The Winnipeg Institute for Theoretical Physics
Annual Report

P.G. Blunden, Director

September 1993 – August 1994

Contents

2 Current List of Members (September, 1994)

2.1 Permanent Members

- B. Bhakar[1], *Ph.D. (Delhi)*
- P.G. Blunden[1], *Ph.D (Queen's)*
- M.E. Carrington[1], *Ph.D. (SUNY, Stony Brook)*
- R.L. Kobes[1], *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
[1] University of Winnipeg
[3] Brandon University
[4] A.E.C.L. Research, Pinawa

1 Director's Narrative Report

The principal long term goal of the Winnipeg Institute for Theoretical Physics is to improve the research environment for all the theoretical physicists working in the province of Manitoba. To this end the Institute organizes workshops and symposia, supports new research collaborations, and runs a seminar series. The seminar series is given by eminent visiting scientists from all over the world. These visitors interact with members of the Institute as well as the group of graduate students and research associates supervised by the members. It is from these interactions that a number of new research collaborations have been initiated.

For the 1992-1993 academic year the list of invited speakers is found in section 4.1 of the report. Section 4.2 reports on a workshop on "Thermal Field Theories and Their Applications" which was organized by the Institute in August 1993. The list of graduate degrees awarded appears in section 4.3 and the published research work of the members, associate members and graduate students are found in sections 4.4 and 4.5. Section 5 gives the Institute budget and a summary of funding sources and expenditures.

Plans for the forthcoming academic year continue our established programs. These plans include a workshop to be held in Winnipeg in the summer of 1994 on "Heat Kernel Asymptotics and Non-perturbative Methods in Curved Spacetime." As in the previous year, 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/symposium activities and for the travel funds needed to support visiting scientists. The Institute has no technical support staff nor administrative staff. All the required administrative work is done on a volunteer basis by the members of the Institute. This year a significant organizational change took place in the granting of formal institute status (Type III) by the University of Manitoba. This document is the first annual report in the format required by this status.

In the academic year 1992-1993 the Institute director was T. A. Osborn, who also prepared this report. In the academic year beginning in September 1993 the Institute director will be P. G. Blunden.

2.2 Associate Members

- T.A. Harriott *(Visiting Scientist)*
- F.H. Molzahn *(Research Associate)*
- P. Kelly *(Postdoctoral Fellow)*
- Huang-Jian Xu *(Postdoctoral Fellow)*

2.3 Graduate Students

- J. Chen (M.Sc.), *(Kobes)*
- G. Gusev (Ph.D.), *(Osborn)*
- G. Lan (M.Sc.), *(Southern)*
- R.J. Lee (Ph.D.), *(Loly)*
- N. Li (M.Sc.), *(Vail and Woo)*
- D. Louis-Martinez (Ph.D.), *(G. Kunstatter)*
- J. Martinez-Cuellar (M.Sc.), *(Southern)*
- J. Wang (M.Sc.), *(Kobes)*

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 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.

R.L. Kobes

The general area of research is quantum field theory at finite temperature and density, with applications in both particle and condensed matter physics. We are presently interested in three specific problems: a study of properties of high temperature gauge theories such as the quark-gluon plasma, a general investigation of calculational methods in finite temperature field theory, and a study of the proximity effect between layers of superconducting materials in structures such as superlattices.

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 current 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.

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 Ising models on these structures and the geometrical properties, and to explore questions about universality in these systems.

J.P. Svenne

The investigation on the π-NNN system has concerned up to now the absorption channel. Absorption amplitudes have been derived for the pion-induced break-up of the 3He target into both two clusters and three free nucleons. Both one- and two-body elementary absorption mechanisms have been considered and harmonized with a dynamically correct few-body theory. As a consequence it is now possible to calculate absorption contributions

in which the energy and momentum of the incoming pion are shared among all the three nucleons. Finally Weinberg's quasiparticle expansion has been employed for the reduction of the multi-dimensional Faddeev-Alt-Grassberger-Sandhas equations into an effective two-body, Lovelace-type equation. The numerical reliability of Weinberg's expansion has also been studied.

Presently we are investigating the numerical treatment of the equations leading to the above-mentioned three-body contributions and the possible generalization of the present work towards a unitary description of the πNNN-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 ultrafine particles of insulating materials (collaboration at Michigan Technological University); (4) a study of the effect of impurities on property changes in metals due to irradiation damage (collaboration with A.E.C.L. Research, Pinawa).

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 and the Anthropic Principle. I am also investigating bubble solutions in (2+1) gravity using Ashtekar's gravitational formalism.

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

Speaker/Date	Institution	Title
Dr. Steve Carlip September 23, 1993	Univ. of California at Davis	Six ways to quantize (2+1)- dimensi gravity
Dr. Mark Burgess April 12, 1994	Univ. of Oslo	Renormalization and effective field the
Dr. Gu Mu August 10, 1994	Tongji University Shanghai	Research on radiation effects and s component suppression in BaF_2 crysta
Dr. M.S. Marinov June 10, 1994	Technion-Israel Inst. of Technology Haifa, Israel	Berezin quantization on homogene Kählet manifolds
Dr. M.S. Marinov June 9, 1994	Technion-Israel Inst. of Technology Haifa, Israel	Quantization of constrained systems
Dr. E. Calzetta March 24, 1994	Univ. of Alberta	Dissipation and fluctuations in quan field theory and cosmology
Dr. Michel Gingras January 11, 1994	TRIUMF Vancouver	Reentrance in spin glasses: does it exi
Dr. Jack Gegenberg March 2, 1994	Univ. of New Brunswick	The life and times of a black hole
Dr. Hank Miller December 16, 1993	Univ. of Pretoria Pretoria	A semi-empirical determination of properties of nuclear matter
Dr. Ian Lawrie April 20, 1994	Univ. of Leeds Leeds	Scaling in high-tempera superconductors

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. Richard Epp, Ph.D., Oct. 1993, (G. Kunstatter ~~and B. Bhakar~~)
~~"Title"~~ Diffeomorphism invariant quantization of Poincaré-invariant gauge theories
" Covariant quantization of

4.4 Publications of Associate Members and Graduate Students

[1]

Yu.V. Gusev

1. 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. (C1)

2. 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. (C1)

3. 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). (G)

4. 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. (C3)

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). (C1)

[1] Publications not co-authored with a Permanent Member

4.2 Workshops and Conferences

Conference on
Heat Kernel Techniques and Quantum Gravity

University of Manitoba, Winnipeg, Canada

August 2-6, 1994

An International Conference on Heat Kernel Techniques and Quantum Gravity was held at the University of Manitoba from August 2-6, 1994. Two members of the WITP, Gabor Kunstatter and Tom Osborn, were the local organizers. Other members of the organizing committee were G.A. Vilkovisky (Lebedev Physical Institute), A.O. Barvinsky (U. of Alberta), and S.A. Fulling (Texas A&M).

This conference is the highest profile activity that the WITP has sponsored so far. The list of invited speakers, detailed in Appendix A of this report, collectively make up a solid cross section of the world's scientific leadership in the field of quantum gravity. The event attracted about 75 participants from around the world, including xx graduate students. In addition to the substantial support from the WITP, the Conference received support from NSERC and the University of Manitoba.

A schedule of the talks is provided in Appendix A of this report.

4.5 Publications of Permanent Members

P.G. Blunden

1. A. S. Raskin and P. G. Blunden (1993), Comment on "Collective Modes in Dense Neutrino Systems", Phys. Rev. **D**, in press. (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.E. Carrington and G. Kunstatter (1994), "Phase Transitions in Massless Scalar QED with non-minimally coupled Chern-Simons Term", Phys. Lett. **B321**, 223. (C1)

2. M.E. Carrington (1993), "Self-Consistent Resummation Scheme in Scalar QED", Phys. Rev. **D48**, 3836. (C1)

3. M.E. Carrington and J.I. Kapusta (1993), "Dynamics of the Electroweak Phase Transition", Phys. Rev. **D47**, 5304. (C1)

4. M.E. Carrington (1992), "The Effective Potential at Finite Temperature in the Standard Model", Phys. Rev. **D45**, 2933. (C1)

5. 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)

6. M.E. Carrington, T.H.Hansson, H.Yamagishi, and I. Zahed (1989), "Linear Response of Hot Gluons", Annals of Physics **190**, 373. (C1)

7. 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)

8. M.E. Carrington (1993), "Ring Diagram Summations in the Finite Temperature Effective Potential", Can. J. Phys. **71**, 227. (C3)

R.L. Kobes

1. R. Baier and R. Kobes (1994), "Damping rate of a fast fermion in hot QED", Phys. Rev. **D**, in press. (C1)

2. M. van Eijck, R. Kobes, and Ch. G. van Weert (1994), "Transformations of real time thermal Feynman rules", Phys. Rev. **D**, in press. (C1)

3. P. Kelly, R. Kobes, and G. Kunstatter (1994), "Parameterization invariance and the resolution to the unitary gauge puzzle", Phys. Rev. **D**, in press. (C1)

4. R. Kobes and K. Mak (1993), "Role of the Infrared Cutoff in Fermion Damping Rates", Phys. Rev. **D48**, 1868-1870. (C1)

5. R. Kobes, G. Kunstatter and K. Mak (1992), "Fermion Damping in Hot Gauge Theories", Phys. Rev. **D45**, 4632-4639. (C1)

6. R. Kobes (1992), "Feynman Rules for Response Functions at Thermal Equilibrium", Phys. Rev. **B45**, 3230-3235. (C1)

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

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

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

10. R. Kobes (1991), "Retarded Functions, Dispersion Relations, and Cutkosky Rules at Zero and Finite Temperature", Phys. Rev. **D43**, 1269-1282. (C1)

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

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

13. 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)

14. 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)

15. 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)

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

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

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

19. 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)

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

21. R. Kobes, 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)

22. 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)

23. 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)

24. 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)

25. 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)

26. 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)

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

28. 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)

G. Kunstatter

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

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

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

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

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

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

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

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

9. R. Kobes, G. Kunstatter and K. Mak (1992), "Fermion Damping in Hot Gauge Theories", Phys. Rev. **D45**, 4632. (C1)

10. R. Baier, G. Kunstatter and D. Schiff (1992), "High Temperature Fermion Damping Rate: Resummation and Gauge Independence", Phys. Rev. **D45**, R4381-R4384. (C1)

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

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

13. 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)

14. 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)

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

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

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J.A. Zuk

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

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7. 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)

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

9. 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)

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5 Financial

5.1 Annual Budget

Income

Carryover from 1993		$15.000.00
University of Manitoba Support		
Faculty of Science	$5,000.00	
Research Administration	$7,500.00	
	$12,500.00	$12.500.00
Total Funds Available		$27,500.00

Expenditures

Visitors		
Shender	$516.82	
Misc. (mail, fax, printing, etc.)		$378.80
Banff Conference Centre		$3,640.00
Total Expenditures		$9.994.97
Available Balance:		$20,438.91

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 Manitoba. The host departments also supply occasional secretarial support such as the preparation of seminar notices and this report.

5.2 Financial Stability, Growth, etc.

The Institute has no substantial fixed costs and for this reason is intrinsically stable. It can operate in a productive fashion at a variety of funding levels. All the funds the Institute receives are transformed directly into its research enhancing activities. In view of the research productivity of the members, in terms of published papers and graduate students supervised, the Institute is achieving its goals. Because the Institute now incorporates all the theoretical physicists in the Province there will be no growth in its membership. However there can be growth in its activities and the extend of this growth is entirely dependent on the financial support the Institute receives.

The report guideline suggest that we indicate the percentage of time the members spend on Institute research. Since the Institutes programs enhance the ongoing research interests of its members there is no distinction between individual research and Institute research. The director has spent 5% of his time with the administrative aspects of the Institute.

6 Appendix A — Conference Program

Schedule of Talks
Winnipeg Institute for Theoretical Physics Conference on
HEAT KERNEL TECHNIQUES AND QUANTUM GRAVITY
University of Manitoba, Winnipeg, Canada
August 2–6, 1994

TUESDAY August 2

9:00 – 10:00 a.m.	Registration and Coffee Department of Physics, Allen Building – Foyer University of Manitoba
	Session Chairman T. Osborn
10:00 – 11:00 a.m.	G. Vilkovisky (Lebedev Phys. Inst., Moscow) Heat kernel, effective action and quantum gravitational collapse
11:00 – 12:00 a.m.	I.G. Avramidi (U. of Greifswald) New algebraic methods for calculating the heat kernel and the effective action in quantum gravity and gauge theories
12:00 – 1:30 p.m.	Lunch
	Session Chairman G. Kunstatter
1:30 – 2:30 p.m.	R. Sorkin (Syracuse U.) Energy extremality in the presence of a black hole
2:30 – 3:00 p.m.	R. Myers (McGill U.) Black hole entropy in higher curvature theories
3:00 – 3:30 p.m.	Coffee
3:30 – 4:30 p.m.	A. Kamenshchik (Nuc. Safety Inst., Moscow) Zeta-function technique on manifolds with boundaries and its applications in quantum cosmology
4:30 – 5:00 p.m.	G. Kennedy (Glasgow Caledonian U.) Connected graphs and the exponential expansion of the heat kernel

Session Chairman D. Page

9:00 – 10:00 a.m. V.P. Frolov (U. of Alberta)
Dynamical origin of the black hole entropy

10:00 – 10:30 a.m. Coffee

10:30 – 11:30 a.m. A.O. Barvinsky (U. of Alberta)
Covariant perturbation theory in quantum gravity and theory of gauge fields

11:30 – 12:00 a.m. A. Mirzabekian (Lebedev Phys. Inst., Moscow)
The vacuum radiation in effective equations of quantum gravity

12:00 – 1:30 p.m. Lunch

Session Chairman V. Frolov

1:30 – 2:30 p.m. P.R. Anderson (Wake Forest U., NC)
Backreaction effects in black hole spacetimes: How quantum fields affect the geometries, temperatures and entropies of static black holes.

2:30 – 3:00 p.m. D. Gal'tsov (Moscow State U.)
Stringy sphalerons and black holes

3:00 – 3:30 p.m. Coffee

3:30 – 4:30 p.m. V.P. Gusynin (Inst. for Theor. Phys., Kiev)
Heat kernel techniques for non-minimal operators

4:30 – 5:00 p.m. P. Haberl (U. of Heidelberg)
Effective actions from heat kernels with string inspired methods

THURSDAY August 4

Session Chairman L. Parker

9:00 - 10:00 a.m.	B-L. Hu (U. of Maryland) Quantum fluctuations in semiclassical gravity
10:00 - 10:30 a.m.	Coffee
10:30 - 11:30 a.m.	E. Calzetta (Ciudad U., Buenos Aires) Correlations, dissipation and noise in quantum field theory
11:30 - 12:00 a.m.	K. Kirsten (U. of Barcelona) Mass generation in self-interacting ϕ^4 scalar field theories
12:00 - 1:30 p.m.	Lunch

Session Chairman S. Dowker

1:30 - 2:30 p.m.	P.B. Gilkey (U. of Oregon) The Gromov Lawson Rosenberg Conjecture - when do manifolds admit metrics of positive scalar curvature?
2:30 - 3:00 p.m.	G. Esposito (INFN, Naples) Euclidean Maxwell theory in the presence of boundaries
3:00 - 3:30 p.m.	Coffee
3:30 - 4:30 p.m.	G. Kunstatter (U. of Winnipeg) Observables for spherically symmetric black holes
4:30 - 5:00 p.m.	A. Zelnikov Cosmic string in thermal bath and Casimir effect in accelerated frame
THURSDAY evening	CONFERENCE BANQUET AT THE FORKS

FRIDAY August 5

Session Chairman W. Unruh

9:00 - 10:00 a.m.	S. Christensen (MathSolutions, Inc.) The computational challenges of heat kernel calculations
10:00 - 10:30 a.m.	Coffee
10:30 - 11:30 a.m.	D.N. Page (U. of Alberta) Information loss in black holes and/or conscious beings?
11:30 - 12:00 a.m.	G. Lavrelashvili (Max Planck Inst. für Phys., Munich) Gravitating, gravitational and dilatonic sphalerons
12:00 - 1:30 p.m.	Lunch

Session Chairman P. Gilkey

1:30 - 2:00 p.m.	D. Louis-Martinez (U. of Winnipeg) Generalized Birkhoff's Theorem in 2-D Dilaton Gravity
2:00 - 2:30 p.m.	Y. Gusev (U. of Manitoba) Heat kernel and loop currents by the generating function method
2:30 - 3:00 p.m.	A. Rogers (Kings College, London) Heat kernels, Dirac operators and stochastic calculus in superspace
3:00 - 3:30 p.m.	Coffee
3:30 - 4:30 p.m.	R.B. Mann (U. of Waterloo) New results in 1+1 dimensional gravity
4:30 - 5:00 p.m.	A. Bonanno (U. of Alberta) Average action in the Einstein universe
FRIDAY evening	PRE-DINNER CONCERT ON CAMPUS (Eva Clare Hall)

SATURDAY August 6

Session Chairman S. Fulling

9:00 - 10:00 a.m.	J. Gegenberg (U. of New Brunswick) Heat equation methods in the classification of three-manifolds
10:00 - 10:30 a.m.	Coffee
10:30 - 11:00 a.m.	J. S. Dowker (U. of Manchester) Heat kernels and polytopes
11:00 - 11:30 a.m.	V. Zhytnikov (Nat. Central U., Taiwan) The basis of nonlocal curvature invariants in quantum gravity
11:30 - 12:00 a.m.	S. Poletti (U. of Adelaide) Conformal anomalies on Einstein spaces with boundary
12:00 - 1:30 p.m.	Lunch

Session Chairman G. Vilkovisky

1:30 - 2:30 p.m.	W.G. Unruh (U. of British Columbia) Black holes, dumb holes, high-frequency effects and thermal emission
2:30 - 3:30 p.m.	L. Parker (U. of Wisconsin-Milwaukee) Topics in quantum electrodynamics and quantum gravity

CONFERENCE ENDS