The Winnipeg Institute for Theoretical Physics Annual Report

September 1994 – October 1995

Contents

1 Director's Narrative Report

The Winnipeg Institute of 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 14 permanent members of this Institute are drawn from the University of Manitoba, the University of Winnipeg, Brandon University and the Atomic Energy of Canada Laboratory at Pinawa.

The past year (1994-1995) was the fifth year of the Institute's existence. It saw a continuation of the activities of previous years with research seminars being given by 10 short term out-of-province visitors, and with the successful collaborative stay of one long term visitor from the United States. Other researchers connected with and taking part in the Institute activities were the following: one research associate, three postdoctoral fellows, and six graduate students.

For the 1994-1995 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 list of graduate degrees awarded appears in section 4.3, and the published research work of members, associate members and graduate students is found in sections 4.4 and 4.5. Section 5.1 contains a summary of income and expenditures for the period September 1994 – September 1995.

Plans for the forthcoming year continue our established programs. As in previous years, the seminar program of invited guest speakers aims to bring to Winnipeg about a dozen new visiting physicists.

Essentially all the funds available to the Institute are expended for the workshop and symposium activities and for the travel funds 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 the costs of visitors.

The Institute director for the past academic year has been D. Vincent (University of Winnipeg), who prepared this report. Other members of the Institute executive were the past director, P.G. Blunden (University of Manitoba), and the incoming director, J.P. Svenne (University of Manitoba). J.P. Svenne will begin his term in October 1995. The executive for the 1995-1996 year consists of D. Vincent, J.P. Svenne and J. Williams (Brandon University) who has agreed to be the director in 1996-1997.

2 Current List of Members (September, 1995)

2.1 Permanent Members

- B. Bhakar[1], *Ph.D. (Delhi)*
- P.G. Blunden[1] , *Ph.D (Queen's)*
- M.E. Carrington[2], *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)*
- C.H. Woo[4], *Ph.D. (Waterloo)*
- J.A. Zuk[1] , *D.Phil. (Oxford)*

[1] University of Manitoba
[2] University of Winnipeg
[3] Brandon University
[4] A.E.C.L. Research, Pinawa

2.2 Associate Members

- B.K. Rao *(Visiting Scientist)*
- J.I. Johansson*(Research Associate)*
- D. Louis-Martinez *(Postdoctoral Fellow)*
- F.H. Molzahn *(Research Associate)*
- E. Petitgirard *(Postdoctoral Fellow)*
- Huang-Jian Xu *(Postdoctoral Fellow)*

2.3 Graduate Students

- J. Chen (M.Sc.), *(Kobes)*
- Yu.V. Gusev (Ph.D.), *(Osborn)*
- R.J. Lee (Ph.D.), *(Loly)*
- N. Li (M.Sc.), *(Woo)*
- J. Martinez-Cuellar (M.Sc.), *(Southern)*
- T. Melde (Ph.D.), *(Svenne)*
- Iain Stewart(M.Sc.),*(Blunden)*

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 of the topics under current investigation include: Dirac-Hartree-Fock calculations for the properties of finite nuclei; hadronic and electromagnetic reactions; a relativistic treatment of mesonic currents; and exact and approximate treatments of the negative energy Dirac sea in finite nuclei.

M.E. Carrington

Chern-Simons theories are topological gauge theories in 2+1 dimensions that have no classical dynamics but have interesting quantum mechanical behaviour. These theories have been studied in the context of the Quantum Hall Effect and high temperature superconductivity. Non-minimal Chern-Simons theories are closely related to theories that take into account magnetic moment interactions in 2+1 dimensions. The study of finite temperature phase transitions in these non-minimal theories is of particular interest.

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 interested in a study of properties of high temperature gauge theories such as the quark-gluon plasma, as well as a general investigation of calculational methods in finite temperature field theory.

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 dealing with Hawking radiation 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) focuses on pion absorption on very light nuclei. The pion plays an important role in the understanding of the nucleon-nucleon interaction and in nuclear reactions and structure. As the lightest meson, it is responsible, in the boson-exchange model of the NN interaction, for the longest-range part of the interaction. In addition, it is considered to be the particle, resonating with a nucleon, which gives rise to the lowest- energy and strongest isobar resonance of the nucleon, the Δ resonance. Thus, any treatment of πd reactions and related inelasticities require (at least) the simultaneous description of the πNN–ΔN–NN dynamics. These same processes dominate pion reactions and absorption on other light nuclei, such as ^{3}He. In addition, any model which explicitly takes the pion degrees of freedom into account must be carefully constructed so as to avoid any double counting with the pion exchange included in standard NN interaction models.

We have completed calculations of the $\pi^+ d \leftrightarrow p+p$ reaction with a relatively simple meson–exchange isobar model. Pion absorption on the deuteron is a well-studied system. We use it to fine–tune our model and test our mathematical and computational procedures, in preparation to applying the model to pion absorption on three–nucleon systems. Calculations are under way on ^{3}He. Beyond that, we intend to study ^{4}He and three–cluster systems such as ^{6}Li ad ^{9}Be. On the longer term, we also intend to use other probes, such as kaons and photons. In addition, progress has been made in understanding the complete coupled three– and four–body equations of the $\pi NNN - NNN$ system.

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 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 optical and spin resonance properties of color centers and impurities, derivation of effective interatomic forces, hole trapping by impurities in oxides, and quantum diffusion.

Four projects are currently in progress: (1) simulation of complicated impurity F-type centers, such as $(F_2^+)^*$ in NaF:Mg; (2) overlap effects from the embedding region in the simulation of defects by small clusters (collaboration at Virginia Commonwealth University); (3) simulation of optical properties of high density luminescent materials: (a) the optical excitation of oxygen in BaF_2 ; (b)electronic structure and optical properties of $PbWO_4$ (collaboration at Michigan Technological University).

D. 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 uses techniques of differential geometry and algebraic topology to study general relativistic metrics that represent homotopically nontrivial light cone configurations on spacetime manifolds that can be either simply or multiply connected. Progress to date includes the discovery of a number of perfect fluid solutions to the classical Einstein equations representing such twists in the light cone field. Work in (2+1) dimensions has demonstrated the existence of similar interesting solutions for the Einstein-Maxwell equations for a fluid with rotation and electric charge. For (2+1)-dimensional relativity, the manifold that forms the range of mapping for the light cone field has no natural group structure and is merely a set. Because of this, the homotopy analysis of the metric tensor bundle is considerably more complicated than in the usual (3+1)-dimensional case, and new kinds of topological invariants have been shown to arise. Future effort will be directed towards studying the quantization of scalar fields in these kinds of non-globally hyperbolic spacetimes.

J.A. Zuk

The methods of quantum field theory are applied to problems in both condensed matter and elementary particle physics. In condensed matter physics, attention is focused on conductance and conductivity of electrons in disordered media, where such systems are described by random Hamiltonians. The general technique employs the representation of transport coefficients in terms of a generating functional involving integration over both commuting and anti-commuting variables. The direct ensemble averaging of the generating functional maps the problem onto a theory of interacting graded matrices of the non-linear sigma-model type. Applications include universal conductance fluctuations and Aharonov-Bohm oscillations in mesoscopic systems. Also amenable, is the study of the integer quantum Hall effect from the point of view of localization theory, in terms of an effective non-linear sigma-model with topological term, defined on a supersymmetric coset manifold.

In particle physics, the emphasis is on the construction and analysis of low-energy effective theories of fundamental interactions. Therefore, methods for the derivative expansion of the effective action, and other non-local approximation schemes, are investigated. In particular, attention is focused on fermion contributions to the effective action which can give rise to topological effects such as anomalies, Wess-Zumino terms, charge fractionization, etc. One application of such ideas is the derivation and analysis of a chiral-soliton theory of the nucleon form the large-N_c , low-energy limit of QCD.

4 Research Activities

4.1 Seminars

Date	Speaker	Institution	Title
Sept. 12, 1995	Dr. Tim Evans	Imperial College	Galactic Magnetic Fields From Quantum Field Fluctuations
September 14, 1995	Dr. Mikhail Karasev	MIEM, Moscow	Membrane Quantization and the Semiclassical Approximation
July 27, 1995	Dr. B.K Rao	Virginia Commonwealth Univ	Interaction of Hydrogen with Metal Atoms, Clusters and Ions
April 26, 1995	Dr. E. Martinez	Univ. of Alberta	Microcanical Functional Integral and Entropy for External Black Holes
March 28, 1995	Dr. Oleg Soloviev	Univ. of London	Gross-Neveu versus Dashen-Frishman
March 7, 1995	Dr. Raj Vatsya	University of Manitoba	Wave-Particle Duality in Quantum Mechanics
November 24, 1994	Dr. C.P. Burgess	McGill University	Bosonization as Duality
November 22, 1994	Dr. Dan Riska	Univ. of Helsinki	Decoding the Baryon Spectrum
Nov 17, 1994	Dr. T. Steele	Univ. of Sask.	The Nielsen Identities for Gauge Theories
October 20, 1994	Dr. Dan Neuhauser	Univ. of Calif. Los Angeles	The Auxiliary-Field Monte Carlo for Electronic-Structure Calculations

4.2 Visiting Scientists

Dates	Visitor	Institution
July 25-August 3	Dr. B.K. Rao	Virginia Commonwealth University

4.3 Graduate Degrees Supervised

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

2. Ning Li, M.Sc., Feb. 1995 *(C.H. Woo)*

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

4.4 Publications of Associate Members/Graduate Students

Yu.V. Gusev

1. A. O. Barvinsky, Yu. V. Gusev, G. A. Vilkovisky, and V. V. Zhytnikov, "The one-loop effective action and trace anomaly in four dimensions", Nucl. Phys. B. **439**, p. 561 (1995).

2. A. O. Barvinsky, Yu. V. Gusev, G. A. Vilkovisky, and V. V. Zhytnikov, "The basis of nonlocal curvature invariants in quantum gravity theory. (Third order)", J. Math. Phys. **35**, p. 3525 (1994).

3. A. O. Barvinsky, Yu. V. Gusev, G. A. Vilkovisky, and V. V. Zhytnikov, "Asymptotic behaviors of the heat kernel in covariant perturbation theory", J. Math. Phys. **35**, p. 3543 (1994).

4. A. O. Barvinsky, Yu. V. Gusev, G. A. Vilkovisky, and V. V. Zhytnikov, "Covariant nonlocal effective action", *in* Proceedings of the fifth Canadian conference on general relativity and relativistic astrophysics, Waterloo, Canada, May 1993 (World Scientific: Singapore, 1994), eds. R. B. Mann and R. G. McLenaghan, p. 147.

5. A. O. Barvinsky and Yu. V. Gusev, "Heat kernel and one-loop radiation currents by the generating function method", *in* Proceedings of the Heat kernel techniques and quantum gravity conference, Winnipeg, Canada, August 1994, (Texas A&M University Press: College Station, *in press*), ed. S. Fulling. 12 pp.

6. A.O. Barvinsky, Yu.V. Gusev, G.A. Vilkovisky and V.V. Zhytnikov (1994), "The basis of nonlocal curvature invariants in quantum gravity theory (Third order)", J. Math. Phys. **35**, 3525.

7. A.O. Barvinsky, Yu.V. Gusev, G.A. Vilkovisky and V.V. Zhytnikov (1994), "Asymptotic behaviours of the heat kernel in covariant perturbation theory", J. Math. Phys. **35**, 3543.

8. A. O. Barvinsky, Yu. V. Gusev, G. A. Vilkovisky, and V. V. Zhytnikov, "Covariant perturbation theory (IV). Third order in the curvature", report of the University of Manitoba, 192 pp. (University of Manitoba, Winnipeg, 1993).

9. A.O. Barvinsky, Yu.V. Gusev, G.A. Vilkovisky and V.V. Zhytnikov (1993), "Covariant Perturbation Theory (IV): Third order in the curvature", 192pp., (University of Manitoba Report, Winnipeg).

10. A.O. Barvinsky, Yu.V. Gusev, G.A. Vilkovisky and V.V. Zhytnikov (1993), "Covariant Nonlocal Effective Action", in *Proceedings of the 5th Conference on General Relativity and Gravitation*, ed. R. Mclenaghan (World Scientific), in press.

F.H. Molzahn

1. F.H. Molzahn (1993), "Exponential Cluster Solutions to Quantum Transport Equations," J. Phys. A: Math. Gen. **25**, 4913-4940; **26**, 2275-2276 (Corrigendum).

H-J. Xu

1. B.W. Southern and H-J. Xu (1995) "Monte Carlo Study of the Heisenberg Antiferromagnet on the Triangular Lattice", Phys. Rev. **B52**, R3836-R3839.
2. H-J. Xu and L. Knopoff (1994) "Periodicity and Chaos in a One-Dimensional Dynamical Model of Earthquakes", Phys. Rev. **E50**, 3577-3581.
3. H-J. Xu , B. Bergersen and K. Chen (1993) "A Plaquet Representation of Ruptures and Models for Earthquakes", J. de Physique **3**, 2029-2040.
4. H-J. Xu , B. Bergersen and Z. Racz (1993) "Long-Range Interactions Generated by Random Levy Flights - Spin-Flip and Spin-Exchange Kinetic Ising Model in 2 Dimensions" Phys. Rev. **E47**, 1520-1524.
5. H-J. Xu , B. Bergersen and K. Chen (1992) "Self-Organized Ruptures in an Elastic Medium - A Possible Model for Earthquakes" J. Phys. A: Math. Gen. **25**, L1251-L1256.
6. H-J. Xu , B. Bergersen and Z. Racz (1992) "Monte-Carlo Simulations on Ising Dipoles - Finite Size Scaling and Logarithmic Corrections" J. Phys. Condensed Matter **4**, 2035-2042.
7. H-J. Xu , B. Bergersen and Z. Racz (1991) "Ordering of Ising Dipoles" J. Phys. Condensed Matter **3**, 4999-5012.

4.5 Publications of Permanent Members

P.G. Blunden

1. A.S. Raskin and P.G. Blunden (1994), Comment on "Collective Modes in Dense Neutrino Systems", Phys. Rev. **D50**. 7742. (C1)
2. 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)
3. 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)
4. P.G. Blunden and D.O. Riska (1992), "The Isoscalar Electromagnetic Current Operator and the Nucleon-Nucleon Interaction", Nucl. Phys. **A536**, 697. (C1)
5. P.G. Blunden and E.J. Kim (1991), "One-Pion Exchange Currents in the QHD Formalism", Nucl. Phys. **A531**, 461. (C1)
6. P.G. Blunden (1990), "Evaluation of Dirac Sea Effects in a Finite System", Phys. Rev. **41C**, 1851. (C1)
7. P.G. Blunden and C.J. Horowitz (1990), "Elastic Magnetic Electron Scattering and Vacuum Polarization", Phys. Lett. **B240**, 6. (C1)
8. P.G. Blunden, W.R. Greenberg and E.L. Lomon (1989), "New Comparisons of the Coupled Channel Model with Elastic Deuteron Form Factors", Phys. Rev. **40C**, 1541. (C1)
9. P.G. Blunden and M.N. Butler (1989), "The Effect of Meson Exchange Currents in a Relativistic Model of Quasi-Elastic (e,e')", Phys. Lett. **B219**, 151. (C1)
10. 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)
11. P.G. Blunden and M.N. Butler (1989), "A Relativistic Treatment of Mesonic Contributions to Quasielastic Electron Scattering", in *Weak and Electromagnetic Interactions in Nuclei*, ed. P. Depommier (Éditions Frontières, Gif-sur-Yvette Cédex, France), p. 779. (C3)
12. P.G. Blunden and E.J. Kim (1989), "Effect of Meson Exchange Currents in a Relativistic Study of Nuclear Electroweak Response Functions", in *Weak and Electromagnetic Interactions in Nuclei*, ed. P. Depommier ((Éditions Frontières, Gif-sur-Yvette Cédex, France), p. 783. (C3)

M.E. Carrington

1. M. Burgess and M.E. Carrington (1995), 'Junctions in Two Parity Violating Models in 2+1 Dimensions' , Phys. Rev. B52 (5052). (C1)
2. M.E. Carrington and G. Kunstatter (1995), "Maxwell-Chern-Simons scalar QED with magnetic moment interactions' , Phys. Rev. D 51 (1903). (C1)
3. M.E. Carrington (1995), "Meissner Effect in scalar QED with magnetic moment interactions", Phys. Rev D 51, (4451). (C1)
4. M.E. Carrington and G. Kunstatter (1994), "Massless scalar QED with non-minimal Chern-Simons coupling," Phys. Rev D 50 (2830). (C1)
5. 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)

6. M.E. Carrington (1993), "Self-Consistent Resummation Scheme in Scalar QED", Phys. Rev. **D48**, 3836. (C1)
7. M.E. Carrington and J.I. Kapusta (1993), "Dynamics of the Electroweak Phase Transition", Phys. Rev. **D47**, 5304. (C1)
8. M.E. Carrington (1992), "The Effective Potential at Finite Temperature in the Standard Model", Phys. Rev. **D45**, 2933. (C1)
9. 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. **B44**, 7519. (C1)
10. M.E. Carrington, T.H. Hansson, H. Yamagishi, and I. Zahed (1989), "Linear Response of Hot Gluons", Ann. Phys. **190**, 373. (C1)
11. M.E. Carrington and G. Kunstatter (1994), "Phase Transitions in Non-Minimally Coupled Chern-Simons Scalar QED", in *Proceedings of the Banff/CAP Workshop on Thermal Field Theory*, F.C. Khanna ed., (World Scientific). (C3)
12. M.E. Carrington (1993), "Ring Diagram Summations in the Finite Temperature Effective Potential", Can. J. Phys. **71**, 227. (C3)

R.L. Kobes

1. J. Chen, R. Kobes and J.Wang (1994), "Finite layers effect in metallic superlattices", Can. J. Phys. (in press). (C1)
2. P. Elmfors and R. Kobes (1995), "The thermal β-function in Hot Yang-Mills Theory' ,Phys. Rev. bf D51, 774. in hot QED", Phys. Rev. **D**, in press. (C1)
3. R. Baier and R. Kobes (1994), "Damping rate of a fast fermion in hot QED", Phys. Rev. **D50**,5944. (C1)
4. M. van Eijck, R. Kobes, and Ch.G. van Weert (1994), "Transformations of real time thermal Feynman rules", Phys. Rev. **D50**, 4097. (C1)
5. P. Kelly, R. Kobes, and G. Kunstatter (1994), "Parameterization invariance and the resolution to the unitary gauge puzzle", Phys. Rev. **D50**, 7592. (C1)
6. R. Kobes and K. Mak (1993), "Role of the Infrared Cutoff in Fermion Damping Rates", Phys. Rev. **D48**, 1868-1870. (C1)
7. R. Kobes, G. Kunstatter and K. Mak (1992), "Fermion Damping in Hot Gauge Theories", Phys. Rev. **D45**, 4632-4639. (C1)
8. R. Kobes (1992), "Feynman Rules for Response Functions at Thermal Equilibrium", Phys. Rev. **B45**, 3230-3235. (C1)
9. R. Kobes (1992), "Comment on: Causal Structure of the Thermal Propagator in Real Time Formalisms", Z. Phys. **C53**, 537. (C1)
10. R. Kobes (1991), "Three-Point Function at Finite Temperature in the Real Time Formalism", Phys. Rev. Lett. **67**, 1384-1387. (C1)
11. R. Kobes, G. Kunstatter and A. Rebhan (1991), "Gauge Dependence Identities and Their Application at Finite Temperature", Nucl. Phys. **B355**, 1-37. (C1)
12. R. Kobes (1991), "Retarded Functions, Dispersion Relations, and Cutkosky Rules at Zero and Finite Temperature", Phys. Rev. **D43**, 1269-1282. (C1)

13. R. Kobes, G. Kunstatter and A. Rebhan (1990), "QCD Plasma Parameters and the Gauge Dependent Gluon Propagator", Phys. Rev. Lett. **64**, 2992-2995. (C1)

14. R. Kobes (1990), "Correspondence Between Imaginary Time and Real Time Finite Temperature Field Theory", Phys. Rev. **D42**, 562-572. (C1)

15. A. Burnel, R. Kobes, G. Kunstatter and K. Mak (1990), "Quantization of Yang-Mills Fields in a General Class of Linear Gauges", Ann. Phys. **204**, 247-280. (C1)

16. R. Kobes, G. Kunstatter and K. Mak (1989), "The Gluon Propagator in a Static Temporal Gauge at Finite Temperature", Phys. Lett. **B223**, 433-438. (C1)

17. R. Kobes, G. Kunstatter and K. Mak (1989), "Linear Response of the Hot QCD Plasma from the Gluon Propagator", Z. Phys. **C45**, 129-140. (C1)

18. R. Kobes and G. Kunstatter (1988), "Stability of Plasma Oscillations in Hot Gluonic Matter", Phys. Rev. Lett. **61**, 392-395. (C1)

19. R. Kobes, J. Whitehead and B. Yuan (1988), "A Calculation of the Critical Temperature of Metallic Superlattices", Phys. Lett. **A132**, 182-186. (C1)

20. R. Kobes and J. Whitehead (1988), "Free Energy Calculations in a Self-Consistent Model of the Proximity Effect", Phys. Rev. **B38**, 1268-1274. (C1)

21. 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)

22. 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)

23. 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)

24. 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)

25. 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)

26. 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)

27. R. Kobes and G. Kunstatter (1990), "Gluon Response Functions in Non-Standard Gauges", in *The Proceedings of the Vienna Conference on Physical and Non-Standard Gauges*, Lecture Notes in Physics **361**, pp. 272-284. (C3)

28. R. Kobes and G. Kunstatter (1989), "Gauge Dependence of the Damping Constant in Hot Gluonic Matter", in *The Proceedings of the 1st Workshop on Thermal Field Theories and Their Applications*, Physica **A158**, 192-200. (C3)

29. W. Keil and R. Kobes (1989), "Mass and Wave Function Renormalization at Finite Temperature", in *The Proceedings of the 1st Workshop on Thermal Field Theories and Their Applications*, Physica **A158**, pp. 47-58. (C3)

30. R. Kobes, G. Kunstatter and D. Toms (1989), "The Vilkovisky-DeWitt Effective Action: Panacea or Placebo", in *TEV Physics: Proceedings of the Johns Hopkins Workshop in Particle Theory 12*, eds. G. Domokos and S. Kovesi-Domokos (World Scientific, Singapore), pp. 73-111. (C3)

G. Kunstatter

1. D. Louis-Martinez and G. Kunstatter, "2-D Dilaton Gravity Coupled to an Abelian Gauge Field", Phys. Rev. **D52**, 3494-3505, 1995. (C1)
2. M. Carrington and G. Kunstatter, "Maxwell Chern Simons Theory with Magn etic Moment Interactions", Phys. Rev. **D52**, 1903-1905 (1995).(C1)
3. R. Epp and G. Kunstatter, "Dirac vs. Reduced Quantization of the Poincare Symmetry in Scalar Electrodynamics", Phys. Rev. **D51**, 781-789 (1 995).(C1)
4. J. Gegenberg, G. Kunstatter and D. Louis-Martinez, "Observables for 2-D Black Holes", Phys. Rev. **D51**, 1781-1786, (1995). (C1)
5. P.F. Kelly, R.L. Kobes and G. Kunstatter, "Parametrization invariance and the Resolution to the Unitary Gauge Puzzle", Phys. Rev. **D51** (1995). (C1)
6. J. Gegenberg, D. Louis-Martinez and G. Kunstatter, "Classical and Quantum Mechanics of Black Holes in Generic 2-D Dilaton Gravity" in *Proceedings of the Conference on Heat Kernel techniques and Quantum Gravity (Discourses in Mathematics and its Applications)*, Texas A&M University Press, 1995) ed. S. Fulling.(C3)
7. M.E. Carrington and G. Kunstatter (1994), "Massless Scalar QED with Non-Minimal Chern-Simons Coupling", Phys. Rev. **D**, in press. (C1)
8. D. Louis-Martinez, J. Gegenberg and G. Kunstatter (1994), "Exact Dirac quantization of all 2D dilaton gravity theories", Phys. Lett. **B321**, 193-198. (C1)
9. D. Louis-Martinez and G. Kunstatter, "Birkhoff's theorem in two-dimensional dilaton gravity", Phys. Rev. **D49**, 5227-5230. (C1) (1994).
10. 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)
11. J. Gegenberg and G. Kunstatter (1994), "Partition Function for Topological Field Theories' , Annals of Physics **231**, 270-289. (C1)
12. J. Gegenberg and G. Kunstatter (1993), "Quantum Theory of Black Holes", Phys. Rev. (Rapid Comm.) **D47**, R4192-4195. (C1)
13. R. Epp, G. Kunstatter and D.J. Toms (1993), "Path Integral Quantization of Scalar QED", Phys. Rev. **D47**, 2474-2482. (C1)
14. G. Kunstatter (1992), "Dirac vs. Reduced Quantization: A Geometrical Approach", Class. Qu. Grav. **9**, 1469-1485. (C1)
15. R. Kobes, G. Kunstatter and K. Mak (1992), "Fermion Damping in Hot Gauge Theories", Phys. Rev. **D45**, 4632. (C1)
16. R. Baier, G. Kunstatter and D. Schiff (1992), "High Temperature Fermion Damping Rate: Resummation and Gauge Independence", Phys. Rev. **D45**, R4381-R4384. (C1)
17. R. Baier, G. Kunstatter and D. Schiff (1992), "Gauge Dependence of the Thermal Gluon Self Energy", Nucl. Phys. **B388**, 287-314. (C1)
18. R. Kobes, G. Kunstatter and A. Rebhan (1991), "Gauge Dependence Identities and their Application at Finite Temperature", Nucl. Phys. **B355**, 1-37. (C1)
19. 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)

20. A. Burnel, R. Kobes, G. Kunstatter and K. Mak (1990), "Quantization of Yang-Mills Theories in a General Class of Linear Gauges", Annals of Physics **204**, 247-280. (C1)

21. R. Kobes, G. Kunstatter and A. Rebhan (1990), "QCD Plasma Parameters and the Gauge Dependent Gluon Propagator", Phys. Rev. Lett. **64**, 2992-2995. (C1)

22. J. Gegenberg, G. Kunstatter and H.P. Leivo (1990), "Topological Matter Coupled to Gravity in 2+1 Dimensions", Phys. Lett. **B252**, 381-386. (C1)

23. R. Kobes, G. Kunstatter and K. Mak (1989), "The Gluon Propagator in a Static Axial Gauge at Finite Temperature", Phys. Lett. **B223**, 433-438. (C1)

24. R. Kobes, G. Kunstatter and K. Mak (1989), "Linear Response of the Hot QCD Plasma from the Gluon Propagator," Z. für Physik **C45**, 129-140. (C1)

25. J. Gegenberg, P.K. Kelly, G. Kunstatter, R.B. Mann, R. McArthur and D. Vincent (1989), "Classical and Quantum Properties of Algebraically Extended Bosonic Sigma Models", Phys. Rev. **D40**, 1919-1924. (C1)

26. P. Ellicott, G. Kunstatter and D.J. Toms (1989), "Geometrical Derivation of the Faddeev-Popov Ansatz", Mod. Phys. Letts. **4**, 2397-2407. (C1)

27. J. Gegenberg and G. Kunstatter (1989), "The Conformal Anomaly and One-Loop Effective Action in a Midisuperspace Model", Phys. Lett. **B233**, 331-335. (C1)

28. D. Evens and G. Kunstatter (1988), "Hamiltonian Analysis of Topologically Massive Yang-Mills Theory", Phys. Rev. **D37**, 435-440. (C1)

29. R. Kobes and G. Kunstatter (1988), "Stability of Plasma Oscillations in Hot Gluonic Matter", Phys. Rev. Lett. **61**, 392-395. (C1)

30. D. Evens and G. Kunstatter (1988), "Hamiltonian Analysis of Linearized Topologically Massive Gravity", Class. Qu. Gravity **5**, 1627-1645. (C1)

31. J. Gegenberg and G. Kunstatter (1993), "Exact Quantum Wave-Functionals for 2-D Black Holes", in *Proceedings of the 5th Conference on General Relativity and Gravitation*, ed. R. Mclenaghan (World Scientific), in press. (C3)

32. R. Epp and G. Kunstatter (1993), "Dirac vs. Reduced Quantization of Poincare Invariant Gauge Theories", in *Proceedings of the 5th Conference on General Relativity and Gravitation*, ed. R. Mclenaghan (World Scientific), in press. (C3)

33. 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)

34. 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)

35. 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)

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

37. 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)

38. 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)

39. 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)

40. 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)

41. 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)

42. J. Gegenberg, P.K. Kelly, G. Kunstatter, R.B. Mann, R. McArthur and D. Vincent (1990), "The Weyl Anomaly in Algebraically Extended Bosonic Sigma Models", in *Proceedings of the Third Canadian Conference on General Relativity and Relativistic Astrophysics*, eds. A. Coley, F. Cooperstock and B. Tupper (World Scientific, Singapore), pp. 127-131. (C3)

43. J. Gegenberg and G. Kunstatter (1990), "A Two-Dimensional Sigma Model for Conformally Invariant Spherically Symmetric Gravity", in *Proceedings of the Third Canadian Conference on General Relativity and Relativistic Astrophysics*, eds. A. Coley, F. Cooperstock and B. Tupper (World Scientific, Singapore), pp. 117-121. (C3)

44. R. Kobes and G. Kunstatter (1990), "Gluon Response Functions in Non-Covariant Gauges", Lectures Notes in Physics **361**, 272-284. (C3)

45. R. Kobes, G. Kunstatter and D.J. Toms (1989), "Vilkovisky DeWitt Effective Action: Panacea or Placebo", in *TEV Physics: Proceedings of the Johns Hopkins Workshop on Current Problems in Particle Theory*, eds. G. Domokos and S. Kovesi-Domokos (World Scientific, Singapore), pp. 73-110. (C3)

46. R. Kobes and G. Kunstatter (1989), "Gauge Dependence of the Gluon Plasma Damping Constant", in *Proceedings of the Workshop on Thermal Field Theories and Their Applications*, Physica **A158**, 1992-200. (C3)

47. J. Gegenberg, P.F. Kelly, R.B. Mann, R. McArthur, G. Kunstatter and D. Vincent (1989), "Non-linear Sigma Models with Generalized Geometry", in *Proceedings of the Fifth Marcel Grossman Meeting*, Perth, eds. D.G. Blair and M.J. Buckingham (World Scientific, Singapore), pp. 851-854. (C3)

48. 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)

49. 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)

P.D. Loly

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

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

3. 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)

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

5. S.C. Bell, P.D. Loly and B.W. Southern (1989), "Two-Magnon States of the Alternating Ferromagnetic Heisenberg Chain", J. Phys.: Condensed Matter **1**, 9899-9910. (C1)
6. 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 (with electronic supplement "Fermi.ma" on Mathsource)

T.A. Osborn

1. F.H. Molzahn and T.A. Osborn (1994), "Moyal Quantum Mechanics: The Semiclassical Content", [Proceeedings of the 4th Drexel Symposium on Quantum Nonintegrability: Quantum Classical Correspondence], in press. (C3)
2. T.A. Osborn and F.H. Molzahn (1994), "Moyal Quantum Mechanics: The Semiclassical Heisenberg Dynamics", Annals of Physics, Annals of Physics (NY). **241**, 79-127 (C1)
3. A.O. Barvinsky, T.A. Osborn and Yu.V. Gusev (1994), "Phase-space Technique for the Perturbation Expansion of Schrödinger Propagators", J. Math. Phys. (1994), in press. (C1)
4. F.H. Molzahn and T.A. Osborn (1994), "A Phase Space Fluctuation Method for Quantum Dynamics", Annals of Physics **230**, 343-394. (C1)
5. T.A. Osborn and F.H. Molzahn (1993), "Cluster WKB", in *Mathematical Quantum Theory: Schrödinger Operators*, eds. J. Feldman, R. Froese and L. Rosen, (Canadian Mathematical Society) Conference Proceedings, in press. (C3)
6. 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)
7. A. Saksena, T.A. Osborn and F.H. Molzahn (1991), "An Asymptotic Analysis of Quantum Evolution with Electromagnetic Fields", J. Math. Physics **32**, 938-955. (C1)
8. 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)
9. F.H. Molzahn, T.A. Osborn and S.A. Fulling (1990) "Gauge Invariant Asymptotic Expansion for Schrödinger Propagators on Manifolds", Annals of Physics **204**, 64-113. (C1)
10. R.A. Corns and T.A. Osborn (1990) "Representations of Relativistic Propagators for Systems with Non-Abelian Interactions", J. Math. Phys. **31**, 901-915. (C1)
11. J.P. Svenne, T.A. Osborn, G. Pisent and D. Eyre (1989), "Resonances and Time-Delay in Three-Body Scattering", Phys. Rev. **C40**, 1136-1146. (C1)
12. D. Bollé, C. Danneels and T.A. Osborn (1989) "Local and Global Spectral Shift Functions in R^2", J. Math. Phys. 30, 420-432. (C1)
13. J.P. Svenne, T.A. Osborn, G. Pisent and D. Eyre (1989), "Resonances and Time-Delay in Three-Body Scattering", contributed paper to Few Body XII, the 12th International Conference on Few Body Problems in Physics, Vancouver. (C3)

B.W. Southern

1. B.W. Southern and H-J. Xu (1995) "Monte Carlo Study of the Heisenberg Antiferromagnet on the Triangular Lattice", Phys. Rev. **B52**, R3836-R3839. (C1)
2. 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)
3. B.W. Southern and A.P. Young (1993) "Spin Stiffness in Frustrated Antiferromagnets", Phys. Rev. **B48**, 13170-13173. (C1)
4. 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)
5. B.W. Southern and Y. Achiam (1993), "Critical Dynamics of the D = 1 Kinetic Ising Model," J. Phys. A.: Math. Gen. **26**, 2505-2517. (C1)
6. 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)
7. 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)
8. 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)
9. 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)
10. A.J.M. Medved, B.W. Southern and D.A. Lavis (1991), "Two-Magnon States the Alternating-Bond Ferrimagnetic Chain", Phys. Rev. **B43**, 816-824. (C1)
11. A.J.M. Medved, B.W. Southern and D.A. Lavis (1991), "Two-Magnon States the Alternating-Bond Ferrimagnetic Chain", Phys. Rev. **B43**, 816-824. (C1)
12. S.C. Bell, P.D. Loly and B.W. Southern (1989), "Two-Magnon States of the Alternating Ferromagnetic Heisenberg Chain", J. Phys.: Condensed Matter **1**, 9899-9910. (C1)
13. S. Masui, T. Li, B.W. Southern and A.E. Jacobs (1989), "Metastable States of Ising Models on the Honeycomb Lattice", Phys. Rev. **B40**, 7096-7100. (C1)
14. B.W. Southern, T.S. Liu and D.A. Lavis (1989), "Scaling Approach to Two-Magnon Excitations in Quantum Spin Chains", Phys. Rev. **B39**, 12160-12164. (C1)
15. S. Masui, B.W. Southern and A.E. Jacobs (1989), "Metastable States of Ising Spin Glasses and Random Ferromagnets", Phys. Rev. **B39**, 6925-6933. (C1)

J.P. Svenne

1. L. Canton, G. Cattapan, P.J. Dortmans, G. Pisent, and J.P. Svenne (1995), "A meson-exchange isobar model for the $\pi^+ d \leftrightarrow pp$ reaction", submitted to Can. J. Phyiscs, revised November 1995. (C1)
2. G. Pisent and J.P. Svenne (1995), "Analysis of compound and quasicompound resonances in a multi-channel, finite-rank model", Phys. Rev. C **51**, 3211-3221. (C1)
3. 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. (C1)

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

5. M.B. Wango, J. Birchall, J.S.C. McKee and J.P. Svenne (1990), "Evidence for Three-Body Forces on p-d Breakup at 25 MeV?", Can. J. Phys. **68**, 1200-1202. (C1)

6. R. Abegg, M. Ahmad, D. Bandyopadhyay, J. Birchall, E. Cairns, K. Chantziantoniou, G.H. Coombes, C.A. Davis, N.E. Davison, P.P.J. Delheij, P.W. Green, L.G. Greeniaus, H.P. Gubler, D.C. Healey, C. Lapointe, W.P. Lee, W.J. McDonald, C.A. Miller, G.A. Moss, S.A. Page, G.R. Plattner, P.R. Poffenberger, W.D. Ramsay, N.L. Rodning, G. Roy, J. Soukup, J.P. Svenne, R.R. Tkachuk, W.T.H. van Oers, G.D. Wait, J.W. Watson, Y. Ye and Y.P. Zhang, "np Elastic Scattering Analyzing Power Characteristics at Intermediate Energies", Phys. Rev. C **40**, 2406-2409. (C1)

7. J.P. Svenne, T.A. Osborn, G. Pisent and D. Eyre (1989), "Resonances and Time-Delay in Three-Body Scattering", Phys. Rev. **C40**, 1136-1146. (C1)

8. R. Abegg, D. Bandyopadhyay, J. Birchall, E. Cairns, H. Coombes, C.A. Davis, N.E. Davison, P.P.J. Delheij, P.W. Green, L.G. Greeniaus, H.P. Gubler, D.C. Healey, C. Lapointe, W.P. Lee, W.J. McDonald, C.A. Miller, G.A. Moss, G.R. Plattner, P.R. Poffenberger, W.D. Ramsay, G. Roy, J. Soukup, J.P. Svenne, R. Tkachuk, W.T.H. van Oers, G.D. Wait and Y.P. Zhang (1989), "Charge Symmetry Breaking in np Elastic Scattering at 477 MeV", Phys. Rev. D **39**, 2464-2483. (C1)

9. 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)

10. G. Cattapan, L. Canton, G. Cattapan, P.J. dortmans, G. Pisent, and J.P. Svenne (1991), "Pion absorption in few-nucleon systems", invited paper in *Perspectives in Theoretical Nuclear Physics. Proceedings of the "V Convengo su problemi di fisica teorica" EIPC*, Cortona, Italy (ETS, Pisa), A. Bonaccorso, *et al* eds., pp. 217-226. (C3)

11. G. Cattapan, L. Canton, G. Pisent, G.H. Rawitscher, J.P. Svenne (1991), "Few-Body Aspects of Pion Absorption on A=3 Nuclei", in *Perspectives in Theoretical Nuclear Physics. Proceedings of the "IV Convengo su problemi di fisica teorica" EIPC*, Marciana Martina, Italy (ETS, Pisa), pp. 170-179. (C3)

12. L. Canton, G. Cattapan, G. Pisent and J.P. Svenne (1991), "Few-Body Dynamics in Pion Absorption on ^{3}He", contributed paper to *Workshop on Mathematical Aspects of Quantum Scattering Theory and Applications*, (St. Petersburg, Russia). (C3)

13. J.P. Svenne, T.A. Osborn, G. Pisent and D. Eyre (1989), "Resonances and Time-Delay in Three-Body Scattering", contributed paper to *Few Body XII, the 12th International Conference on Few Body Problems in Physics*, Vancouver. (C3)

J.M. Vail

1. T. McMullen, J. Meng, J.M. Vail, and Jena,P.(1995), 'Quantum Diffusion of Muonium in Alkali Halides' Physical Review **B51**,pp. 15879-15884.(C1)

2. 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)

3. 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, editor (Nova Science Publishers, Commack NY, in press, accepted November 30, 1993). (E2)

4. J.M. Vail.,(1995), 'Embedding Theory and Quantum Cluster Simulation of Point Defects in Ionic Crystals' , invited review, in Fundamentals Materials Science, series ed. M.F. Thorpe, Vol. 1, Electronic Properties of Solids Using Cluster Methods, ed. T.A. Kaplan and S.D. Mahanti,12 pages (Plenum Press, NY, in press, accepted Oct. 1994). (D)

5. 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)

6. J.M. Vail, T. McMullen, and J. Meng (1994), "Electronic-Structure Determination of Light Impurity-Phonon Interaction in Solids", Phys. Rev. **B49**, 193-200. (C1)

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

8. 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**. pp.7649-7656. (C1)

9. J.M. Vail, B.K.. Rao, (1993),' A Method for the Simulkation 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)

10. 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)

11. 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)

12. 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)

13. 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)

14. J. Meng, P. Jena and J.M. Vail (1990), "Hole Trapping in $Li_xNi_{1-x}O$", Journal of Physics: Condensed Matter **2**, 10371-10377. (C1)

15. J. Meng, J.M. Vail, A.M. Stoneham and P. Jena (1990), "Charge-State Stability of Ni and Cu Impurities in MgO", Phys. Rev. **B42**, 1156-1162. (C1)

16. J.M. Vail (1990), "Theory of Electronic Defects: Applications to MgO and Alkali Halides", invited paper, Journal of Physics and Chemistry of Solids **51**, 589-607. (D)

17. J.M. Vail (1989), "Boundary Conditions for Quantum Clusters Embedded in Classical Ionic Crystals", American Society of Metals-World Materials Congress, Chicago, September 25-30, 1988: *Atomistic Simulation of Materials: Beyond Pair Potentials*, Edited by V. Vitek and D.J. Srolovitz, Plenum Press, pp. 239-244. (C3)

18. J. Meng, R. Pandey, J.M. Vail and A.B. Kunz (1989), "Impurity Potentials Derived from Embedded Quantum Clusters: Ag^+ and Cu^+ Transport in Alkali Halides", Journal of Physics: Condensed Matter **1**, 6049-6057. (C1)

19. R. Pandey and J.M. Vail (1989), "F-Type Centers and Hydrogen Anions in MgO: Hartree-Fock Ground States", Journal of Physics: Condensed Matter **1**, 2801-2820. (C1)

D. Vincent

1. J. Gegenberg, P.K. Kelly, G. Kunstatter, R.B. Mann, R. McArthur and D. Vincent (1989), "Classical and Quantum Properties of Algebraically Extended Bosonic Sigma Models", Phys. Rev. **D40**, 1919-1924. (C1)

2. J. Gegenberg, P.K. Kelly, R.B. Mann, and D. Vincent (1990), "Non-Riemannian Spacetime and the Nonlinear Sigma Model", in *Proceedings of the Third Canadian Conference on General Relativity and Relativistic Astrophysics*, eds. A. Coley, F. Cooperstock and B. Tupper (World Scientific, Singapore) pp. 122-126. (C3)

3. J. Gegenberg, P.K. Kelly, G. Kunstatter, R.B. Mann, R. McArthur and D. Vincent (1990), "The Weyl Anomaly in Algebraically Extended Bosonic Sigma Models", in *Proceedings of the Third Canadian Conference on General Relativity and Relativistic Astrophysics*, eds. A. Coley, F. Cooperstock and B. Tupper (World Scientific, Singapore) pp. 127-131. (C3)

4. J. Gegenberg, P.K. Kelly, R.B. Mann, R. McArthur and D. Vincent, (1990), "Two-Dimensional Gravity", in *Proceedings of the XIth Warsaw Symp. on Elem. Particle Physics*, eds. Z. Adjuk et al., (World Scientific, Singapore), pp. 57-63. (C3)

5. J. Gegenberg, P.F. Kelly, R.B. Mann, R. McArthur, G. Kunstatter and D. Vincent (1989), "Non-linear Sigma Models with Generalized Geometry", in *Proceedings of the Fifth Marcel Grossman Meeting*, Perth (1988), eds. D.G. Blair and M.J. Buckingham, (World Scientific, Singapore), pp. 851-854. (C3)

J.G. Williams

1. 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)

2. 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)

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

4. J.G. Williams (1994), "(2+1)-Dimensional Spacetime with Rotation and Expansion", Gen. Rel. Grav. **26**, 499-512. (C1)

5. J.G. Williams (1994), "Topologically Massive Gravity with a Two-Fluid Source", Phys. Rev. **D49**, 1117-1119. (C1)

6. J.G. Williams (1992), "Rotating Charged Fluid in 2+1 Dimensions", Gen. Rel. Grav. **24**, 1083-1090. (C1)

7. 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)

8. 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)

9. J.G. Williams, K.A. Dunn and T.A. Harriott (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)

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

11. J.G. Williams, K.A. Dunn and T.A. Harriott (1992), "Toy Model for Gravitational Kinks", J. Math. Phys. **33**, 1437-1444. (C1)

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

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

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

15. J.G. Williams and P. Zvengrowski (1990), "Homotopy and Lorentz metrics in 2 + 1 dimensions", in *Proceedings of the 3rd Canadian Conference on General Relativity and Relativistic Astrophysics*, edited by A.A. Coley, F.I. Cooperstock and B.O.J. Tupper (World Scientific, Singapore), pp. 364-367. (C3)

16. J.G. Williams and T.A. Harriott (1989), "Imperfect fluid solution for a kinked metric", in *Proceedings of the Fifth Marcel Grossmann Meeting on General Relativity*, edited by D.G. Blair and M.J. Buckingham, (World Scientific, Singapore), pp. 395-398. (C3)

17. J.G. Williams and T.A. Harriott (1989), "Homotopically nontrivial solutions for a spherically symmetric gravitational field", Int. J. Theor. Phys. **28**, 511-525. (C1)

18. J.G. Williams and K.A. Dunn (1989), "De Sitter kinks", J. Math. Phys. **30**, 87-89. (C1)

C.H. Woo

1. F.A. Garner, M.L. Grossbeck and C.H. Woo (1994), "The Relative Roles of He/dpa Ratio and Displacement Rate on Irradiation Creep of Austenitic Steels", ASTM STP, in press. (C1)

2. F.A. Garner, M.B. Toloczko and C.H. Woo (1994), "A Reinterpretation of Irradiation Creep Data from Pressurized Tubes that Resolves Some Previously Unexplained Mysteries", J. Nucl. Materials, in press. (C1)

3. C.H. Woo (1994), "Correlation Between Void-Swelling and SIPA Creep", J. Nucl. Materials, in press. (C1)

4. C.N. Tome, N. Christodoulou, R. Holt, C.H. Woo, R.A. Lebenson, P.A. Turner (1994), "Deconvolution of Experimental Data of Aggregates Using Self-Consistent Polycrystal Models", in *Numerical Predictions of Deformation Processes and the Behaviour of Real Materials*, eds. S.I. Anderson and J.B. Bilde-Sorenson, pp. 169-204. (C3)

5. H. Trinkaus, V. Naundorf, B.N. Singh, C.H. Woo (1994), "On the Experimental Determination of the Migrating Defect Fraction Under Cascade Damage Conditions", J. Nucl. Materials **210**, 244. (C1)

6. B.N. Singh, H. Trinkaus and C.H. Woo (1994), "Production Bias and Interstitial Removal: Why Necessary?", J. Nucl. Materials, in press. (C1)

7. H. Trinkaus, B.N. Singh and C.H. Woo (1994), "Defect Accumulation Under Cascade Damage Conditions", J. Nucl. Materials, in press. (C1)

8. A.A. Semenov and C.H. Woo (1994), "Void Swelling and Spatial Heterogeneity in Microsrtucture Evolution in Pure metals at Very Low Irradiation Doses", J. Nucl. Materials, in press. (C1)

9. C.H. Woo (1994), "Irradiation Creep and Growth Under Cascade Damage Conditions", Phil. Mag., in press. (C1)

10. P.A. Turner, C.N. Tome and C.H. Woo (1994), "Self-consistent Modeling of Textured Anisotropic Visco-Elastic Polycrystal", in *Proceedings of the 4th International Symposium on Plasticity*, Baltimore, June 1993, in press. (C3)

11. P.A. Turner, C.N. Tome and C.H. Woo, "Self-consistent Modeling of Visco-Elastic Polycrystal— An Appriximate Scheme", Phil. Mag., in press. (C1)

12. M. Griffith, R.C. Styles, C.H. Woo, F. Phillipp and W. Frank (1994), "Study of Point Defect Mobilities in a Zirconium by Direct Observation of Dislocation Climb and Cavity Growth During Electron Irradiation in a HVEM", J. Nucl. Materials **208**, 324. (C1)

13. C.H. Woo, A.A. Semenov and B.N. Singh (1993), "Analysis Of Microstructural Evolution Driven By Production Bias" J. Nucl. Materials **206**, 170. (C1)

14. A.A. Semenov and C.H. Woo (1993), "Stochastic Fluctuations And Microstructural Evolution During Irradiation By Neutron And Heavy Ions", J. Nucl. Materials **205**, 74. (C1)

15. C.H. Woo and A.A. Semenov (1993), "Dislocation Climb and Interstitial Loop Growth under Cascade damage Irradiation", Phil. Mag. **A67**, 1247. (C1)

16. N. Christodoulou, A.R. Causey and C.H. Woo, (1993), "Modeling the Effect of texture and Dislocation Structure on Irradiation Creep of Zr Alloys", ASTM STP **1197**, 1111. (C1)

17. R.A. Holt, C.H. Woo and C.K. Chow (1993), "Production Bias: A Potential Driving Force for Irradiation Growth", J. Nucl. Materials, in press. (C1)

18. C.H. Woo, F.A. Garner and R.A. Holt (1993), "Irradiation Creep due to SIPA in the Peak Swelling Regime", ASTM STP **1175**, 27. (C1)

19. C.N. Tomé, C.B. So and C.H. Woo (1993), "Self-Consistent Calculation of Steady-State Creep and Growth in Textured Zirconium", Phil. Mag. **A67**, 917. (C1)

20. C.H. Woo, A.R. Causey and R.A. Holt (1993), "Measurement and Analysis of Irradiation Creep in Non-Cubic Metals", Invited article for "Irradiation Creep", volume of Diffusion and Defect Data-Solid State Data, in press. (B)

21. C.H. Woo (1993), "The Effects of Stress and Point Defect Kinetics in Irradiated Metals", Invited article for "Irradiation Creep", volume of Diffusion and Defect Data-Solid State Data, in press. (C1)

22. B.N. Singh and C.H. Woo (1992), "Collision Cascades and Defect Accumulation During Irradiation", in *Materials Modeling: from Theory to Technology*, (Institute of Physics Publishing, Bristol and Philadelphia), p. 117. (C3)

23. C.H. Woo, R.A. Holt and M. Griffith (1992), "Anisotropic Diffusion of Point Defects: Effects on Irradiation Deformation", in *Materials Modeling: from Theory to Technology*, (Institute of Physics Publishing, Bristol and Philadelphia), p. 55. (C3)

24. C.H. Woo, B.N. Singh and F.A. Garner (1992), "Production Bias, A New Driving Force for Void Swelling Under Cascade Damage Conditions", J. Nucl. Materials **191-194**, 1224. (C3)

25. C.H. Woo and F.A. Garner (1992), "A SIPA-Based Theory of Irradiation Creep in The Low-Swelling Rate Regime", J. Nucl. Materials **191-194**, 1309. (C1)

26. B.N. Singh and C.H. Woo (1992), "Role of Interstitial Clustering and Production Bias in Defect Accumulation During Irradiation at Elevated Temperatures", (Invited paper, International Conference on physics of Irradiation Effects in Metals, Siofolk, Hungary, 1991) Mater. Sci. Forum **97-99**, 75. (C3)

27. C.H. Woo and B.N. Singh (1992), "Production Bias Due to Clustering of Point Defects in Irradiation-Induced Cascades", Phil. Mag. **A65**, 889. (C1)

28. C.H. Woo (1992), "Rate Theory Analysis of Radiation Damage Effects Near Surfaces in Hexagonal Metals", Phil. Mag. **63**, 915. (C1)

29. C.H. Woo, B.N. Singh and H.L. Heinish (1991), "Diffusion Based Evaluation of Defect Processes in Cascade Zones", presented at International Conference of Fusion Materials, Kyoto, December 1989, J. Nucl. Mat. **179**, 951. (C3)

30. C.H. Woo and B.N. Singh (1990), "The Concept of Production Bias and its Possible Role in Defect Accumulation Under Cascade Damage Conditions", Phys. Stat. Sol. **B159**, 609. (C1)

31. C.H. Woo, B.N. Singh and H.L. Heinisch, (1990), "A Diffusion Approach to Modelling Irradiation Damage Cascades", Invited article presented at Silkeborg Workshop on "Radiation Damage Correlation for Fusion Conditions", J. Nucl. Materials **174**, 190. (C1)

32. R. Dutton and C.H. Woo (1989), "Irradiation-Induced Deformation in CANDU Fuel Channels", in *Proceedings CNS 10th Annual Conference*, **4**, 1. (C3)

J.A. Zuk

1. I.J.R. Aitchison, C.D. Fosco and J.A. Zuk (1993), "Temperature Dependence of the Induced Chern-Simons Term in 2+1 Dimensions", Phys. Rev. D48, 5895-5904. (C1)

2. J.A. Zuk (1992), "Cooperons from Statistical Scattering Theory, with Application to the Disordered Ring", Phys. Rev. **B45**, 8952-8969. (C1)

3. J.A. Zuk (1992), "Eigenvalue Problem for Tridiagonal Matrices Arising in the Scattering Theory Analysis of Disordered Conductors", Can. J. Phys. **70**, 257-267. (C1)

4. I. Adjali, I.J.R. Aitchison, and J.A. Zuk (1992), "The Two-Point Approximation for the Casimir Energy in the Self-Consistent Chiral Soliton Model of the Nucleon", Nucl. Phys. **A357**, 457-485. (C1)

5. J.A. Zuk and I. Adjali (1992), "On the Two-Point Approximation to the Effective Chiral Action for Large Solitons", Int. J. Mod. Phys. **A7**, 3549-3565. (C1)

6. G. Chanfray, H.J. Pirner, and J.A. Zuk (1991), "Chiral Symmetry Breaking in the Colour Dielectric Model", Z. für Phys. **A339**, 503. (C1)

7. J.A. Zuk (1991), "Regularization of the Vacuum Energy in the Chiral Soliton Model as an Energy-Eigenvalue Sum", Phys. Rev. **D43**, 1358. (C1)

8. I. Adjali, I.J.R. Aitchison, and J.A. Zuk (1991), "On an Approximation for Casimir Energies, with Application to the Self-Consistent Soliton of the Effective Chiral Action", Phys. Lett. **B256**, 497. (C1)

9. J.A. Zuk (1990), "Asymptotic Behaviour of the Vacuum Energy for Small Skyrmions", Int. J. Mod. Phys. **A5**, 3549. (C1)

10. S. Iida, H.A. Weidenmüller and J.A. Zuk (1990), "Statistical Scattering Theory, the Supersymmetry Method and Universal Conductance Fluctuations", Annals of Physics **200**, 219. (C1)

11. S. Iida, H.A. Weidenmüller and J.A. Zuk (1990), "Wave Propagation Through Disordered Media and Universal Conductance Fluctuations", Phys. Rev. Lett. **64**, 583. (C1)

5 Financial

5.1 Statement of Income and Expenditures

Income

Income Source	Amount
University of Manitoba	
Carry over from Aug. 31, 1994	$11,913.52
Faculty of Science	$5,000
University of Winnipeg	
Carry over from Aug. 31, 1994	$2189.32
Total Funds That Were Available	$19102.84

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 University of Manitoba members draw upon approximately $125,000 of individual NSERC funds while the University of Winnipeg members draw upon approximately $91,000. These NSERC funds have a nontrivial fortifying effect on the level of activities that we engage in.

Expenditures

Activity	Particulars	Amount Spent
Seminars		
	(1) Dan Neuhauser, Oct. 20, 1994	$1,061.00UM
	(2) Dr. T. Steele, Nov._17,1994	$516.02UW
	(3) Olof Riska, Nov. 22, 1994	$942.40UM
	(4) C.P. Burgess, Nov. 24, 1994	$570.34UW
	(5) S. Raj Vatsya, March 7, 1995	100% Paid by sponsor
	(6) Olleg Soloviev, March 28, 1995	$1,035.21UM
	(7) Dr. E. Martinez	$618.17UW
	(8) B.K. Rao, July 26, 1995	$946.82UM
	(9) Tim Evans, Sept. 12, 1995	$273.60UW
	(10) Mikhail Karasev, Sept. 14, 1995	$1,207.52UM
	Total Seminar Costs (UofM funds)	$5,192.95UM
	Total Seminar Costs (UofW funds)	$1978.13UW
Conferences		
Heat Kernel Conference (Summer 1994)		
	(1) Hotel rooms	$1,550.21UM
	(2) Conference rooms	$1,999.40UM
	(3) Advances to speakers	$1,360.00UM
	(4) Supplies, printing	$266.84UM
	Total Conference Expenses	$5,176.45UM
	Minus Conference Income	-$3640
	Net Cost To WITP	$1,536.45UM
Miscellaneous	FAX, mail, printing, supplies	$953.29UM
	Total Expenditures (1994-1995)	
	U of M funds (to Sept. 15/95)	$7682.69UM
	U of W funds (to Sept. 15/95)	$1978.13UW
	Grand Total	$9660.82

The Institute had no endowment and/or 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 University of Winnipeg and the University of Manitoba. 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, Growth, etc.

The Institute has no substantial fixed costs and for this reason it is an intrinsically stable entity. 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 top notch 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 only upon the associate members (i.e. graduate students, postdoctoral fellows, research associates, etc.) that it can attract. The number and quality of these associate members is entirely dependent on the positive research atmosphere that we can create. This in turn depends highly upon the level of funding that the Institute receives.

The report guidelines suggest that we indicate the percentage of time the 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 approximately 5% of his time with the administrative aspects of the Institute.