WITP ANNUAL REPORT

September 1992 — August 1993

CONTENTS:

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 CURRENT LIST OF MEMBERS (September, 1993)

(a) Permanent Members

- B. Bhakar[1], *Ph.D. (Delhi)*
- P.G. Blunden[1], *Ph.D (Queen's)*
- 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)*

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[1] University of Manitoba

[2] University of Winnipeg

[3] Brandon University

[4] AECL, Pinawa

(b) Associate Members

- M. Carrington *(Postdoctoral Fellow)*
- V. Cherepanov *(NSERC International Fellow)*
- P. Kelly *(Postdoctoral Fellow)*
- V. I. Kukulin *(Visiting Scientist)*
- F. H. Molzahn *(Research Associate)*
- A. S. Raskin *(Research Associate)*

(c) Graduate Students *(Supervisor)*

- J. Chen (M.Sc.), *(Kobes)*
- S. Cyr (Ph.D.), *(Southern)*
- R. Epp (Ph.D.), *(Bhakar \& Kunstatter)*
- G. Gusev (Ph. D.), *(Osborn)*
- N. Li (M. Sc.), *(Vail \& Woo)*
- R. J. Lee (M.Sc.), *(Southern)*
- G. Lan (M.Sc.), *(Southern)*
- K. Mak (Ph.D.), *(Kobes \& Kunstatter)*
- D. L. Martinez (Ph.D.), *(Kunstatter)*
- J. Wang (M.Sc.), *(Kobes)*

3. RESEARCH INTERESTS OF PERMANENT MEMBERS

B. Bhakar

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

P.G. Blunden

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

Another area of interest is in a quantum field theory of mesons and hadrons (QHD). Some 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 ^{3}He 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.

John 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 AECL, 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.

4.1 SEMINARS

Speaker/Date	Institution	Title
Dr. C. K. Ong Sept. 14, 1992	Univ. of Singapore Malaysia	Theoretical Studies of Surface Processes in Semiconductors and Metals
Dr. E. F. Shender Sept. 24, 1992	Inst. of Nuclear Physics St. Petersburg, Russia	Diluted Quasi 1D Antiferro-magnets
Dr. E. F. Shender Sept. 25, 1992	Inst. of Nuclear Physics St. Petersburg, Russia	Order by Disorder in Quantum Magnetism
Dr. C. E. Wulfman Oct. 7, 1992	Univ. of the Pacific Stockton, CA	Using Lie Groups to Uncover Laws of Classical and Quantum Physics
Dr. S. Rudaz Oct. 13, 1992	Univ. of Minnesota Minneapolis, MN	Effective Lagrangians for Nuclear Physics
Dr. W. Stephan Jan. 5, 1993	Kings College London, UK	Cluster Calculations on Models for High T_c Compounds
Dr. J. Tuszynski March 25, 1993	Univ. of Alberta Edmonton	Non-Gaussian Statistics and its Consequences
Dr. H. Weigert April 26, 1993	Inst. for Theoretical Physics Regensburg, Germany	Radial Gauges for Kinetic Theories of Hot QCD
Dr. S. Braham May 11, 1993	Univ. British Colombia Vancouver	Can Black Holes Not Evaporate
Dr. A. Mogilner May 12, 1993	Univ. British Colombia Vancouver	Self-Orientation of Cells: Model for Pattern Formation
Dr. C. Calman June 16, 1993	Concordia Univ. Montreal	Experimental Consequences of Supergravity
Dr. O. A. Soloviev June 21, 1993	Queen Mary and Westfield College London, UK	Non-Local Currents and Non-Perturtative Quantum Field Theory

4.2 SUMMER SCHOOL AND WORKSHOP

CAP Banff Summer School and Workshop on

Finite Temperature Field Theory

Banff, Alberta, August 16-27, 1993

Finite Temperature Field Theory is playing an increasingly important role in our understanding of the fundamental interactions. It is relevant to early condensed matter physics, universe cosmology, astrophysics and accelerator physics. In fact, much recent interest in the field has been generated by the possibility of seeing at heavy ion accelerators evidence for the existence of a new state of hadronic matter at high temperatures and pressures.

The CAP Banff Summer School and Workshop was the third in a series of international meetings in the area of Finite Temperature Field Theory. The first of these was held in Cleveland in 1988, while the second was in Tsukuba, Japan in 1990. The most recent meeting was attended by over 75 physicists from all over the world. It consisted of pedagogical lectures series (three hours each) given by well known experts in the field, as well as invited technical seminars and contributed talks. The proceedings of the School/Workshop will be published by World Scientific.

In addition to the substantial support from the Winnipeg Institute for Theoretical Physics, the Conference received support from:

- The Natural Sciences and Engineering Research Council
- The University of Alberta
- The University of Winnipeg
- The International Science Foundation

The organizing committee for the meeting consisted of Randy Kobes (University of Winnipeg), Faqir Khanna (University of Alberta), Gabor Kunstatter (University of Winnipeg) and H. Umezawa (University of Alberta).

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

4.3 GRADUATE DEGREES SUPERVISED

Wang Jing M.Sc. Oct. 1992 (R. Kobes)
"Proximity Effect and the Thermodynamics Properties of Superlattice Systems"

Richard Lee M.SC. May 1993 (B.W. Southern)
"Three Magnon Excitations in One Dimensional Quantum Spin Chains"

4.3 PUBLICATIONS OF ASSOCIATE MEMBERS AND GRADUATE STUDENTS [a]

L. Canton

1. G. Pisent, K. Amos, P.J. Dortmans and L. Canton (1993), "Separable Expansions of the NN t-matrix via exact half-off-the-energy-shell Methods", *Phys. Rev. C*48, 64-73. (C1)

2. L. Canton, G. Cattapan, G. Pisent and G. H. Rawitscher (1993),"Singular Value Decomposition of the Nucleon—Nucleon Reactance Matrix", *Nuovo Cimento* 106A, 71-77. (C1)

M. E. Carrington

1. M. E. Carrington (1993), "Self-Consistent Resummation Scheme in Scalar QED", *Phys. Rev. D*, in press.

2. M. E. Carrington and J. I. Kapusta (1993), "Dynamics of the Electroweak Phase Transition", *Phys. Rev.*, D47, 5304-5315.

V. Cherepanov

1. V.B. Cherepanov, I.V. Kolokolov and V.S. L'vov (1993), "The saga of YIG or spectra, thermodynamics, interaction and relaxation of magnons in a complex magnet", *Phys. Reports*, 229, 81-144. (C1)

2. V.B. Cherepanov and A.N. Slavin (1993), "A model for spin wave auto-oscillations in finite-size ferromagnetic samples", *J. Appl. Phys.*, 73, 6811-6813. (C1)

3. E.F. Shender, V.B. Cherepanov, P.C.W. Holdsworth and A.J. Berlinsky (1993), "The kagomé antiferromagnet with defects: satisfaction, frustration, and spin folding in a random spin system", *Phys. Rev. Lett.*, 70, 3812-3815. (C1)

4. V.B. Cherepanov and A.N. Slavin (1993), "Spin wave auto-oscillations in finite-size ferromagnetic samples", *Phys. Rev. B*, 47, 5874-5880. (C1)

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

5. V.B. Cherepanov (1992), "Influence of weak localization on the threshold of parametric excitation of magnons in low-dimensional magnets", *Phys. Rev. B*, **45**, 12397-12404. (C1)

6. V.B. Cherepanov (1991), "On the threshold of parametric instability of spin waves in a film with rough surface", *J. Appl. Phys.*, 69(8), 5733-5735. (C1)

Yu. V. Gusev

1. A.O. Barvinsky, Yu. V. Gusev, G. A. Vilkovisky and V.V. Zhytnikov (1993), "Covariant Nonlocal Effective Action", *Proceedings of the 5th Conference on General Relativity and Gravitation*, ed. R. Mclenaghan (World Scientific), in press. (C3)

V. I. Kukulin

1. V.I. Kukulin and V.N. Pomerantsev (1992), "Symmetry in the Nucleon-Nucleon Interaction and the Model of Moscow Potential", *Prog. Theo. Phys. (Kyoto)* 88, 159-209. (C1)

A. I. Mogilner

1. A.N. Melnikov, A.I.Mogilner, "A Generalization of the Iorrio-O'Carrol Theorem to of Lattice Hamiltonians", *J.Phys.* **A24**, 3671-3676 (1991)

2. A.I.Mogilner, "Hamiltonians in Solid State Physics as Multiparticle Discrete Schrödinger Operators: Problems and Results", *Adv. in Soviet Math.* **3**, 5-59 (AMS Publ., Prov. 1991)

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)

4.4 PUBLICATIONS OF 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. C*, in press. (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. A*, in press. (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)

13. P. G. Blunden and M. N. Butler (1988), "Contribution of Meson Exchange Currents to the Nuclear Quasielastic Peak", in *Momentum Distributions*, eds. (Plenum, New York), p. 341. (C3)

R. Kobes

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

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

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

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

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

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

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

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

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

10. 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)

11. 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)**

12. 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)**

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

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

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

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

17. R. Kobes (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)**

18. 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)**

19. 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)**

20. 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)**

21. 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)**

22. 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)**

23. 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. J. Gegenberg and G. Kunstatter (1993), "Partition Function for Topological Field Theories", *Annals of Physics*, in press. **(C1)**

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

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

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

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

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

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

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

9. 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)**

10. 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)**

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

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J. A. Zuk

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2. 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)

3. 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)

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

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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8. J. A. Zuk (1990), "Asymptotic Behaviour of the Vacuum Energy for Small Skyrmions", *Int. J. Modern 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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5.1 SOURCES OF FUNDING (ACADEMIC 1992—1993)

University of Manitoba

Faculty of Science	$5,000.00
Office of Research Administration	$7,500.00
Members Contribution	$2,786.46
Total	$15,286.46

Funds received to support the 1993 Banff Workshop on "Thermal Field Theories and Their Application" (G. Kunstatter and R. Kobes)

Funding Source:

NSERC	$10,000.00
Univ. of Alberta	$5,000.00
International Science Foundation	$4,000.00
Total	$19,000.00

Comments: 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 ANNUAL BUDGET

Carryover from 1992		$15,147.42
University of Manitoba Support:		
Faculty of Science	$5,000.00	
Research Administration	$7,500.00	
Members Contribution	$2,786.46	
Total Funds Available		$30,433.88
Expenditures:		
Long term visitor:		
Kukulin		$2,435.04
Seminar speakers:		
Shender	$516.82	
Kalman	$300.00	
Soloviev	$697.66	
Weigert	$1,052.14	
Ong	$381.00	
Braham	$593.51	
		$3,541.13
Misc. (mail, fax, printing, etc.)		$378.80
Banff Conference Centre		$3,640.00
Total Expenditures		$9,994.97
Available Balance:		$20,438.91

Comments: The pattern of expenses for this year are somewhat distorted from that of a typical year. The outside support for the Banff conference was unusual generous and for this reason the Institute budget only had to contribute a minimal amount from the Institute controlled accounts. The outside support of $19,000.00 and other monies, such as the conference fees, went into accounts not controlled by the Institute and for that reason do not appear as part of the Annual Budget.

5.3 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% percent of his time with the administrative aspects of the Institute.

APPENDIX A.

Timetable
3rd Workshop on Thermal Field Theories
and their Applications
Banff, Alberta, Canada
August 15–27, 1993

	Monday, Aug. 16	Tuesday, Aug. 17	Wednesday, Aug. 18
9:00–10:00	R. Jackiw (MIT) Field theoretical background for thermal physics	Ch. van Weert (Amsterdam) General aspects of thermal field theories	R. Jackiw (MIT) Field theoretical background for thermal physics
10:00–10:30	B.–S. Skagerstam (Chalmers) The QED effective action at finite temperature and density – external field problems	A. Nieto (Madrid) Casmir effect in quantum field theory	U. Wiedemann (DAMTP) Convexity of the effective potential
10:30–10:50	BREAK		
10:50–11:50	B.–L. Hu (Maryland) Gravitation and cosmology	R. Pisarski (Brookhaven) Heavy ion collisions	B.–L. Hu (Maryland) Gravitation and cosmology
11:50–12:20	I. Lawrie (Leeds) Dynamics of phase transitions in the early universe	R. F. Alvarez–Estrada (Madrid) Pion interactions in thermal field theories	B. Harms (Alabama) Modifications of black hole thermodynamics due to non–local effects
	FREE AFTERNOON		
6:30–7:30	H. Umezawa (Alberta) Equilibrium & non–equilibrium thermal physics	M. Le Bellac (Nice) Infrared and mass singularities at finite temperature	H. Umezawa (Alberta) Equilibrium & non–equilibrium thermal physics
7:30–8:00	J.–G. Demers (MIT) First quantization description of thermal propagation	M. Carrington (Winnipeg) Infrared behaviour of hot gauge theories	Y. Yamanaka (Waseda) Entropy in inhomogeneous TFD
8:00–8:20	BREAK		
8:20–8:50	T. Evans (Imperial) A new time contour for thermal field theories	S. Vokos (Seattle) Analytic structure of self–energies of massive gauge bosons at finite temperature	M. Revzen (Technion) Diagramatics
8:50–9:20	F. Guerin (Nice) Diagrams with retarded–advanced Green functions	M. Moshe (Technion) The double scaling limit of O(N) vector models	H. Chu (Alberta) Feynman diagram recipes in TFD

	Thursday, Aug. 19	Friday, Aug. 20	Saturday, Aug. 21
9:00–10:00	Ch. van Weert (Amsterdam) General aspects of thermal field theories	R. Jackiw (MIT) Field theoretical background for thermal physics	Ch. van Weert (Amsterdam) General aspects of thermal field theories
10:00–10:30	N. Weiss (Vancouver) To be announced	E. Mottola (Los Alamos) Non-equilbrium dynamics in QED & QCD in the large N expansion	P. Elmfors (Nordita) Thermalization of the Higgs field
10:30–10:50	BREAK		
10:50–11:50	R. Pisarski (Brookhaven) Hard thermal loops	B.–L. Hu (Maryland) Gravitation and cosmology	R. Pisarski (Brookhaven) QCD phase transitions
11:50–12:20	T. Altherr (CERN) Plasmon decay: from QED to QCD	D. Pavon (Barcelona) Causal cosmology	C. Korthals Altes (Marseille) Symmetries of the effective action in hot QCD
	FREE AFTERNOON		
6:30–7:30	Conference Banquet	H. Umezawa (Alberta) Equilibrium & non-equilibrium thermal physics	
7:30–7:50		BREAK	
7:50–8:50	Conference Banquet	S.–Y. Pi (Boston) The effective potential at finite temperature	
8:50–9:20	Conference Banquet	G. Amelino–Camelia (Boston) Rayleigh–Ritz variational approximation of the finite temperature effective potential	

	Sunday, Aug. 22 Free day	Monday, Aug. 23	Tuesday, Aug. 24
9:00–10:00		G. Vitiello (Salerno) Quantum dissipation and q-groups	A. A. Abrikosov (ITEP) Ground state problem in TFD
10:00–10:30		N.–P. Chang (New York) Braaten–Pisarski Lagrangian for quark propagation & chiral symmetry disorientation	A. Pearson (Imperial) Why the real time formalism doesn't factorise
10:30–10:50		BREAK	
10:50–11:20		C. Stephens (Utrecht) Finite temperature field theory and the renormalization group	U. Heinz (Regensburg) Quark–gluon transport theory
11:20–11:50		M. van Eijck (Amsterdam) The renormalization group at finite temperature	E. Iancu (Saclay) Soft fields and hard particles in hot gauge plasma
11:50–12:20		H. Yokota (Nara) RGE improvement of the effective potential at finite temperature ($\lambda\phi^4$ theory)	S. Jeon (Seattle) Calculation of transport coefficients in finite temperature field theories
		FREE AFTERNOON	
6:30–7:00		P. Henning (Darmstadt) Applications of Thermo Field Dynamics to nuclear physics	N. Arimitsu (Yokohama) A formulation of time-resolved optical spectrum for transient resonant light scattering
7:00–7:30			R. Parwani (Saclay) Checking gauge invariance of perturbative calculations
7:30–8:00		J. da Providencia (Coimbra) The nuclear many body problem at finite temperature : the width of the collective states	P. Landshoff (DAMTP) Alternative approach to the real time formalism
8:00–8:20		BREAK	
8:20–8:50		K. Tanabe (Saitama) Nuclear structure at finite temperature	P. Kelly (MIT) Parameterization and gauge invariance of the transition temperature
8:50–9:20			M. Staley (Guelph) Calculations in the temporal gauge using the Leibbrandt–Mandelstan prescription

	Wednesday, Aug. 25	Thursday, Aug. 26	Friday, Aug. 27
9:00–10:00	R. Baier (Bielefeld) Recent results of perturbative gauge theories	V. P. Nair (Columbia) Chern–Simons theory and the quark-gluon plasma	T. Arimitsu (Tsukuba) Quantum Brownian motion in non–equilibrium TFD
10:00–10:30	H. A. Weldon (West Virginia) *Thermal* QED: definition of reaction rates, cancellation of IR divergences, and an effective mass $\sim \alpha T$	M. Burgess (Oslo) A problem in Maxwell Chern Simons theory	M. Morikawa (Ocha–no–mizu) Back reaction of quantum fluctuations – many Hilbert spaces induced from the generalized effective action
10:30–10:50	BREAK		
10:50–11:20	A. Rebhan (Bielefeld) Gauge–independent extraction of the next–to–leading order Debye mass from the gluon propagator	T. Lee (Kangwon) Thermodynamics of non–Abelian Chern–Simons particles	G. Cheetham (Sussex) Fluctuations around defects
11:20–11:50	H. Nakkagawa (Nara) More on the perturbative calculation of the fermion damping rate	G. Kunstatter (Winnipeg) Phase transitions in Chern–Simons models	L. Bettencourt (Imperial) The role of local defects on phase transitions
11:50–12:20	A. Smilga (ITEP) Plasmon damping revisited	K. Klimenko (IHEP) Four–fermion theories in three dimensions at nonzero temperature and external gauge fields	
	FREE AFTERNOON		
6:30–7:30	R. Rivers (Imperial) Phase transitions in the early universe	A. Smilga (ITEP) Are Z bubbles really there?	
7:30–7:50	BREAK		
7:50–8:20	W. Zimdahl (Duesseldorf) Cosmology with matter creation	Y. X. Gui (Dalian) Background spacetime for finite temperature field theory	
8:20–8:50	S. D. Mathur (MIT) Particle creation in string theory		