M. Vail

1. J. M. Vail (1998), "Quantum Mechanics for Materials Science Curricula", Journal of Materials Education, in press: accepted June 24, 1998. (C1).

2. J. M. Vail, E. Emberly, T. Lu, M. Gu, R. Pandey (1998), "Simulation of Point Defects in High-density Luminescent Crystals: Oxygen in Barium Fluoride", Physical Review B 57, pp. 764-772. (C1).

3. J. M. Vail, M. Bromirski, E. Emberly, T. Lu, Z. Yang, and R. Pandey (1998), "A Simulation Study for the Ground State Configuration of the $(F_2^+)^*$ Center in NaF:Mg" Radiation Effects and Defects in Solids, 145, pp. 29-38. (C1).

4. J. M. Vail, E. Emberly, T. Lu, Z. Weng, M. Gu and R. Pandey (1998) "Oxygen in BaF2: A Computational Study", 8th Europhysical Conference on Defects in Insulating Materials, July 6-11, 1998, Keele University, Keele, Staffs., U.K., abstract PWe18, p.175. (E2).

5. J.M. Vail, M. Gu, R. Pandey, T. Lu, and E. Emberly (1996), "Calculated Optical Absorption of O^- Impurity in BaF_2 Crystal", 13th International Conference on Defects in Insulating Materials, July 15–19, 1996, Wake Forest University, Winston–Salem, NC, abstract TuD1, p. 58. (E2)

6. J.M. Vail (1995), "Local Electronic Properties of Crystals: Theory and Computer Simulation", Proceedings of the International Autumn School–Conference for Young Scientists, Solid State Physics: Fundamentals and Applications, Uzhgorod, Ukraine, September 18–26, 1995 (National Academy of Sciences of Ukraine, Kiev, 1995), pp. L67–L83. (C3)

7. T. McMullen, J. Meng, J.M. Vail, and P. Jena,.(1995), "Quantum Diffusion of Muonium in Alkali Halides" Physical Review B**51**, pp. 15879-15884. (C1)

8. J.M. Vail, B.K. Rao (1995), "Electronic-Structure of Crystals: Embedded Quantum Cluster with Overlap" International Journal of Quantum Chemistry, **53**, 67-76. (C1)

9. J.M. Vail (1995), "Electronic Structure of Defects in Ionic Crystals" , invited paper, International Symposium on Local Order in Condensed Matter Physics, June 14-17,1993, Jekyll Is., GA, S.D. Mahanti, and P. Jena, editors (Nova Science Publishers, Commack, NY), pp.103–109. (C3)

10. J.M. Vail (1995), "Embedding Theory and Quantum Cluster Simulation of Point Defects in Ionic Crystals" , invited review, in Fundamentals of Materials Science, series ed. M.F. Thorpe, Vol. 1, Electronic Properties of Solids Using Cluster Methods, ed. T.A. Kaplan and S.D. Mahanti, (Plenum Press, NY), pp.29–39. (D)

11. J.M. Vail (1994), "Molecular Cluster Theory Applied to Point Defects in Crystals" , invited review, Trends in Chemical Physics, **3**, pp. 95-108 (Research Trends, Trivandrum, India). (D)

12. J.M. Vail, T. McMullen, and J. Meng (1994), "Electronic-Structure Determination of Light Impurity-Phonon Interaction in Solids", Phys. Rev. B**49**, 193-200. (C1)

13. J.M. Vail and R. Pandey (1994), "The Shell Model for Small Oxide Clusters" , in *Seventh Europhysical Conference on Defects in Insulating Materials*, Lyon, France, Abstract PW III 14, p. 38. (E2)

14. J.M. Vail and Z. Yang (1993),"Simulation of F, F_2^+, and $(F_2^+)^*$ Centres in NaF:Mg", Journal of Physics: Condensed Matter, **5**, 7649-7656. (C1)

15. J.M. Vail, B.K. Rao, (1993),"A Method for the Simulation of Electronic and Structural Properties of Small Clusters on Metallic Substrates", The Second Workshop for the Center for Atomically Engineered and Nanoscale Materials, Oct. 15-16,1993, College Park, MD, Abstracts, p16. (E2)

16. R. Pandey, X. Yang, J.M. Vail and J. Zuo (1992), "Derivation of Pair Potentials from First Principles and Simulation of NaF Clusters", Solid State Communications,**5**, 549-552. (C1)

17. J.M. Vail and Z. Yang (1992), "Electronic and Atomistic Configuration of the $(F_2^+)^*$ Center in NaF:Mg", International Conference on Defects in Insulating Materials, Nordkirchen, Germany, August 16-22,1992, Final Program, Abstract Mo-P011, p.66. (E2)

18. J.M. Vail and Z. Yang (1992), "A New Method for Simulating Complicated Electronic Defects in Insulators", 94th Annual Meeting, The American Ceramic Society, Minneapolis, MN, April 12-16, 1992, Final Program, Abstract 14-SI-92, p.4. (E2)

19. J.M. Vail, R. Pandey and A.B. Kunz (1991), "Embedded Quantum Cluster Simulation of Point Defects and Electronic Band Structures of Ionic Crystals", invited review, Reviews of Solid State Science, 5, pp. 241-283. (D)

J.G. Williams

1. J.G. Williams (1998), "Rotating kink spacetime in 2+1 dimensions", Gen. Rel. Grav. 30, 27–33 (C1)

2. K.A. Dunn, T.A. Harriott and J.G. Williams (1997), "Energy conditions for a spherically symmetric kink spacetime", J. Math. Phys. 38, 6470–6474. (C1)

3. K.A. Dunn, T.A. Harriott and J.G. Williams (1997), "Matching conditions for the 1+1 de Sitter kinked spacetime", in *Proceedings of the 6th Canadian Conference on General Relativity and Relativistic Astrophysics, Fields Institute Communications, Volume 15*, edited by S.P. Braham, J.D. Gegenberg and R.J. McKellar (American Mathematical Society, Providence, RI), pp. 233–236. (C3)

4. J.G. Williams and P. Zvengrowski (1997), "Counting kinks in 1+1 dimensions", in *Proceedings of the 6th Canadian Conference on General Relativity and Relativistic Astrophysics, Fields Institute Communications, Volume 15*, edited by S.P. Braham, J.D. Gegenberg and R.J. McKellar (American Mathematical Society, Providence, RI), pp. 357–360. (C3)

5. K.A. Dunn, T.A. Harriott and J.G. Williams (1996), "Kinks and geodesic incompleteness", J. Math. Phys. **37**, 5637–5651. (C1)

6. K.A. Dunn, T.A. Harriott and J.G. Williams (1996), "Geodesic incompleteness and the kinked de Sitter spacetime", in *Proceedings of the 7th Marcel Grossmann Meeting on General Relativity*, edited by R.T. Jantzen and G.M. Keiser (World Scientific, Singapore), pp. 294–295. (C3)

7. J.G. Williams (1994), "Topologically massive gravity with a fluid source," in *Proceedings of the Fifth Canadian Conference on General Relativity and Relativistic Astrophysics*, edited by R.B. Mann and R.G. McLenaghan (World Scientific, Singapore), pp. 473-476. (C3)

8. J.G. Williams (1994), "Thermodynamics of a rotating and expanding spacetime in 2+1 dimensions," in *Proceedings of the Fifth Canadian Conference on General Relativity and Relativistic Astrophysics*, edited by R.B. Mann and R.G. McLenaghan (World Scientific, Singapore), pp. 477-480. (C3)

9. K.A. Dunn, T.A. Harriott and J.G. Williams (1994), "Extension of the de Sitter kink," J. Math. Phys. **35**, 4145-4156. (C1)

10. J.G. Williams (1994), "(2+1)-dimensional spacetime with rotation and expansion", Gen. Rel. Grav. **26**, 499-512. (C1)

11. J.G. Williams (1994), "Topologically massive gravity with a two-fluid source", Phys. Rev. D49, 1117-1119. (C1)

12. J.G. Williams (1992), "Rotating charged fluid in 2+1 dimensions", Gen. Rel. Grav. **24**, 1083-1090. (C1)

13. J.G. Williams and P. Zvengrowski (1992), "Homotopy classification of metrics in 2+1 dimensions", in *Proceedings of the Sixth Marcel Grossmann Meeting on General Relativity*, edited by H. Sato and T. Nakamura (World Scientific, Singapore), pp. 540-542. (C3)

14. J.G. Williams and P. Zvengrowski (1992), "2 + 1 gravity kinks for multiply connected spacetime manifolds", in *Proceedings of the Fourth Canadian Conference on General Relativity and Relativistic Astrophysics*, edited by G. Kunstatter, D.E. Vincent and J.G. Williams (World Scientific, Singapore), pp. 364-367. (C3)

15. K.A. Dunn, T.A. Harriott and J.G. Williams (1992), "Kinks in 1+1, 2+1 and 3+1 dimensions", in *Proceedings of the Fourth Canadian Conference on General Relativity and Relativistic Astrophysics*, edited by G. Kunstatter, D.E. Vincent and J.G. Williams (World Scientific, Singapore), pp. 360-363. (C3)

16. K.A. Dunn, T.A. Harriott and J.G. Williams (1992), "FLRW kinks", Phys. Lett. **A163**, 152-154. (C1)

17. K.A. Dunn, T.A. Harriott and J.G. Williams (1992), "Toy model for gravitational kinks", J. Math. Phys. **33**, 1437-1444. (C1)

18. J.G. Williams and P. Zvengrowski (1992), "Kink metrics in (2+1)-dimensional spacetime", J. Math. Phys. **33**, 256-266. (C1)

19. J.G. Williams (1991), "Combed hedgehog kink metric in 2+1 dimensions", Gen. Rel. Grav. **23**, 181-187. (C1)

20. K.A. Dunn, T.A. Harriott and J.G. Williams (1991), "Kink number in general relativity", J. Math. Phys. **32**, 476-479. (C1)

5 Financial

5.1 Statement of Income and Expenditures

Income

Income Source	Amount
University of Manitoba	
Carry over from Aug. 31, 1997	$7,603.70
University of Winnipeg	
Vice President (Academic)	$670.90
Total Funds That Were Available	$8,274.60

Expenditures

Activity	Particulars	Amount Spent
Seminars		
	(1) M. Karasev, Sept., 1997	$1,000.00
	(2) Y. Hosotani, Oct., 1997	$670.90
	(3) R. Baier, May, 1998	$612.03
	Total Seminar Costs	$2,282.93
Miscellaneous	FAX, mail, printing, supplies	$1.65
	Total Expenditures (1997–1998)	$2,284.58

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 $200,100 of individual NSERC Research Grants. In addition, members of the Institute receive research support from other sources, notably NATO, and other external and internal sources, for an additional total of $48,087. These funds have a significant fortifying effect on the level of activities in which we are able to engage.

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 Faculty of Science at the University of Manitoba are fortified by the individual NSERC research grants of members. This shows 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 entirely dependent on the Institute being able to create a positive research atmosphere. This in turn depends highly upon the level of funding that the Institute receives. In recent years, there has been a marked decrease in the funds made available to the Institute by the three Manitoba universities. The Institute has approached the appropriate university Departments of Private Funding with a view to financing part of its activities from the private sector. To date, nothing definitive has resulted.

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.