The Winnipeg Institute for Theoretical Physics[1] Annual Report

September 2001 – August 2002

[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 and by financially supporting workshops, visiting colloquium speakers, and short and long term visits by research collaborators of international standing. The thirteen permanent members of this Institute are drawn from the University of Manitoba, the University of Winnipeg, and Brandon University.

The past year was the eleventh year of the Institute's existence. There were research colloquia by out-of-province visitors. Associated with the Permanent Members were research associates, postdoctoral fellows, and graduate students.

For the 2000-2001 academic year, the list of invited speakers is found in section 4.1. Visiting scientists whose stay lasted longer than one week are listed in section 4.2. The cumulative list of graduate degrees awarded appears in section 4.3, and the published research work of associate members/graduate students and of members are found, respectively, in sections 4.4 and 4.5. The total number of publications by full members listed in section 4.5 is 38 for 2000-2002. 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, 2001 to August 31, 2002. The plans for the coming year include a program of invited speakers, visiting research collaborations, and the promotion of postgraduate and postdoctoral research.

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

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

2 Current List of Members (September, 2002)

2.1 Permanent Members

- B. Bhakar[1], *Ph.D. (Delhi)* [Director, Jan - June 2000]
- P.G. Blunden[1], *Ph.D (Queen's)* [Director, 93-94]
- M.E. Carrington[3], *Ph.D. (SUNY, Stony Brook)*
- R.L. Kobes[2], *Ph.D. (Alberta)* [Director,97-98]
- G. Kunstatter[2], *Ph.D. (Toronto)* [Director, 91-92]
- P.D. Loly[1], *Ph.D. (London)* [Director, Fall 99, Acting Director July 2000 - October 2001]
- T.A. Osborn[1], *Ph.D. (Stanford)* [Director, 92-93, 02-03]
- B.W. Southern[1], *Ph.D. (McMaster)* [Director, 90-91]
- J.P. Svenne[1], *Ph.D. (M.I.T.)* [Director, 95-96]
- G.C. Tabisz[1], *Ph.D. (Toronto)*
- J.M. Vail[1], *Ph.D. (Brandeis)* [Director, 98-99]
- D.W. Vincent[2], *Ph.D. (Toronto)* [Director, 94-95]
- J.G. Williams[3], *Ph.D. (Birmingham)* [Director, 96-97]

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

2.2 Associate Members

Research Associates

- Ruth E. Cameron B.Sc. (Manitoba), M.Sc. (Rochester), Ph.D(Rochester)
- Qiu Qingchun, Shantou University, Shantou, PR China
- Xu Yan, Lanzhou University, Lanzhou, PR China
- Wang Zhoufei, Northeast Normal University, Changchun, PR China

Postdoctoral Fellows

- Weixing Qu (Tabisz) 2001 -present
- S. Bekhechi (Southern) 2001-present
- D. Ahrensmeier, (shared with R. Kobes and M. Carrington) Feb. '02-Dec. '02.
- H. Zaratek, (shared with R. Kobes and M. Carrington) Feb. '02–Sept. '02
- W. Chen, (shared with R. Kobes) Sept. 2002- Nov., 2002

2.3 Graduate Students

- A. J. Penner (M.Sc.) *(Kobes)*
- Aleksandrs Alexsejevs (M.Sc.) *(Blunden)*
- Svetlana Barkanova (Ph.D.) *(Blunden)*
- Jason Bland (Ph.D.) *(Kunstatter)*
- Amra Peles (Ph.D.), *(Southern)*
- J. Medved (Ph.D.), *(Kunstatter)* GRADUATED 2000
- T. Melde (Ph.D.), *(Svenne)* GRADUATED 2001
- Slaven Peles (Ph.D.), *(Kobes)* GRADUATED 2001

2.4 Summer Undergraduate Research Students 2001-2002

- D. Irvine, *(Carrington)*
- C. Palmer, *(Carrington)*
- J. Kettner, *(Kunstatter)*
- B. Preston, *(Kunstatter)*
- M. Birukou, *(Kunstatter)*
- S. Russell, *(Southern)*
- A. Yang, *(Vail)*
- O. Penner, *(Vail)*

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

For several years I have been increasingly interested in the dialogue between Carl Gustave Jung and Wolfgang Pauli (Nobel Laureate in Physics in 1945 for discovering the exclusion principle in 1924, and a key contributer to the foundations of quantum physics). Recently Pauli's scientific correspondence in the period 1950-1952 has been published (in German) and I am studying how this dialogue, an intriguing book by their colleague Marie-Louise von Franz ("Number and Time"), and the evident influence on a number of physicists (including Nobel Laureates Maurice Wilkins and Alex Müller) fits with a binary-geometric multi-dimensional classification scheme that I have discovered (talks given in Munich in 1998, and to selected high school mathematics students under the auspices of the Institute for Industrial Mathematics from 1995-99. There is much promise in this dialogue for incorporation into a variety of courses. I can report one surprising outcome this work, namely the discovery of a family of square binary-logic matrices in which all "pandiagonals" have the same sum, but which are not the magic squares which had been expected.

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 use analogues of the Kronig-Penney potential to study bandstructures of mesoscopic ultrasmall quantum box structures now etched routinely in AlGaAs in semiconductor heterostructures, as an application of our multi-dimension nearly-free-electron code. The programs developed can also be applied to photonic band gap questions.

We take into account realistic band structure effects (e.g. van Hove singularities) that are particularly important in optical processes, especially in my own forte of 2-magnon spectra. Using a Green's function formalism that is rigorous and applicable across ALL dimensions of practical interest we have found a significant interplay between the band singularities and continuum resonances which helps determine resonant frequencies and thus afford a new spectroscopy. The 2D calculations use our linear-analytic triangular scheme for 2D. I also have direct experience of methods restricted to 1D: alternating bond chain using real space rescaling and a continuing study with the Bethe Ansatz.

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 numerical computation of all observables of interest: scattering amplitudes, stress energy tensors, etc. Recent works have concentrated on the development of quantum phase space theories and the semiclassical dynamics embedded within them. A quantum phase space is an altered version of classical phase space in which the usual product of functions is replaced by a noncommutative (star) product, whose small $\hbar$ asymptotic expansion is the Poisson bracket. With this one structural modification, it is possible to state all of quantum mechanics as a phase space theory. The goal of constructing a gauge invariant quantum phase space (in the context of linear phase spaces) has been achieved in joint work with M. V. Karasev. The extensions of this theory to non-Abelian gauge theories supported on curved space time manifolds is the main focus of ongoing research.

B.W. Southern

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

J. P. Svenne

Our current work, 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 TRIUMF), focuses on pion absorption on very light nuclei. The work on pion absorption is proceeding 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 included.

The second line of inquiry is further to develop the complete coupled three-body to four-body theory of the $\pi NNN - NNN$ system, for which a definitive publication has now been published by Luciano Canton, a member of the collaboration: Phys. Rev. **C58**, 3121 (1998). 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 have been developed for a simplified, perhaps schematic, model. This could be useful in deriving methods for treating more realistic problems. Current work has indicated an interesting link between this theory and three-nucleon forces, which leads to new results in describing three-nucleon observables.

Finally, in a separate collaboration with Drs. L. Canton, G. Pisent (Padova), K. Amos and P.J. Dortmans (Melbourne), 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, local phonon mode frequencies, and classical and quantum diffusion.

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

D.W. Vincent

My general research interests lie in gravitation theory and early universe cosmology. I am currently involved with calculations on multidimensional cosmology solutions of Einstein's equations, which have relevance to the cosmological constant problem, the Anthropic Principle, and the Many-Worlds approach to quantum cosmology .

J.G. Williams

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

4 Research Activities

4.1 Seminars

Date	Speaker	Institution	Title
Oct. 24, 2001	Dr. Raymond Laflamme	University of Waterloo	Quantum Information Processing
March 25, 2002	Dr. Slaven Peles	Georgia Institute of Technology	Symbolic Analysis of Chaotic Systems
May 1, 2002	Dr. Howard Burton	Perimeter Institute for Theoretical Physics	An Overview of the Perimeter Institute

4.2 Visiting Scientists

Dates	Visitor	Institution
Sept. 2001	Prof. Wang Zhoufei	Northeast Normal University, China
Oct. - Dec. 2001	Prof. M. V. Karasev	Moscow Institute for Mathematics and Electronics

4.3 Graduate Degrees Supervised

1. J. Medved (2000), "Thermodynamics of Charged Black Holes in Two-Dimensional Gravity". Ph.D. thesis, University of Manitoba, 2001. (University Microfilms)
2. S. Peles (2001), "Nonlinear Phenomena and Chaos in Periodically Driven Classical Systems". Ph.D. thesis, University of Manitoba, 2001. (University Microfilms)
3. T. Melde (2001), "The Three Nucleon System including one Dynamical Pion: A one dimensional test case". Ph.D. thesis, University of Manitoba, May 2001. (University Microfilms)

4.4 Publications of Associate Members/Graduate Students

T. Melde

1. Pion Dynamics in the Three-Nucleon System, Juris P. Svenne, Thomas Melde and Luciano Canton, contributed paper to the 2nd World Congress of Latvian Scientists, Riga, Latvia, August 14-15, 2001 (paper delivered orally in Latvian). (C3)
2. Meson Dynamics and the resulting "3-Nucleon Force" diagrams: Results from a simplified test case. L. Canton, T. Melde and J.P. Svenne, contributed paper to "Mesons and Light Nuclei" conference, Prague, Czech Republic, July 2-6, 2001. Proceedings to be published. (C1)
3. Three-Nucleon Portrait with Pion, L. Canton, G. Pisent, W. Schadow, T. Melde, and J.P. Svenne, contributed paper to the "VIII Convengo su problemi di fisica teorica", Cortona, Italy, October 18-20, 2000. Proceedings: *Theoretical Nuclear Physics in Italy*, G. Pisent, S. Boffi, L. Canton, A. Covello, A. Fabriocini, and S. Rosati, eds. (World Scientific, Singapore, 2001) pp.249-256. (C1)
4. Practical Approximation Scheme for the Pion Dynamics in the Three-Nucleon System, L. Canton, T. Melde, and J.P. Svenne, Physical Review C, **63**, 034004-1-10 (2001)
5. L. Canton, T. Melde and J.P. Svenne, Practical scheme for approximate treatment of the pion dynamics in three-nucleon systems (poster), Few Body XVI conference at Taipei, Taiwan, March 6-10, 2000. (C1)
6. Pion Dynamics and Three-Nucleon Forces, T. Melde, J.P. Svenne, and L. Canton, contributed paper to the DNP-2000 Conference of the APS, October 4-7, 2000, Williamsburg, VA, U.S.A. (oral presentation by Svenne) (C1)
7. L. Canton, T. Melde and J.P. Svenne, "Interpreting the 3-nucleon force diagrams" (oral presentation by Melde), CAP-2000, York University. (C1)
8. T, Melde and J.P. Svenne, The piNNN scattering problem revisited (oral presentation by Melde), CAP-1999, University of New Brunswick, Fredricton. (C1)

4.5 Publications of Permanent Members

P.G. Blunden

1. P.G. Blunden, M. Burkardt, and G.A. Miller (2000), Light-front nuclear physics: Toy models, static sources, and tilted light-front coordinates, Phys. Rev. **C61**, 025206. nucl-th/9908067 (C1)

2. P.G. Blunden, M. Burkardt and G.A. Miller, 1999, Light-front nuclear physics: Mean field theory for finite nuclei, To appear in Phys. Rev. C, nucl-th/9906012. (C1)

3. P.G. Blunden, M. Burkardt and G.A. Miller, 1999, Rotational invariance in nuclear light-front mean field theory, Phys. Rev. **C59**, R2998 (1999). (C1)

4. I.W. Stewart and P.G. Blunden (1997), "Quantum solitons at strong coupling", Phys. Rev. **D55**, 3742. (C1)

5. 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)

Invited conference talk

1. Light-front nuclear physics: Mean field theory for finite nuclei, International Workshop on Relativistic Dynamics and Few-Hadron Systems, ECT Trento, November 6-17, 2000.

M.E. Carrington

1. Mark Burgess, M.E. Carrington and G. Kunstatter, "*Covariant approach to equilibration in effective field theories,*", hep-ph/0103188 to be published in Canadian Journal of Physics.

2. M.E. Carrington, Hou Defu, R. Kobes, "*Nonlinear Response from Transport Theory and Quantum Field Theory at Finite Temperature,*", Phys. Rev. **D64** 025001 (2001).

3. D.S. Irvine, M.E. Carrington, G. Kunstatter and D. Pickering, "*Spontaneous Symmetry Breaking for Scalar QED with Nonminimal Chern-Simons Coupling,*", Phys. Rev. **D64** 045015 (2001).

4. M.E. Carrington, WF Chen and R. Kobes, "*Spontaneous Scale Symmetry Breaking in 2+1 Dimensional QED at Both Zero and Finite Temperature,*", Eur. Phys. J **C18**, 757 (2001).

5. M.E. Carrington, Hou Defu and J.C. Sowiak, "*KMS conditions for 4-point green functions at finite temperature,*" , Phys. Rev. **D62**, 065003 (2000)

6. M.E. Carrington, Hou Defu and R. Kobes, "*Shear Viscosity in ϕ^4 Theory from an Extended Ladder Resummation,*", Phys. Rev. **D62**, 085013, (2000).

7. Hou Defu, M.E. Carrington, R. Kobes and U. Heinz, "*Four-Point Spectral Functions and Ward Identities in Hot QED,*", Phys. Rev. **D61**, 085013 (2000).

8. M.E. Carrington, R. Kobes and G. Kunstatter, "*A New Formulation of a 1+1 Dimensional Field Theory Constrained to a Box,* Phys. Rev. **D61**, 12500 8 (2000).

9. M.E. Carrington, Hou Defu, A. Hachkowski, D. Pickering and J.C. Sowiak, "*Evaluating Real Time Finite Temperature Feynman Amplitudes*", Phys. Rev. **D61**, 25011 (2000).

10. M.E. Carrington, W.F. Chen, G. Kunstatter and J. Mottershead, "*Two-Loop Quantum Corrections of Scalar QED with non-Minimal Chern-S imons Coupling,*", Phys. Rev. **D60**, 125018 (1999).

11. M.E. Carrington, Hou Defu and Markus Thoma, "*Equilibrium and Non-Equilibrium Hard Thermal Loop Resummation in th e Real Time Formalism,*", Eur. Phys. J. **C7**, 347 (1999).

12. D. Leary, S. Yau, M.E . Carrington, R. Kobes and G. Kunstatter, "*Approach to Equilibrium in the Micromaser,*", physics/9907010, to be published in the Canadian Journal of Physics.

13. M.E. Carrington, Hou Defu and Markus Thoma, "*Ward Identities in Non-Equilibrium QED,*", Phys. Rev. **D58**, 085025 (1998).

14. M.E. Carrington and R. Kobes, "*The General Cancellation of Ladder Graphs at Finite Temperature,*", Phys. Rev. **D57**, 6372 (1998).

15. M.E. Carrington, Hou Defu, M.H. Thoma, *"Non-Equilibrium HTL Resummation"*, refereed paper published electronically in the proceedings at the 5th International Workshop on 'Thermal Fields and their Applications,' August 10-14, 1998, Regensburg, Germany

16. M.E. Carrington, R. Kobes and E. Petitgirard, "*Cancellation of Ladder Graphs in an Effective Expansion.*", Phys. Rev. **D57**, 2631 (1998).

17. M. Burgess, M.E. Carrington and G. Kunstatter, "*The Effective Action For a Relativistic Jaynes-Cummings Model,*", Can. J. Phys. **76**, 1 (1998).

18. M.E. Carrington and U. Heinz, "*Three Point Functions at Finite Temperature,*", Eur. Phys. J. **C1**, 619 (1998).

1. S. Das, R. Kobes, and G. Kunstatter, 2002, "Adiabatic quantum computation and Deutsch's algorithm", Phys. Rev. **A** (to appear). (C1)

2. M. Carrington, T. J. Hammond, and R. Kobes, 2002, "Infrared behaviour of the pressure in $g\phi^3$ theory", Phys. Rev. **D 65**, 067703. (C1)

3. R. Kobes and H. Letkeman, 2002, "Non-linear fractal interpolating functions", Visual Mathematics **4**, No. 1. (C1)

4. M. E. Carrington, Hou Defu, and R. Kobes, 2001, "A diagrammatic interpretation of the Boltzmann equation", Phys. Lett. **B523**, 221. (C1)

5. M. E. Carrington, Hou Defu, and R. Kobes, 2001, "Nonlinear response from transport theory and quantum field theory at finite temperature", Phys. Rev. **D64**, 025001. (C1)

6. R. Kobes, J. –X. Liu, and S. Peles, 2001, "Analysis of a parametrically driven pendulum", Phys. Rev. **E63**, 036219. (C1)

7. M. E. Carrington, W. F. Chen, and R. Kobes, 2001, "Spontaneous Scale Symmetry Breaking in 2+1-Dimensional QED at Both Zero and Finite Temperature", Eur. Phys. J. **C18**, 757. (C1)

8. D. Leary, S. Yau, M. Carrington, R. Kobes, G. Kunstatter, 2001, "Approach to equilibrium in the micromaser", Can. J. Phys. **79**, 783. (C1)

9. M. E. Carrington, Hou Defu, and R. Kobes, 2000, "Shear viscosity in ϕ^4 theory from an extended ladder resummation", Phys. Rev. **D62**, 025010. (C1)

10. Hou Defu, M. E. Carrington, R. Kobes, and U. Heinz, 2000, "Four-point spectral functions and Ward identities in hot QED", Phys. Rev. **D61**, 085013. (C1)

11. M. E. Carrington, Hou Defu, and R. Kobes, 2002, "Chapman–Enskog expansion of the Boltzmann equation and its diagrammatic representation", (XXX1 International Symposium on Multiparticle Dynamics, in press). (C3)

12. M. Carrington, R. Kobes and G. Kunstatter, 2000, "A new formulation of a 1+1 dimensional field theory constrained to a box", Phys. Rev. **D61**, 125008. (C1)

13. P. Aurenche, F. Gelis, R. Kobes, and H. Zaraket, 1999, "Two loop Compton and annihilation processes in thermal QCD", Phys. Rev. **D** (to appear). (C1)

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

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

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

17. 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)

Refereed conference proceedings

1. R. Kobes, 2000, "Calculating the viscosity (the hard way)", in *BNL Summer Study on QCD at Nonzero Temperature and Density*, edited by H. de Vega, D. Boyanovsky, and R. Pisarski, (BNL publication, 2000).

2. R. Kobes, 1998, "Beyond the hard thermal loop approximation in thermal QCD", workshop on thermal fields in and out of equilibrium (Brookhaven, 1998).

G. Kunstatter

1. Andrei Barvinsky, Saurya Das and Gabor Kunstatter, "Discrete Spectra of Charged Black Holes", to appear in a special issue of Foundations of Physics in Honour of Prof. J. Bekenstein.

2. M. Birukou, V. Husain, G. Kunstatter, M. Olivier and E. Vaz, "Scalar Field Collapse in d Spacetime Dimensions", Phys.Rev. **D65**:104036,2002 . (C1)

3. S. Das, R. Kobes and G. Kunstatter, "Adiabatic Quantum Computation and Deutsch's Algorithm", quant-ph/0111032v1, 2001, to appear in Phys. Rev. A. (C1)

4. M. Burgess, M.E. Carrington and G. Kunstatter, "Covariant approach to equilibration in effective field theories", Can. J. Phys. **80**, 97-107 (2002) (C1)

5. E. Vaz, M.E. Carrington, R. Kobes and G. Kunstatter, "Equilibration in an Interacting Field Theory", to appear in Can. J. Phy (C1)

6. A. Barvinksy, S. Das and G. Kunstatter, "Quantum Mechanics of Charged Black Holes", Physics Lett. **B517**, 415-420 (2001). (C1)

7. A. Barvinsky, S. Das and G. Kunstatter, "The Spectrum of Charged Black Holes–The Big Fix Mechanism Revisited", Class. and Qu. Grav. **18**, 4845-4862 (2001) gr-qc/0012066 (C1)

8. D.S. Irvine, M.E. Carrington, G. Kunstatter and D. Pickering, "Spontaneous Symmetry Breaking for Scalar QED with Non-minimal Chern-Simons Coupling", Phys. Rev. **D64** 045015, 2001. (C1)

9. A.J.M. Medved and G. Kunstatter, "One-Loop Corrected Thermodynamics of the Extremal and Non-Extremal BTZ Black Hole", Phys. Rev. **D63**, 104005 (2001); hep-th/0009050 (C1)

10. W. Chen and G. Kunstatter, "Constraint from the Lamb shift and anomalous magnetic moment on radiatively induced Lorentz and CPT violation effects in quantum elecrodynamics", Phys. Rev. **D62** (2000) 105029; hep-ph/0002294 (C1)

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T.A. Osborn

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J.P. Svenne

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2. Meson Dynamics and the resulting "3-Nucleon Force" diagrams: Results from a simplified test case. L. Canton, T. Melde and J.P. Svenne, contributed paper to "Mesons and Light Nuclei" conference, Prague, Czech Republic, July 2-6, 2001. Proceedings to be published. (C3)

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J.M. Vail

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D. E. Vincent

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J.G. Williams

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

6. 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)

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5 Financial

5.1 Statement of Income and Expenditures

Income

Income Source	Amount
Carry over from Aug. 31, 2001	$1024
Total Funds That Were Available	$1024

Expenditures

Activity	Particulars	Amount Spent
Miscellaneous	FAX, mail, printing, supplies	$91.65
	Total Expenditures (2001-2002)	$91.65

In relation to the supporting funds indicated above, it should be pointed out that the members of the Institute use their individual NSERC grants to subsidize Institute activities. Currently the members from the three universities draw upon more than $200,000 of individual NSERC Research Grants. These funds have a significant fortifying effect on the level of activities in which we are able to engage. The financial contribution of the members associated with the expenses of visiting guest theorists, supports the activity and goals of the Institute, but does not appear in the budget data shown above.

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

5.2 Financial Stability and Growth

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

NSERC research grants of members. This is a strong commitment to the Institute by the Institute members. In view of its overall research productivity, in terms of published papers and supervised graduate students, its capacity for running very successful conferences and workshops, and the demonstrated ability to attract excellent short-term and long-term visiting scientists, the Institute is achieving its goals. The Institute membership includes all of the theoretical physicists in the province. Hence its growth relies solely upon the associate members that it can attract (i.e. graduate students, postdoctoral fellows and research associates). The number and quality of these associate members is dependent on the Institute being able to create a positive research atmosphere. This in turn depends strongly upon the level of funding that the Institute receives. In recent years, there has been a marked decrease in the funds made available to the Institute by the three Manitoba universities. In this past year we received no support at all, and as a result the number of invited guest theorists and general Institute sponsored activity was very low.

A new development of some importance is the offer by the University of Manitoba of Tier 1 chair appointment in the area of theoretical nanophysics. Assuming this appointment goes through, this will bring a new area of work into the range of research supported by the Institute. It is also expected that this new chair appointment will bring with him one or more research associated and post docs as well as substantial grant support.

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.