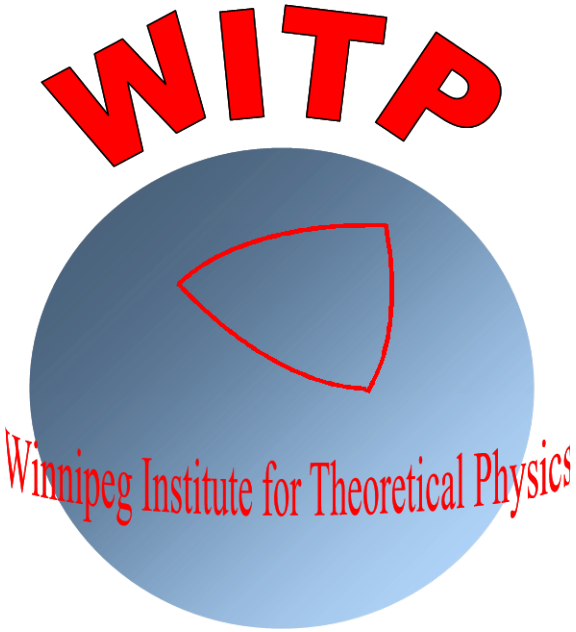
The Winnipeg Institute for Theoretical Physics Annual Report



September 2015 – August 2016

Web site: `http://www.physics.umanitoba.ca/~witp/`

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1 Director's Narrative Report

The Winnipeg Institute for Theoretical Physics is a type III research Institute and 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 permanent members of this Institute are drawn from Brandon University, the University of Manitoba, and the University of Winnipeg. Associated with the Permanent Members are research associates, postdoctoral fellows, graduate students and summer undergraduate research assistants.

The past year was the 26th year of the Institute's existence. As usual, the Institute sponsored several research colloquia by out-of-province visitors as well as Institute members. The Institute has been providing support for Canadian theoretical physics and astronomy meetings, for example by being a sponsor of the Theory Canada conference, the main national conference for theoretical physics, and this past year a sponsor of the 2016 Annual Meeting of the Canadian Astronomical Society (CASCA) which was held in Winnipeg. In order to emphasize the strong base of theoretical physics in Manitoba throughout the rest of Canada, the WITP has also recently agreed to co-sponsor a new PhD thesis prize in conjunction with the Canadian Association of Physicists Division of Theoretical Physics.

For the 2015-2016 academic year, the list of visitors is found in section 4.1, invited speakers in section 4.2, a description of the WITP Summer Student Symposium appears in 4.3, the cumulative list of graduate degrees awarded appears in section 4.5, and the published research work of members is found in section 4.6. Section 5.1 contains a summary of income and expenditures for one year (since the filing of last year's report.) The plans for the coming year include a program of invited speakers, visiting research collaborations, and the promotion of postgraduate and postdoctoral research. For the fifth year in a row, the WITP held a summer research symposium, highlighting the summer research done by undergraduate and graduate students under the supervision of WITP members. The symposium was hosted this year at the University of Winnipeg on August 25, 2016.

All of the funds available to the Institute are spent for scientific research expenses, including conference support, seminar activities, and 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.

The WITP Executive Committee (two-year terms), as of January 1, 2015, consists of the Director, K. Shamseddine (Manitoba), the Director-Elect, J. Sirker (Manitoba), and the Past-Director, A. R. Frey (Winnipeg). A. R. Frey was the director from January 1, 2013 to December 31, 2014; and J. Sirker will become the new director as of January 1, 2017.

Khodr Shamseddine
Director, WITP

2 Current List of Members (2015-16)

2.1 Permanent (Faculty) Members

- M.E. Alexander[2], *Ph.D. (Manchester University, UK)*
- S. Bacca[14], *Ph.D. (Trento, Italy & Mainz, Germany)*
- P.G. Blunden[1], *Ph.D (Queen's)* [Director, 93-94]
- M.E. Carrington[3], *Ph.D. (SUNY, Stony Brook)*
- T. Chakraborty[1], *Ph.D. (Dilbrugarh University, India)*
- J. D. Fiege[1], *Ph.D. (McMaster)*
- A.R. Frey[2] *Ph.D. (UCSB)* [Director, 13-14]
- T.D. Fugleberg[3], *Ph.D. (UBC)*
- D. Krepski[1], *Ph.D. (Toronto)*
- G. Kunstatter[2], *Ph.D. (Toronto)* [Director, 91-92, 09-12]
- C. O'Dea[1], *Ph.D. (Massachusetts)*
- S. Plosker[3], *Ph.D. (Guelph)*
- A. Prymak[1], *Ph.D. (Kyiv National Taras Schevchenko)*
- S. Safi-Harb[1], *Ph.D. (Wisconsin-Madison)*
- E. Schippers[1], *Ph.D. (Toronto)*
- A. Shalchi[1], *Ph.D. (Ruhr-Universität Bochum)*
- K.M. Shamseddine[1], *Ph.D. (Michigan State)* [Director, 15-16]
- J. Sirker[1], *Ph.D. (Universität Dortmund)*
- D.W. Vincent[2], *Ph.D. (Toronto)* [Director, 94-95]
- M. Whitmore[1], *Ph.D. (McMaster)*
- J.G. Williams[3], *Ph.D. (Birmingham)* [Director, 96-97]

Senior Scholars

[1]University of Manitoba
[2]University of Winnipeg
[3]Brandon University
[4]Home Institution: TRIUMF

- B. Bhakar[1], *Ph.D. (Delhi)* [Director, Jan. - June 00]
- P.D. Loly [1], *Ph.D. (London)* [Director, Fall 99, 00-01]
- T.A. Osborn[1], *Ph.D. (Stanford)* [Director, 92-93, 01-04]
- B.W. Southern[1], *Ph.D. (McMaster)* [Director, 90-91, 07-09]
- 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]

2.2 Associate Members

Research Associates

- Rebecca Danos (Frey/Kunstatter)
- Nir Nevo Dinur (TRIUMF) (Bacca)
- Gilles Ferrand (Safi-Harb)

Postdoctoral Fellows

- Wenchen Luo (Chakraborty)
- Noemi Rocco (TRIUMF) (Bacca)
- Adam Rogers (Safi-Harb)
- Kiyoumars Sohrabi (Carrington)
- Jennifer Vaughan (PIMS postdoctoral fellow) (Schippers)
- Sarka Wykes (O'Dea)
- Yang Zhao (Sirker)

2.3 Graduate Students

- J. Ahmed (Ph.D.) (Blunden)
- Mykhailo Akhtariiev (M.Sc.) (Schippers, co-supervised with Chipalkatti, Manitoba)
- Bassel Alkadour (Ph.D.) (Southern, co-supervised with van Lierop, Manitoba)
- Victor Arendt (M.Sc.) (Schalchi)
- Kelvin Au (M.Sc.) (Fiege)

- Chelsea Braun (M.Sc./Ph.D.) (Safi-Harb)
- Angel Barria Comicheo (Ph.D.) (Shamseddine, co-supervised with R. Craigen, Manitoba)
- Ye Cheng Chen (M.Sc.) (Sirker)
- Bradley Cownden (Ph.D.) (Frey)
- Darren Flynn (Ph.D.) (Shamseddine)
- Erica Franzmann (Ph.D.) (Fiege)
- Robert Gleisinger (M.Sc.) (O'Dea)
- William Grafton (M.Sc.) (Shamseddine)
- Benson Guest (Ph.D.) (Safi-Harb)
- Emrul Hassan (M.Sc.) (Southern)
- Javier Hernandez-Melgar (PhD) (Bacca)
- Martin Heusen (Ph.D.) (Shalchi)
- P. Jaeger (German Diploma) (Sirker)
- M. Kiefer (German Diploma) (Sirker)
- Daniel Maciel (M.Sc.) (Southern)
- Brett Meggison (M.Sc.) (Carrington/Frey)
- Paul Mikula (Ph.D.) (Carrington/Kunstatter)
- Mirko Miorelli (Ph.D.) (Bacca)
- Mitulkumar Patel (M.Sc.) (Frey)
- Andrew Senchuk (Ph.D.) (Shamseddine, co-supervised with G. Gwinner, Manitoba)
- K. Shiells (Ph.D.) (Blunden)
- Mohammad Shirazi (Ph.D.) (Schippers)
- Olena Usoltseva (Ph.D.) (Prymak)
- Jennifer West (Ph.D.) (Safi-Harb)
- Xiaohong Zhang (Ph.D.) (Plosker, co-supervised with S. Kirkland, Manitoba)
- L.J. Zhou (Ph.D.) (Carrington/Kunstatter)

2.4 Undergraduate Research Students 2015-16

- S. Ahmed (Sirker)
- D. Allum (Trent University) (Kunstatter)
- A. Banerjee (Mitacs Globalink Research Intern) (Frey)
- B. Blaikie (O'Dea)
- G. Bookatz (Shamseddine)
- A. Gill (O'Dea)
- T. Hanson (Kunstatter)
- R. Hoult (Frey)
- B. Kacsmar (Plosker)
- J. Lasuik (Shalchi)
- C. Lawlor-Forsythe (O'Dea)
- C. McRae (Sirker)
- B. Meggison (Carrington)
- M. Radica (Co-op from McMaster) (O'Dea)
- R. Storey (Plosker)
- T. Xu (TRIUMF/UBC) (Bacca)
- Y. Zhan (Safi-Harb)

3 Research Interests of Members

M.E. Alexander

My principal research interest is the **mathematical modeling of complex biological systems**. One aspect is pattern formation (such as swarming/clustering behaviour of cells and other microorganisms). The second aspect is modelling the internal dynamics of cells and their interactions with the environment. The latter orchestrates collective behaviour at the macroscopic scale, giving rise to phase transitions, signalling dramatic changes in immune response, from containment to uncontrolled spread of infection. The mechanisms of interest are chemotaxis and electrotaxis, and I am collaborating with Dr Francis Lin's group (Univ. Of Manitoba, Physics) to complement their single-cell experimental studies. I have formulated a delay model for chemotactic memory through G-protein activation, by coupling the dynamics inside and on the surface of the cell with the extracellular environment. Also, we are formulating a electro-hydrodynamical model to attempt to

explain proton currents and cytoplasmic streaming inside of cells, based on experiments on behaviour of individual cells in an electric field.

A separate interest is in **close binary star systems**, and developing a model for stellar winds in subdwarf B-type binary systems, in order to explain observational data on orbital period changes in these systems. This work is in collaboration with Dr. D. Kilkenny (Univ. Western Cape, South Africa) and Dr. A.E. Lynas-Gray (Univ. of Oxford, UK), and a continuation of a project on the effects of stellar winds arising from the late-type secondary in these systems caused by irradiation by the hot subdwarf primary component. We are attempting to model the interaction of the wind with the magnetic field of the secondary, to try to explain the observed period changes in these systems, several of which cannot be explained by other mechanisms (e.g., Applegate mechanism, exoplanets, gravitational radiation).

Under contract to Newcastle Innovation Ltd. (Callaghan, New South Wales, Australia), I completed development of a fast algorithm for **analyzing 2D NMR spectra**. The goal was to replace current methods based on the Fast Fourier Transform, with a fast method for obtaining higher-resolution 2D spectra, with application to reliable early detection of breast cancer. The software developed will be used to clean up raw data acquired on a NMR spectrometer prior to submitting for classification of these spectra for disease diagnosis.

Finally, with Dr P. Shivakumar (Professor Emeritus, Univ. Manitoba) and collaborators, I analyzed a model for the dynamics and feedback control of a glucose-insulin system for diabetes. We are also finalizing a manuscript for publication as an undergraduategraduate-level monograph on modelling of biological systems.

S. Bacca

My research interests lie in nuclear physics, with a focus on the theoretical description of electro-weak observables.

Atomic nuclei are fascinating objects constituted of strongly interacting protons and neutrons. Nuclei drive the synthesis of the chemical elements, they serve as star fuel and as laboratories to test fundamental interactions and the Standard Model. Predictions of nuclear properties that start from the forces among nucleons and their interactions with external probes as described by chiral effective field theory, are arguably the doorway to a solid connection between experimental observations and the underlying fundamental theory of quantum chromo-dynamics. Forging such a strong tie is the objective of my research and is key to answer questions like: *How do protons and neutrons tie together to form stable and unstable nuclei and what are the limits of their existence? How can nuclear physics help discover properties of fundamental interactions and particles?*

Electro-weak observables are well suited to test the predictive power of nuclear theory. The perturbative nature of the electro-weak probes allows for a clear connection between measured cross sections and the calculated nuclear properties. I have a broad portfolio of interests on electro-weak observables, which connects to contemporary experimental efforts and has applications to nuclear physics, astrophysics, atomic physics and particle physics.

Electromagnetic reactions on light nuclei – I contributed to the study of electro-

magnetic reactions of light nuclei with a series of papers, the last being a commissioned review, which I wrote for J. Phys. G: Nucl. Part. Phys. (2014) together with S. Pastore. My theoretical studies have often motivated experimental activity. For example, the finding that the ^{4}He transition from factor strongly depends on nuclear forces and disagrees with previous experiments [Phys. Rev. Lett. **110**, 042503 (2013)] has led to new proposals to measure this observable via electron scattering [N. Pietralla *et al.*, DFG proposal, S-DALINAC, Darmstadt] and via $\alpha-$scattering [F. Cappuzzello (spokeperson), S. Bacca (co-spokeperson) *et al.*, LNS proposal, Catania].

Halo nuclei – Neutron-rich light nuclei exhibit fascinating phenomena like the formation of a halo structure of loosely-bound neutrons surrounding a tightly bound core, similar to electrons in atoms. The precise mass and charge radii measurements of halo nuclei harvested by the TITAN collaboration at TRIUMF are challenging *ab-initio* theories to provide theoretical interpretations of the data. I have built a strong collaboration with the experimentalists of the TITAN group that led to a joint experimental and theoretical publication [Phys. Rev. Lett. **108**, 052504 (2012), selected as *editor's suggested reading*], which pointed to the importance of three-nucleon forces in ^{6}He, the lightest of the halo nuclei. Refinements of the above mentioned calculations including a study of the convergence in chiral effective field theory and benchmarks with other many-body methods (such as the no-core-shell model and Green's function Monte Carlo method) will be investigated in the future.

Muonic atoms – The "proton radius puzzle" (7σ discrepancy between the proton charge radius extracted in muonic hydrogen and the one obtained from ordinary hydrogen) is posing one of the most compelling questions of the decade. Several beyond-the-standard-model theories, including lepton universality violations, have attempted to solve the puzzle. To date, no commonly accepted explanation of the puzzle exists. Owing to the heavier mass, the muon orbits much closer to the nucleus than does an electron, so that nuclear polarizations modify the atomic energy levels. The theoretical knowledge of such nuclear effects is key to the experimental program at PSI (Switzerland), aimed at shedding light on the proton radius puzzle. By measuring the Lamb-shifts in μ-D, μ-^{3}He$^+$ and μ-^{4}He$^+$, the CREMA collaboration plans to extract the charge radii of light nuclei and to investigate if the discrepancy with ordinary atoms persists or changes as a function of mass number and proton number. To help understanding the proton radius puzzle, I initiated a new research line to deliver the crucial theoretical estimates of nuclear structure corrections in muonic atoms. Using *ab-initio* theoretical tools for electromagnetic reactions, we have performed the first calculation of the nuclear polarizability corrections in μ-^{4}He$^+$ [Phys. Rev. Lett. **111**, 143402 (2013) and Phys. Rev. C **89**, 064317 (2014)] and in μ-D [Phys. Lett. B **736**, 344 (2014)] with chiral effective field theory. In the future, we plan to address μ-^{3}He$^+$ and to investigate nuclear structure corrections relevant to the hyperfine splitting measurements in light muonic atoms, planned at PSI.

Electro-weak reactions in medium-mass nuclei – Predictive *ab-initio* calculations of electro-weak reactions have traditionally been limited to relatively light mass number. Medium-mass and heavy nuclei are typically studied with more phenomenological theories, which, despite being extremely useful, lack a clear connection to quantum chromo-dynamics and solid estimates of the errors introduced by approximations. To extend *ab-initio* studies of electro-weak reactions to medium-mass nuclei, we recently

developed a new theoretical approach. We have merged the advantage of the Lorentz integral transform method (*i.e.*, transforming the continuum problem to a bound-state problem) with the mild computational scaling that characterizes coupled-cluster theory with increasing mass number. In a recent paper [Phys. Rev. Lett. **111**, 122502 (2013)] we have first benchmarked this theory on ^{4}He with exact hyperspherical harmonics and then presented the first calculations of the photodisintegration cross section in ^{16}O based on a realistic chiral potential. This study paves the way for many future investigations of continuum responses in medium-mass nuclei for both stable and unstable isotopes.

Applications to astrophysics – Nuclear physics and in particular electro-weak reactions, play a crucial role in nuclear astrophysics. Responding to the quest of improving the nuclear physics input in astrophysical simulations, I have investigated the neutrino response for neutron matter, relevant in supernovas and neutron star cooling [ApJ **758** 34 (2012)], where we found that that chiral effective field theory predicts such observable to be a factor of two smaller with respect to the simple model used in state-of-the-art supernova simulations. More recently, we investigated neutrino-bremsstrahlung from neutron-^{4}He collisions [arXiv:1411.3266], which may play an important role in the supernova environment, where both α-particles and neutrons are available.

Future – I plan to continue in these research directions and, in particular, further develop of the coupled-cluster theory for electro-weak reactions on medium-mass nuclei. My long-term goal is to use the *ab-initio* coupled-cluster technology to tackle neutrino-nucleus interactions. They are crucial to experiments aimed at measuring fundamental properties of neutrinos such as T2K, where presently the data analysis is systematically limited by simple nuclear models for the interaction of neutrinos with the nuclei in the detectors.

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

The objective underlying my research program is understanding the fundamental properties of nucleons and nuclei through electromagnetic and electroweak interactions.

In the electromagnetic sector, calculations of two-photon exchange (TPE) radiative corrections have been instrumental in resolving the discrepancy between measurements of electron-nucleon scattering form factors using Rosenbluth and polarization-transfer techniques. Pioneering calculations by our group have focussed on a hadronic approach to evaluating the model-dependent TPE amplitudes, including the contribution of nucleon resonances.

Precision low-energy experiments in atomic parity-violation and in parity-violating electron-proton scattering are a vital complement to direct tests of the Standard Model. They also give information about the structure of the proton, such as its weak charge

and strangeness content. These low-energy measurements have the potential to give constraints on new physics, provided that the critical radiative corrections involving hadronic contributions are understood.

A major component of my research is aimed at unravelling these hadronic contributions and their associated uncertainties. Complementary to the TPE program, electroweak radiative corrections from two-boson exchange involve physics on both low-energy hadronic (resonance region) and high-energy (deep inelastic and Regge region) scales. A significant advance by our group in recent years is to reduce the uncertainties associated with the model-dependence of these contributions by using dispersion relations based on structure function data. In addition to atomic parity-violation and the weak charge of the proton, this work is significant for a new generation of upcoming precision experiments utilizing parity- violating electron scattering.

M.E. Carrington

My main area of interest is statistical field theory, with particular emphasis on applications to the quark-gluon plasma. This type of research is also relevant in the context of the study of the early universe.

There are many technical problems associated with statistical field theory. The standard technique for doing field theoretic calculations is perturbation theory. At finite temperature, it has been known for some time that standard perturbation theory leads to inconsistent results. In many cases this problem can be resolved by using the effective expansion developed by Braaten and Pisarski which is based on the resummation of hard thermal loop diagrams into effective green functions.

For systems out of equilibrium, finite temperature field theory cannot be used and completely different techniques are required. There are several strategies that can be used if the system is close to equilibrium. Transport theory uses a linear response approximation to study the transport of conserved quantities over distances that are long compared to the microscopic relaxation scales of the system. There is a non-equilibrium generalization of the htl theory called the hard loop (hl) effective theory, which can be used to study dispersion relations at lowest order. One interesting phenomena that can be studied using this technique is plasma instabilities. These instabilities may significantly delay the equilibration of the system

Far from equilibrium situations require completely new techniques. One approach is the use of nPI effective theories which, in principle, can be used arbitrarily far from equilibrium.

T. Chakraborty

Spin Transport in a Quantum Dot

It has long been recognized that a two-dimensional electron gas (2DEG) in narrow-gap semiconductors, particularly in InAs-based systems with its high values of the g-factor, exhibit zero-field splitting due to the spin-orbit (SO) coupling. This coupling is also the driving mechanism for making futuristic devices based on controlled spin transport, such as a spin transistor, where the electron spins would precess (due to the SO coupling) while being transported through the 2DEG channel. Tuning of this precession in the proposed

spin transistor would provide an additional control that is not available in conventional devices, but may be crucial for the rapidly emerging field of semiconductor spintronics. We have developed a theoretical approach where the SO interaction is treated via exact diagonalization of the Hamiltonian for interacting electrons confined in a parabolic QD. Coulomb interaction causes energy levels to cross and at the crossing point magnetization shows a jump. In an magnetic field the strength of the SO coupling is proportional to the field (in addition to the coupling parameter and the angular momentum). Hence, the effect of the coupling is more prominent for slopes of the higher angular momenta energy curves. As a consequence, an increase in the SO coupling strength causes the energy level crossings to move to weaker fields and the jump in magnetization shows a large shift to weaker magnetic fields. This result can be exploited to tune the SO coupling strength that might be useful for spin transport.

Electron Dynamics in a DNA Molecule

The unique properties of DNA, self-assembly and molecular recognition, has rendered the 'molecule of life' a promising candidate in the rapidly emerging field of molecular nano-electronics. A recent report of a field-effect transistor based on DNA molecules, that was preceded by a series of seminal experiments on the electron conduction in DNA, has sparked a lot of interest on the electronic properties of the DNA. A thorough understanding of the electronic properties of DNA is crucial in the development of the future DNA-based nanoscale devices. In addition, charge transfer through DNA also plays an important role in radiation damage and repair and therefore important for biological processes. We have preformed theoretical calculations of the electron energy spectrum, based on a two-leg charge ladder model for the poly(dA)-poly(dT) DNA and poly(dG)-poly(dC) DNA molecules. We take the electron-electron interactions and the electron spin degree of freedom fully into account in our model. The energy spectra for the G-C and the A-T base pairs show a large gap and the interaction was found to enhance the gap. The effect of interaction is less pronounced for the G-C base pairs than that of the A-T pairs. The spin-flip excitations are not the lowest energy excitations. We also analyze the charge distribution for the ground state as well as for the excitations.

J.D. Fiege

My research program involves three areas of astrophysics, plus an interdisciplinary project in medical physics. The common thread of this research is the application of sophisticated optimization methods solve very large multi objective optimization problems or to mode data. The various components of this research program are enumerated below.

1. Gravitational lens modeling: Gravitational lens systems probe the structure of dark matter haloes, while also using these systems as natural telescopes to study distant extra galactic sources. My Ph.D. student Adam Rogers and I have developed new and very efficient methods to explore and reconstruct the lens density profile and background source in gravitational lens systems, leading to the largest lens reconstructions in the literature.

2. Polarization modeling: Submillimetre polarization mapping is the best observational technique to study magnetic fields in molecular cloud cores. My M.Sc. student Erica Franzmann and I have developed a modeling technique to simultaneously constrain

the density structure and magnetic field geometry in cores and filaments. We are providing theoretical support to two international surveys (JCMT Gould's Belt survey and a CARMA polarization survey).

3. I develop a code called "GalAPAGOS" (Galaxy Parameter Aquisition by Genetic Optimization Software), which uses a genetic algorithm to constrain the kinematics of rotating neutral hydrogen (HI) disks in galaxies by modeling their HI data cubes.

4. I collaborate with Boyd McCurdy on the development of a code called PARETO, as part of unique interdisciplinary project in medical physics, which applies optimization methods to treatment planning in cancer radiotherapy. PARETO is the first software package to use a multi objective GA (Ferret) to simultaneously optimize radiation beam orientations and fluence patterns by solving a large scale, monolithic, multi objective optimization problem.

A. R. Frey

I have a wide range of interests in high-energy theoretical physics, encompassing topics from particle physics phenomenology to formal string theory. I am currently working in three areas.

One focus of my research aims to discover the composition of the modern universe, specifically uncovering the nature of dark matter, yet-to-be-discovered particles known only by their influence on gravity. We are in an era of rapid discovery, with multiple experiments to detect dark matter now active and highly sensitive astrophysical observatories. I relate models of dark matter favored by terrestrial detection experiments can affect astrophysics, finding new tools in astrophysics to unravel the mystery of dark matter, with a particular expertise in models including a new non-Abelian gauge group. As more data becomes available, I am also interested in interpreting results from the Large Hadron Collider at CERN.

Another area of interest is developing a deeper understanding of models of extra dimensions in string theory that have been discovered in the last 15 years. Specifically, I study the relationship of the full 10-dimensional theory to the effective 4-dimensional physics we would observe. I have carried out the first derivations of 4D quantities from the 10D theory; in addition, I am interested in understanding the 10D origins of various contributions to the 4D potential energy that have mostly been considered from the perspective of the 4D effective theory only (specifically including curvature, brane tensions, and gaugino condensation).

At present, the main thread of my research program consists of investigating the stability of small amounts of matter in AdS against gravitational collapse to a black hole. This system has important consequences for non-equilibrium dynamics of strongly coupled gauge theories due to gauge/gravity duality as well the mathematics of nonlinear wave equations on bounded spaces. The key question is whether energy, which cannot disperse in these systems, generically cascades to higher frequency modes, leading to a loss of smoothness, and, in the gravitational context, black hole formation (dual to thermalization of a gauge theory). I am specifically interested in studying systems with additional mass scales and testing whether perturbative approximations can help answer questions of genericity.

T.D. Fugleberg

My current research interests are in three main areas.

The first is the study of a novel form of superconductivity called colour superconductivity. This is the study of a new state of matter - the colour superconducting state - which may be present in neutron and/or quark stars with consequences detectable in astronomical observations. The colour superconducting state arises in the theory of the strong nuclear force, Quantum Chromodynamics, (QCD). I have looked at refining models used in this analysis to include the physical masses of the quarks and other degrees of freedom in as complete a way as possible in order to make definitive quantitative predictions for observation. This research involves free colour charge and is thus related to the main unsolved problem of QCD - colour confinement.

The second area is non-equilibrium and thermal field theory. Both of these topics have important applications in the physics of the early universe and in heavy ion collisions. I am developing techniques for simplifying calculations in the real time formalism of thermal field theory. Non-equilibrium field theory is still in its infancy but has important implications in the search for the quark gluon plasma and the evolution of the universe immediately following the big bang.

The third area of research is in the area of quantum computation. A computer designed to utilize quantum mechanical indeterminacy in the computation process will theoretically be capable of solving difficult problems much more rapidly than a classical computer. This has important implications since international monetary security depends on cryptographic systems based on the fact that certain problems are "too hard" to solve in a reasonable amount of time. Since very simple quantum computers have already been constructed, quantum computation is a very important field of research. In particular I have been studying a particular model of quantum computation - adiabatic quantum computation - with the goal of gaining insight into the fundamental physical quantity or quantities responsible for the power of a quantum computer.

D. Krepski

Research interests: symplectic geometry, algebraic topology, Lie groups and groupoids, Hamiltonian actions, momentum maps, geometric quantization, Verlinde algebra.

G. Kunstatter

In February of 2016, the LIGO (Light Interference Gravitational wave Observatory) Scientific Collaboration announced the detection of gravitational waves emitted by the merger of two massive black holes a billion years ago. This observation provided astounding confirmation of the validity of Einstein's theory of gravity in the strong field region as well as the first direct evidence for the existence of black holes.

According to Einstein's theory, at the center of every black hole there exists a singularity, a region of infinite density and curvature, where the known laws of physics break down. Such singularities do not pose a threat as long as they are concealed beneath the event horizon of a black hole. In the mid 1970's Stephen Hawking showed that quantum processes near the event horizon allow energy to leak out in the form of thermal radiation.

This radiation causes the black hole to shrink and eventually disappear without revealing any information about the matter that fell into the black hole. Consequently black holes appear to have the capacity to irreversibly destroy information, leading to the so-called "black hole information loss conundrum". It is commonly believed that the information loss conundrum can only be fully resolved once quantum mechanics is successfully unified with gravitation theory, something that has eluded theoretical physicists for many decades.

My research for the past few years has focussed on simple models of black formation and evaporation in which the singularity has been eliminated, ostensibly by quantum gravitational effects. Recently, collaborators and I constructed a new and powerful model well suited for this purpose. I am currently investigating in detail the implications of this model for the information loss conundrum. This research will move us closer to the resolution of a long standing, fundamental problem in theoretical physics.

P.D. Loly

Our use of modern data mining techniques to examine simple matrices, triggered by a 2010 paper by Newton and DeSalvo, involving Shannon entropy and a novel index for integer polynomials, has now been extended to the quantum angular momentum matrices, with some interesting preliminary results, and to multimagic squares. The latter, popularized by Christian Boyer, where the rows, columns and main diagonals of full cover magic squares have common "magic" linesums for integer powers p of each element. Bimagic squares corresponding to p=2 begin at orders 8 and 9, trimagic for p=3 begin at order 12, etc. Adam Rogers observed before 2007 that Latin squares are "multi-semi-magic" for rows and columns. Christian Eggermont called diagonal Latin squares "infinitely-multimagic squares" in a 2004 talk. Now after Ron Nordgren drew our attention to Knut Vik Latin designs (which begin at orders 5,7,11,...) and have the pandiagonal property that all transversals parallel to the main diagonals have a common linesum, we realized that Knut Vik squares are "pandiagonal multimagic" to all integer powers. In fact to any power! Moreover following Heyadat and Federer, and our recent studies (Cameron, Rogers and Loly, DMPS 2013), these can be compounded to construct Knut Vik designs of multiplicative orders 5*5,5*7,...

This project, begun early in 2010 with Ian Cameron and Adam Rogers has matured to provide robust measures for comparing doubly stochastic matrices, principally the integer Latin and natural magic squares, by elucidating clan signatures (distinct singular value sets) first glimpsed in P.D. Loly, I.D. Cameron, W. Trump and D.S. Schindel, "Magic square spectra", Linear Algebra Appl. 430 (10) 2659-2680 (2009). This project resulted in a delay in completing several other projects, which were the subject of 2008 and 2009 conference talks, but which can now take advantage of these new features. These can now be completed, taking advantage of the new measures.

In addition we are revisiting the issue of Franklin squares, Schindel, Rempel and Loly, Proc. Roy. Soc. A 462 (2072) 2205-2540 (2006), from order 8 to order 8k, k=2,3,,,, as a result of renewed interest in rank three matrices.

Website: http://home.cc.umanitoba.ca/˜loly/

C. O'Dea

My research is centered on investigating how super massive Black Holes influence their host galaxies, and how the galaxies influence the properties of the Black Hole in turn. We now know that massive black holes form as part of the process of galaxy formation with about 0.1% of the mass of the galaxy going into the central black hole. Whenever gas in the galaxy is able to penetrate down to the vicinity of the black hole large amounts of energy are released. A bright disk of gas (accretion disk) can form if the amount of gas is sufficiently high. In addition, in some cases outflows (jets) of hot plasma and magnetic fields are ejected at velocities approaching the speed of light carrying large amounts of energy. These outflows emit at radio wavelengths - hence the name "radio source". Galaxies in which the black hole and accretion disk are generating radiation and/or a powerful outflow are called Active Galactic Nuclei. I investigate the process of providing gas to the black hole, the formation of the jets, the propagation of the radio source and the interaction of the radio source with the environment. The transfer of energy from the radio source to the environment turns out to provide the solution to a number of outstanding problems in galaxy formation and clusters of galaxies.

T.A. Osborn

My research program aims to achieve a unification of classical and quantum mechanics in a common mathematical framework. The theory that emerges (quantum phase space, QPS) is an altered version of classical phase space in which the usual commutative product of functions is deformed (as Planck's constant varies away from zero) into a noncommutative (star) product. With this one structural modification it is possible to state the full content of quantum mechanics as a noncommutative phase-space theory. In this setting, the Schrödinger wave function never arises, Hilbert space operators are represented by phase-space (Wigner) distributions, and quantum expectation values are given by integrals over phase space. This unification via QPS provides an alternate, autonomous statement of quantum mechanics that clarifies its content and interpretation and at the same time provides a new computational platform that has many parallels to that of classical mechanics.

A series of papers have investigated the quantization of charged particle systems moving in time dependent inhomogeneous magnetic fields on both flat and curved manifolds. This joint work with Mikhail Karasev has developed a QPS representation that is both gauge and geometrically covariant and has an exact star product determined by a symplectic area phase. The resulting quantum phase space that arises has a curvature which is a function of the electromagnetic field entangled with the Riemannian curvature. The discovery of this quantization induced curvature raises a variety of questions: Is this curvature really a part of nature? Can it be measured? Ongoing projects aim at establishing the ways this curvature can be detected.

A second theme in my current research applies the general concepts and methods of noncommutative phase space to problems in quantum optics. This new research direction is undertaken with Karl-Peter Marzlin (St. Francis Xavier). At present, a paper that obtains an exact solution to quantum dynamics for Kerr type nonlinear optical media is complete. For squeezed states, this work predicts a detectable, half-period resonance-

like phenomena. Currently we aim to extend this program by 1) including multimode phenomena in nonlinear quantum optics, 2) obtaining QPS representations of photon entanglement, and 3) developing a quantum phase-space theory for open quantum optical systems coupled to a heat bath.

S. Plosker

My research interests fall under the general umbrella of operator theory and matrix analysis, with applications to quantum information theory. Quantum information theory is the study of quantum properties that can be used to store, transmit, and process information in an efficient, accurate, and secure way. My approach is to build up the mathematical foundations for physical realizations in quantum mechanics through operator theory and matrix algebra techniques with the end goal of advancing the mathematics behind quantum information theory. My current focus is on private quantum channels (quantum cryptography), positive operator valued measures (POVMs), quantum fidelity (probability of state transfer), majorization, and trumping.

A. Prymak

Research interests: Approximation theory and geometric methods in analysis, shape-preserving approximation, measures of smoothness and approximation, relations to other areas of analysis (geometry of Banach spaces, harmonic analysis, Fourier analysis) and mathematics (graph theory), convexity, computational and numerical methods, some problems in quantum information theory (perfect state transfer, mutually unbiased bases).

S. Safi-Harb

My research is focused on the study of supernova remnants (SNRs) and associated phenomena. These include neutron stars, pulsar wind nebulae, the interaction of these objects with the interstellar medium, and the acceleration of cosmic rays at supernova shocks. The science goals of my program are targeted to understand the aftermath of a supernova explosion, the growing diversity of neutron stars (including magnetars), their relativistic outflows, their evolution and interaction with their hosting supernova remnant shells, and the acceleration of cosmic rays to extremely high energies. My program makes use of multi-wavelength observations from radio to very high-energies, with focus on X-ray data acquired with NASA's Chandra and ESA's XMM-Newton telescopes. I am also a member of the international, JAXA-led, ASTRO-H (renamed to Hitomi) X-ray satellite and serve on the science team for the future ATHENA X-ray mission. At gamma-ray energies, I am an associate member of the currently operating H.E.S.S. mission and a member of the upcoming Cherenkov Telescope Facility (CTA). My team also includes numericists/theorists developing models, performing state-of-the-art numerical simulations to apply to data, and making use of a local CFI-funded computing cluster.

E. Schippers

My research interests are in three areas of pure mathematics: complex analysis, Teichmuller theory, and conformal field theory. A unifying theme is the construction and investigation of conformal invariants. These appear in the three fields in very different forms. My work over the next few years will unify these different forms.

Conformal field theory: My work relates to a programme of finding a rigorous mathematical construction of two-dimensional conformal field theory. This programme has been active since the 80s and relates to many disparate branches of mathematics, including representation theory of Lie algebras and vertex operator algebras, so-called monstrous moonshine and modularity, moduli spaces of Riemann surfaces, and stochastic processes.

Friedan/Shenker and Vafa considered moduli spaces of Riemann surfaces with extra data, formulated either as boundary parametrizations or collections of non-overlapping mappings. With David Radnell, I showed that this moduli space is in fact the quasiconformal Teichmuller space. This allowed the resolution of certain analytic problems in the programme of construction of 2D conformal field theory: for example, we showed that the moduli space has a complex structure and the sewing operation is holomorphic. In further work with W. Staubach, we constructed a Teichmuller space modelled on square-integrable local deformations, which we conjecture to be the correct space for the existence of a determinant line bundle of dbar operators with boundary data, which is central to the construction of CFT from moduli spaces of Riemann surfaces.

Future projects include the demonstration of the convergence of the determinant of the operators over the refined space, and drawing connections with classical objects of complex function theory. This will lead to new algebraic and geometric structure in function theory, as well as making function theoretic techniques newly available for the CFT programme.

Teichmuller theory: I also work on applying ideas of conformal field theory to Teichmuller theory.The problem of refinement of Teichmuller space to a smaller space appropriate for conformal field theory was decribed above. It also has implications for Teichmuller theory. Namely, this is precisely the space on which the so-called Weil-Petersson metric converges. The Weil-Petersson metric is a main tool in the investigation of Teichmuller spaces, but until recently has only been available for finite-dimensional Teichmuller spaces. Work of Takhtajan and Teo, as well as our work, considerably broadens its applications.

Another example is that the correspondence between the rigged moduli space of Friedan/Shenker and Vafa described above implies the existence of geometric and aglebraic structure on Teichmuller space. In particular, with D. Radnell I showed that Teichmuller space has a fiber structure. We also showed that the operation of sewing induces an algebraic operation on Teichmuller space. In the case of annuli, this is a group operation, which closely relates to the representation theory of certain function spaces by composition operators.

Future work involves construction of modular invariants on Teichmuller space, and relating them to conformal invariants and the determinant line bundle of dbar operators with boundary data.

Complex analysis: My work in complex analysis is mostly in geometric function theory, which studies the geometric properties of classes of complex analytic functions. It involves for example construction of new variational techniques; discovery of Lie-theoretic structure in semi-groups of complex analytic maps; construction of conformal invariants, from conformal metrics or potential theory; and general techniques for the solution of extremal problems.

In very recent work, I have constructed a complete set of conformal invariants for the case of complex analytic maps from one simply-connected domain into another. These invariants form an infinite-dimensional family, which is necessary to uniquely characterize elements of this space of maps.

In unpublished work I showed that these invariants can be seen as modular invariants on the Teichmuller space of annuli, and that these can be significantly generalized to arbitrary Riemann surfaces. In future work I plan to show that these generalize the so-called theta functions on Teichmuller space of compact Riemann surface to open Riemann surfaces; on these spaces, they are infinite dimensional. Furthermore, they will have applications to understanding so-called modularity phenomena in the conformal field theory setting, and to the investigation of connections on moduli spaces of Riemann surfaces.

A. Shalchi

A fundamental problem in astrophysics is the interaction between space plasmas and energetic particles. Space plasmas can be found in any astrophysical scenario. This could be the plasma of the solar wind or the interstellar medium. Examples for energetic particles are the so-called Solar Energetic Particles (SEPs) and Cosmic Rays. These particles experience strong scattering while they propagate through the interplanetary or interstellar space. Describing these scattering effects theoretically is important to understand the motion of Cosmic Rays through the Universe and the mechanism of diffusive shock acceleration. The latter mechanism is important for understanding the origin of cosmic radiation.

In recent years we have achieved a more complete understanding of the fundamental scattering mechanisms due to the development of computer simulations and nonlinear diffusion theories. Currently, our research team explores these scattering mechanisms to achieve further progress in the theory of charged particle transport by using numerical and analytical tools. The results are applied to different physical scenarios such as Cosmic Ray propagation and acceleration of particles at interplanetary shocks and supernova remnants.

Khodr M. Shamseddine

My research interests and activities include various areas of non-Archimedean Analysis: power series and analytic functions, measure theory and integration, optimization, existence and uniqueness of solutions of differential equations, complex analysis, multivariable analysis, and functional analysis. The focus of my research has been on the Levi-Civita fields which were first introduced by the Italian mathematician Tullio Levi-Civita at the end of the nineteenth century. Of those Levi-Civita fields, one (which we denote by $\mathcal{R}$) is of particular interest; it is shown to be the smallest non-Archimedean field extension

of the real numbers that is complete in the order topology and real closed. In fact, $\mathcal{R}$ is small enough so that the numbers of the field can be implemented on a computer; and this allows for many useful applications, one of which is the fast and accurate computation of the derivatives of real-valued functions up to high orders. Such computational applications are not possible with the structures of the field of Non-Standard Analysis. While in the latter discipline, there is a generally valid transfer principle that allows the transformation of known results of conventional analysis, here all relevant calculus theorems are developed separately. Moreover, the Levi-Civita field $\mathcal{R}$ is not only non-Archimedeanly valued but it also has a total order (which is also non-Archimedean) yielding a richer structure, thus opening up new possibilities of study, like monotonicity, which are not available in other non-Archimedean valued fields like the p-adic fields for example. This makes $\mathcal{R}$ an outstanding example, worth to be studied in detail in its own right.

We have studied convergence of sequences and series in two different topologies, which led to an exhaustive study of power series. A handful of people had investigated power series on the Levi-Civita fields before, but all the previous studies had been restricted to the special case of power series with real coefficients. We have dropped that restriction and showed that power series on Levi-Civita fields have all the nice smoothness properties that real power series have. In particular, they satisfy the intermediate value theorem, the extreme value theorem, and the mean value theorem; they are infinitely often differentiable; and they are re-expandable around any point within their domain of convergence.

While it is a known fact that conventional continuity or differentiability are not sufficient to guarantee that a function on a closed interval of a non-Archimedean field be bounded or satisfy any of the common theorems of real calculus, we have shown that under mild conditions, differentiability is sufficient for the function to assume all intermediate values and have a differentiable inverse function. We also showed that conventional differentiability is not the right one to study optimization questions on non-Archimedean fields in general; and based on a stronger concept of differentiability, we studied finite-dimensional optimization both with and without constraints. In both cases, we derived necessary and sufficient conditions of first and second order for a function to have a local minimum (or maximum) at a point of its domain.

We developed a measure theory and integration on the Levi-Civita field $\mathcal{R}$. We introduced a measure that proved to be a natural generalization of the Lebesgue measure on the field of the real numbers and to have similar properties. Then we introduced a family of simple functions from which we obtained a larger family of measurable functions. We showed how to integrate measurable functions over measurable sets, and we showed that the resulting integral satisfies similar properties to those of the Lebesgue integral of Real Analysis.

We studied existence and uniqueness of solutions of ordinary differential equations (ODE's) over $\mathcal{R}$. In particular, we showed that an ODE of the form $[y'(t) = f(y,t); y(a) = y_0]$, with $f(y,t)$ infinitely often derivate differentiable, admits a solution that is itself infinitely often derivate differentiable and that the solution so obtained is unique among all the in-

finitely often derivate differentibale functions.

We studied two topologies on $\mathcal{R}$: the valuation topology induced by the order on the field, and another weaker topology induced by a family of seminorms, which we call weak topology. We showed that each of the two topologies results from a metric on $\mathcal{R}$, that the valuation topology is not a vector topology while the weak topology is, and that $\mathcal{R}$ is complete in the valuation topology while it is not in the weak topology. Then we studied the properties of both topologies in detail; in particular, we gave simple characterizations of open, closed, and compact sets in both topologies. Finally, we showed that the metric which induces the weak topology is translation invariant.

Most recently, together with two collaborators from Chile, we developed an operator Theory on a Banach space over $\mathcal{C} := \mathcal{R} \oplus i\mathcal{R}$. Let c_0 denote the space of all null sequences $x = (a_n)$, $a_n \in \mathcal{C}$. The natural inner product on c_0 induces the sup-norm of c_0. We showed that c_0 is not orthomodular then we characterized those closed subspaces of c_0 with an orthonormal complement with respect to the inner product; that is, those closed subspaces M of c_0 such that $c_0 = M \oplus M^{\perp}$. Such a subspace, together with its orthonormal complement, defines a special kind of projection, the so-called normal projection. We presented a characterization of such normal projections as well as a characterization of other kinds of operators, the self-adjoint and compact operators on c_0. Then we worked on some B*-algebras of operators, including those mentioned above; we studied normal and Hilbert-Schmidt operators; and finally, we studied the properties of positive operators on c_0, which we then used to introduce a partial order on the B^*-algebra of compact and self-adjoint operators on c_0 and studied the properties of that partial order.

While the Levi-Civita field $\mathcal{R}$ is interesting to study in detail for the reasons stated above, I have recently started expanding my research focus to include any non-Archimedean field F extension of the real numbers R that is real closed and complete in the topology induced by the order and whose Hahn group is Archimedean. For example, with two NSERC USRA students, I recently proved the inverse function theorem and implicit function theorem for locally uniformly differentiable functions from F^n to F^n and from F^n to F^m $(m < n)$, respectively. Then, in a followup paper, we studied the properties of locally uniformly differentiable functions on F or F^n, and most recently, we proved a local version of the mean value theorem and Taylor's theorem for locally uniformly differentiable functions on F. Enlarging the scope of my research will make it more interesting to a wider audience of mathematicians and will thus open the door to new collaborations in non-Archimedean Analysis.

J. Sirker

Quantum mechanics predicts that electrons in a solid or atoms in a gas can loose there single particle properties completely and instead start behaving collectively. This often leads to the emergence of new states of matter which are a fascinating topic for fundamental research and offer the potential for technological advances. Important examples include high-temperature superconductivity in certain cuprates and iron pnictides, quan-

tum wires such as carbon nanotubes, as well as the Bose-Einstein condensation in trapped atomic gases at ultracold temperatures.

More specifically, my research interests lie in the theoretical explanation of the physics of such strongly correlated quantum systems. Recent publications include work on:

- Quenches, thermalization, and many-body localization in quantum systems,
- transport in spin chains and quantum wires,
- multiferroic behavior in spin chains,
- domain walls in ferromagnetic Luttinger liquids,
- compounds with orbital degrees of freedom,
- quantum critical points in magnetic systems with frustration,
- field- or pressure-driven phase transitions in magnetic systems (Bose-Einstein condensation of magnons).

My research on these topics often combines field-theoretical methods (bosonization, conformal field theory, nonlinear sigma-models, renormalization group) with numerical methods, in particular, the density-matrix renormalization group (DMRG). Recently, we have developed in my group several new DMRG-type algorithms to study quantum dynamics both in equilibrium at finite temperatures and in non-equilibrium following a quantum quench.

B.W. Southern

Nanomagnetism

The study of magnetism in confined geometries has produced much new science and many technical applications in the past thirty years and will continue to be a rewarding area of research yielding applications in the foreseeable future. Confined systems that exhibit novel properties often consist of dissimilar materials that include at least one or more magnetic component (ferromagnetic, antiferromagnetic, etc.). A fundamental understanding of nanomagnetism will lead to the development of integrated systems with complex structures and architectures that possess new functionalities. Controlled release of drugs from nanostructured functional materials, especially nanoparticles, is attracting increasing attention because of the opportunities in cancer therapy and the treatment of other ailments. The potential of magnetic nanoparticles stems from the intrinsic properties of their magnetic cores combined with their drug loading capability and the biochemical properties that can be bestowed on them by means of a suitable coating. Magnetic properties at interfaces and surfaces, which make up a large fraction of nanostructured and confined materials, can be qualitatively different from those of bulk systems. Fundamental to understanding these differences is understanding the evolution of the magnetism as the structural scale descends from the bulk to the nanoscale. Due to reduced symmetry, the magnetic anisotropy at a surface or interface can be orders of magnitude larger than in the bulk. This result can lead to magnetic frustration and

reorientation of the magnetization at the surface and interface. For example, when in contact with an antiferromagnet, the properties of a ferromagnet change dramatically; the coercive field is enhanced and, the magnetization curve can become asymmetric showing the exchange bias effect. My research is investigating the complex atomic spin structure of magnetic nanostructures using both analytic and computational approaches in order to gain a fundamental understanding of nanomagnetism.

J. P. Svenne

Our current work involves work with a multi-channel algebraic system (MCAS) to study scattering of nucleons from light nuclei, and reactions initiated by such. This is a four-continent collaboration with Drs. L. Canton, G. Pisent (Padova University, Italy), S. Karataglidis (University of Johannesburg, S.A.) and K. Amos, Paul R. Fraser (now at Padova, It.) and D. van der Knijff (Melbourne University, Australia). The theory uses expansions in Sturmian functions of the channel-coupling interactions, leading to an algebraic solution of the coupled integral equations of the multichannel problem. This enables us to allow for the Pauli principle in the context of a collective model description of the target nucleus, by the use of orthogonalizing pseudo-potentials. The algebraic solution provides us a method of locating all resonances, no matter how narrow, as well as all bound states of the compound system, without the use of an excessively fine energy step sizes. Satisfying the Pauli principle is an essential aspect of the theory, as it removes any spuriosity, in both bound states and resonances and thus provides a theoretical formulation of the scattering problem that has predictive power. The results of the calculations can also be used to give accurate interpretation of the nuclear structure of the target nucleus and the compound system. Our first work was on the well-studied, both theoretically and experimentally, nucleus ^{12}C, with scattering by both neutrons and protons, with inclusion of the Coulomb force. The results compare very well with experiment. We are now working on other light and medium mass nuclear systems including systems well away from the valley of stability. We use the method of mirror nuclei to reach proton-rich nuclei at or near the proton drip line. A "proof of concept" paper for the MCAS method [K. Amos, et al, Nuclear Physics **A728**, 65 (2003)] was our publication in 2006 [L. Canton *et al*,Phys. Rev. Letters, **96**, 072502 (2006)], where we predicted narrow states in the proton-unstable nucleus ^{15}F, whose existence were confirmed in 2009 [Mukha, *et al*, Phys. Rev. C **79**, 061301 (2009)]. Two new developments are our ability, now, to consider systems in which the target nuclei may have particle-unstable excited states, and the ability to apply MCAS to study hypernuclei. The first has been published in a Physical Review Letter and in the Mexican J. of Physics (see publication list, below). The work on hypernuclei has been published in the International Journal of Modern Physics.

G. Tabisz

My research interests involve the theoretical and experimental study of the interaction of light with molecules with the aim of obtaining information on intra- and inter- molecular dynamical processes. Current areas of special interest are nonlinear optical rotation effects in chiral molecules and the theory of collision-broadened spectral line shapes.

J.M. Vail

My principal research area has been in 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. I maintain an interest in my last publication, on the properties of anionsite defects in AlN, a wide band-gap insulator.

My current research is on Charge density waves having the electronic properties of graphene: stability conditions. It examines the physical limitations for stability of such CDWs, and the dependence of the total energy upon the parameter which defines the effective electron-electron interaction, including the phonon-mediated component. A report is being written for publication.

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 .

M. Whitmore

My research group does theoretical studies of soft condensed matter systems, in particular inhomogeneous copolymer systems and end-tethered polymers. These molecules have relatively high molecular weights, have chemically distinct sections, and are chain-like in structure. As a result, they can self-assemble to form complex nano-scale structures, and undergo subtle phase transitions. The end-tethered polymers can be used to stabilize colloids, control the properties of functional surfaces, and control transport properties inside microtubles. We use a variety of techniques including self-consistent feld theory and, with our collaborators, Monte Carlo and molecular dynamics simulations. Our recent work on copolymers has been on the analysis of cylinder-forming polymers, and the use of fluorescence decay measurements to extract detailed interfacial properties. Our work on end-tethered polymers has included identifying universal control parameters of polymers inside microtubles, and flow through these and other related systems. Most recently, we have combined a variety of computational and experimental results into an integrated

picture of end-tethered polymers covering the full range of systems from the one limit of a single, isolated chain through to the other limit of high anchoring density. In addition to formulating this consistent picture, our results provide corrections to previous theories of the two limits, including those introduced by de Gennes and coworkers.

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 includes 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. More recently, I have been studying aspects of a new approach to general relativity due to Ted Newman and his group: the null surface formulation. In this approach, it is the intersection of the light cone with null infinity, the so-called light cone cut, that plays the major role. The metric is no longer a fundamental quantity, but is derivable (to within a conformal factor) from the light cone cut function. Progress to-date includes the explicit construction of a light cone cut function for a (2+1)-dimensional Friedman-Robertson-Walker spacetime and the calculation of the standard NSF functions for this model. Future effort will be directed towards the construction of such cut functions for asymptotically flat spacetimes and the analysis of any resulting singularities.

4 Research Activities

4.1 Visitors: 2012-2016

Date	Visitor	Institution	Host
Nov. 21-25, 2016	Nicholas Sedlmayr	Michigan State University (USA)	J. Sirker
Oct. 18-27, 2016	Hideki Maeda	Hokkai-Gakuen University (Japan)	G. Kunstatter
June 27-July 1, 2016	Jorma Louko	University of Nottingham (UK)	G. Kunstatter
May 16-20, 2016	Nathaniel Johnston	Mount Allison University	S. Plosker
Nov. 5-7, 2015	George Sawatzky	UBC	J. Sirker
Oct. 21-24, 2015	Christopher Fryer	Los Alamos National Laboratory	S. Safi-Harb
Sep. 30-Oct. 2, 2015	Saurya Das	University of Lethbridge	G. Kunstatter
Aug. 12-14, 2015	Sonia Bacca	TRIUMF	J. Svenne
July 16-25, 2015	Hideki Maeda	Hokkai-Gakuen University (Japan)	G. Kunstatter
May 11-20, 2015	Chi-Kwong Li	College of William and Mary (USA)	S. Plosker
Dec. 2-5, 2014	Herb Fertig	Indiana University	T. Chakraborty
Oct. 22-23, 2014	Zlatko Papic	Perimeter Institute	J. Sirker
Oct. 3, 2014	Vikram Dwarkadas	University of Chicago	S. Safi-Harb
Aug. 11 - Sep. 16, 2014	Valentin Freilikher	Bar-Ilan University	J. Page (Manitoba)
May 22-27, 2014	Bret Underwood	Pacific Lutheran University	A. Frey
Jan. 3- July 7, 2014	Tim Taves	C.E.C.s., Chile	G. Kunstatter
Sept. 26-27, 2013	Tom Jones	University of Minnesota	S. Safi-Harb
Aug. 7-10, 2013	David Garfinkle	Oakland University	G. Kunstatter
Jan. 31- Feb. 2, 2013	Sonia Bacca	TRIUMF	J. Svenne
Nov. 7-10, 2012	Keshav Dasgupta	McGill University	A. Frey
Aug. 15-20, 2012	Ehsan Hatefi	I.C.T.P., Trieste	G. Kunstatter/A. Frey
May 21-June 5, 2012	Hideki Maeda	C.E.C.s., Chile	G. Kunstatter
April 1-9, 2012	Jorma Louko	University of Nottingham, U.K.	G. Kunstatter
Feb. 16-18, 2012	R. Brandenberger	McGill Univeresity	G. Kunstatter/A. Frey
Jan.-Apr., 2012	R. Daghigh	Metropolitan State University	G. Kunstatter

4.2 Seminars: 2012-2016

Date	Speaker	Title
Dec. 2, 2016	A. Rogers	"Gravitational Lensing by Compact Objects in Plasma Environments"
Nov. 25, 2016	N. Sedlmayr	"The Superconductivity of Topologically Protected Surface States"
Oct. 21, 2016	H. Maeda	"Exact Solutions with a Scalar Field in General Relativity"
June 29, 2016	J. Louko	"Low Energy Lorentz Violation from High Energy Modified Dispersion"
April 1, 2016	A. Frey	"Black Hole Formation in Anti-de Sitter Spacetime (and What it Means)"
March 10, 2016	A. Prymak	"Compressed Sensing and Quantum State Tomography"
Jan. 28, 2016	S. Wykes	"HD simulations of internal jet-stellar wind interactions: the case of Centaurus A"
Nov. 26, 2015	E. Schippers	"Quasiconformal Teichmuller Theory and Conformal Field Theory"
Nov. 12, 2015	G. Ferrand	"Simulating particle acceleration in supernova remnants"
Nov. 6, 2015	G. Sawatzky	"Electronic structure of the doped Cuprates, Nickelates and superconducting Bismuthates"
Oct. 23, 2015	C. Fryer	"Chasing the Supernova Engine"
Oct. 1, 2015	S. Das	"Quantum Raychaudhuri equation and its applications to gravity and cosmology"
Aug. 13, 2015	S. Bacca	"From Neutron-Rich Nuclei to Stars"
July 17, 2015	H. Maeda	"Unitary Evolution of the Quantum Universe with a Brown-Kuchar Dust"
April 1, 2015	D. Krepski	"Group-valued moment maps and quantization"
Dec. 3, 2014	H. Fertig	"Topological Edges and Defects of Quantized Hall States in Graphene"
Oct. 22, 2014	Z. Papic	"Entanglement and dynamics in topological phases and interacting disordered systems"
Oct. 10, 2014	S. Kirkland	"Sensitivity Analysis for Perfect State Transfer in Quantum Spin Networks"
Oct. 3, 2014	V. Dwarkadas	"CSI Supernova: Hydrodynamic and X-ray Modeling of the Circumstellar Medium as Clues to Supernova Progenitors"
Sep. 18, 2014	W. Töws	"Many-body theory of laser-induced ultrafast demagnetization and angular momentum transfer in ferromagnetic transition metals"
Sep. 15, 2014	V. Freilikher	"Charge transport in graphen and light propagation in dielectric structures with metamaterials: A comparative study"
July 2, 2014	T. Taves	"Modelling the Evaporation of Non-singular Black Holes"
May 26, 2014	B. Underwood	"Non-Canonical Scalar Fields in Inflation and Reheating"
March 20, 2014	S. Plosker	"On Majorization and Trumping"
Sep. 27, 2013	T. Jones	"The Interplay of Shocks, Turbulence and Magnetic Fields in the Formation of Galaxy Clusters"
Aug. 9, 2013	D. Garfinkle	"Collapse of a Massive Scalar field in AdS"
Apr. 10, 2013	K. Shamseddine	"Characterization of compact and self-adjoint operators, and study of positive operators on a Banach space over a non-Archimedean field"
Feb. 1, 2013	S. Bacca	"From Nuclear Forces to Nuclei"
Nov. 8, 2012	K. Dasgupta	"A UV complete model of large N thermal QCD"
Aug. 16, 2012	E. Hatefi	"Critical Collapse in the Axion-Dilaton system in Diverse Dimensions"
Aug. 15, 2012	J. Babb	"Conformal AdS Dumb Holes and Their Quasinormal Mode Spectrum "
May 25, 2012	H. Maeda	"Gauss-Bonnet Braneworld Redux: Novel Scenario for the Bouncing Universe"
Apr. 4, 2012,	J. Louko	"Probing a Quantum Field by a Nonstationary Detector "
Feb. 16, 2012	Robert Brandenberger	"Searching for Cosmic Strings in New Observational Windows"

4.3 Summer Student Symposium 2016

In August 2016, the WITP held its fifth Summer Student Symposium at the University of Winnipeg. Graduate students and undergraduate students working with WITP members between May and August were invited to give a short oral presentation of their work in a somewhat formal but friendly setting. It was a one day event with coffee and lunch provided for all speakers and attendees. The symposium was a great success with about twenty people attending altogether. It provided the students, and the WITP, an opportunity to showcase the world class research in theoretical physics that is being done in Manitoba. This has become a very successful annual event for the WITP.

The schedule of talks is given in the Appendix to this report.

4.4 Conferences, National Events, and Public Lecture

- The WITP provided modest support in recent years for several national and international conferences in theoretical physics, mathematics and astronomy:
  - The 16th Canadian Conference on General Relativity and Relativistic Astrophysics, SFU, July 6-8, 2016, G. Kunstatter and A. Frey members of the organizing committee ($500).
  - CASCA2016: the annual meeting of the Canadian Astronomical Society which was held in Winnipeg (May 30- June 2, 2016) and organized by WITP members from U of M and UW ($2,000).
  - The 15th Canadian Conference on General Relativity and Relativistic Astrophysics, U of Winnipeg, 2014, organized by WITP members: A. Frey, R. Danos, G. Kunstatter, and D. Vincent ($2,000).
  - Theory Canada 9, Wilfrid Laurier University, Waterloo, ON, 2014 ($500).
  - 12th International Conference on p-Adic Functional Analysis, U of Manitoba, 2012, organized by K. Shamseddine ($1,200)
  - Theory Canada VII, Lethbridge, AB, 2012 ($400).

- The WITP co-sponsored a public lecture in 2014 with the 15th Canadian Conference on General Relativity and Relativistic Astrophysics, which was held in Eckhardt-Gramatte Hall at the University of Winnipeg. The lecture, titled "Higgs Bang," was presented by Neil Turok, the Director and Niels Bohr Chair of the Perimeter Institute and the 2013 CBC Massey Lecturer. This was a rare event for Winnipegers to see one of the leading minds of cosmology, and close to 200 people attended.

- The WITP also entered in 2014 into an agreement with the Canadian Association of Physicists Division of Theoretical Physics to co-sponsor a prize for the best Ph.D. thesis in theoretical physics each year. The WITP will provide $250/year for the first three years, at which point the agreement may be renewed. The prize will be known as the DTP/WITP Thesis Prize, and the WITP Past Director will sit on the award committee. The first DTP/WITP Thesis Prize was warded in 2015 to Solomon Akaraka Owerre (PhD Université de Montréal 2014) for his thesis entitled "Etudes

de l'effet tunnel des spins quantiques macroscopiques (Studies of the tunnel effect of macroscopic quantum spins)." The 2016 prize was awarded to Vincent Genest (Université de Montréal 2015) for his thesis entitled "Algebraic Structures, Super-Integrable systems and Orthogonal Polynomials".

4.5 Graduate Degrees Supervised

1. Mykhailo Akhtariev (2016), "Teichmuller Space and Its Representation With The Period Mapping," M.Sc. thesis (Schippers)

2. Chelsea Braun (2016), "An Imaging and Spectroscopic Study of the Supernova Remnant RCW 103 (G332.40.4) with the CHANDRA X-ray Observatory," M.Sc. thesis (Safi-Harb)

3. Will Grafton (2016), "On the Convergence and Analytical Properties of Power Series on Non-Archimedean Field Extensions of the Real Numbers," M.Sc. thesis (Shamseddine)

4. Jennifer West (2016), "The connection between supernova remnants and the Galactic magnetic field", Ph.D. thesis (Safi-Harb)

4.6 Publications of Permanent Members

M.E. Alexander

1. S. Rathee, Nilam, M.E. Alexander. "Dynamics and control of glucose-insulin regulatory system in diabetics using vitamin D." Mathematics in Computer Science, accepted (minor revisions) Dec. 2016.

2. I. Halilovic, J. Wu, M. Alexander, F. Lin. "Neutrophil migration under spatially-varying chemoattractant gradient profiles". Biomed. Microdevices **17**, 57-63, 2015.

3. M. Laskowski, P. Dubey, M.E. Alexander, S. Collinson, J.M. Heffernan, S.M. Moghadas. "What is the Optimal Level of Information Dissemination during an Epidemic?" BIOMAT 2014, Proceedings International Symposium on Mathematical and Computational Biology, Poznan, Poland, World Scientific, 2014.

4. M.E. Alexander, M. Mercredi. "A model for cell migration in competing chemotactic fields." Canadian Applied Math Quarterly **21**(2): 121-144, (Summer 2013).

5. B. Dietz, E. Elhami, M. Alexander, "Registration of positron emission tomography and magnetic resonance imaging for use in stem cell quantification studies of the infarcted myocardium," Accepted: Life Sciences OMICS Group (Oct. 2014).

6. R. Bergen, H. Lin, M. Alexander, and C. Bidinosti. "4-D MR phase and magnitude segmentations with GPU parallel computing." Magnetic Resonance Imaging **33**:134-146, 2015.

7. Q. Zhang, M.E. Alexander, L. Ryner. "Multimodality Neurological Data Visualization with Multi-VOI Based DTI Fiber Dynamic Integration." IEEE Journal of Biomedical and Health Informatics, **PP** Issue 99, 2014.

8. Q. Zhang, M. Alexander, L. Ryner. Synchronized 2D/3D optical mapping for interactive exploration and real-time visualization of multi-function neurological images. Computerized Medical Imaging and Graphics, **37** (7-8): 552 (2013).

S. Bacca

1. Electric dipole polarizability of ^{48}Ca and implications for the neutron skin
   J. Birkhan, M. Miorelli, S. Bacca, S. Bassauer, C.A. Bertulani, G. Hagen, H. Matsubara, P. von Neumann-Cosel, T. Papenbrock, N. Pietralla, V.Yu. Ponomarev, A. Richter, A. Schwenk, A. Tamii, arXiv:1611.07072, submitted to Phys. Rev. Lett.

2. Electric dipole polarizability from first principles calculations
   M. Miorelli, S. Bacca, N. Barnea, G. Hagen, G. R. Jansen, G. Orlandini, T. Papenbrock, Phys. Rev. C **94**,034317 (2016).

3. Nuclear structure corrections to the Lamb shift in μ^3He$^+$ and μ^3H
   N. Nevo Dinur, C. Ji, S. Bacca, and N. Barnea, Physics Letters B **755**, 380-386 (2016).

4. Charge, neutron, and weak size of the atomic nucleus
   G. Hagen, A. Ekström, G. R. Jansen, W. Nazarewicz, T. Papenbrock, K. A. Wendt, B. Carlsson, C. Forssen, M. Hjorth-Jensen, S. Bacca, N. Barnea, M. Miorelli, G. Orlandini, C. Drischler, K. Hebeler, J. Simonis, A. Schwenk,
   Nature Physics **12**, 186-190 (2016).

5. Structure models: from shell model to ab initio methods
   S. Bacca
   Eur. Phys. J Plus **131**, 107 (2016).

6. Neutrino-pair bremsstrahlung from nucleon-α versus nucleon-nucleon scattering
   R. Sharma, S. Bacca and A. Schwenk, Phys. Rev. C **91**, 042801(R) (2015).

7. Examination of the first excited state of ^{4}He as a potential breathing mode
   S. Bacca, N. Barnea, W. Leidemann and G. Orlandini,
   Phys. Rev. C **91**, 024303 (2015).

8. Giant and pigmy dipole resonances in ^{4}He, ^{16,22}O and ^{40}Ca from chiral nucleon-nucleon interactions
   S. Bacca, N. Barnea, G. Hagen, M. Miorelli, G. Orlandini and T. Papenbrock,
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9. Electromagnetic Reactions on Light Nuclei
S. Bacca and S. Pastore, commissioned topical review, J. Phys. G: Nucl. Part. Phys. **41** 123002 (2014).

10. Improved estimates of the nuclear structure corrections in μD
O.J. Hernandez, C. Ji, S. Bacca, N. Nevo Dinur, and N. Barnea, Phys. Lett. B **736** 344 (2014).

11. Effects of three nucleon forces and two-body currents on Gamow-Teller strengths
A. Ekström, G.R. Jansen, K.A. Wendt, G. Hagen, T. Papenbrock, S. Bacca, B. Carlsson, D. Gazit, arXiv:1406.4696, accepted on Phys. Rev. Lett.

12. Efficient method for evaluating energy-dependent sum rules
N. Nevo Dinur, C. Ji, S. Bacca and N. Barnea
Phys. Rev. C **89**, 064317 (2014).

13. Is the first excited state of the α particle a breathing mode?
S. Bacca, N. Barnea, W. Leidemann and G. Orlandini,
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C. Ji, N. Nevo Dinur, S. Bacca, N. Barnea,
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S. Bacca, N. Barnea, G. Hagen, G. Orlandini and T. Papenbrock,
Phys. Rev. Lett. **111**, 122502 (2013).

16. The isoscalar monopole resonance of the alpha particle: a prism to nuclear Hamiltonians
S. Bacca, N. Barnea, W. Leidemann and G. Orlandini,
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17. The nuclear electric polarizability of ^{6}He
R. Goerke, S. Bacca and N. Barnea,
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18. Matter and charge radius of ^{6}He in the hyperspherical-harmonics approach
S. Bacca, N. Barnea, A. Schwenk,
Phys. Rev. C. **86** 034321 (2012).

19. Neutrino processes in partially degenerate neutron matter
S. Bacca, K. Hally, M. Liebendrfer, A. Perego, C. J. Pethick, and A. Schwenk
ApJ, **758**, 34 (2012).

20. First direct mass-measurement of the two-neutron halo nucleus ^{6}He and improved mass for the four-neutron halo ^{8}He
M. Brodeur, T. Brunner, C. Champagne, S. Ettenauer, M.J. Smith, A. Lapierre, R. Ringle, V.L. Ryjkov, S. Bacca, P. Delheij, G.W.F. Drake, D. Lunney, A. Schwenk, J. Dilling,
Phys. Rev. Lett. **108**, 052504 (2012).

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21. Emission of neutrino-antineutrino pairs by hadronic bremsstrahlung processes S. Bacca, R. Sharma and A. Schwenk, Proceedings of the Nucleus-Nucleus 2015 conference, EPJ Web of Conferences Vol. 117 02003 (2016); arXiv:1509.08151.

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T. Xu, M. Miorelli, S. Bacca and G. Hagen,
Proceedings of the 21st International Conference on Few-Body Problems in Physics, EPJ Web of Conferences 113, 04016 (2016); arXiv:1509.03681.

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G. Orlandini, S. Bacca, N. Barnea and W. Leidemann,
Proceedings of the 21st International Conference on Few-Body Problems in Physics, arXiv:1510.02248.

24. Electric dipole polarizability: from few- to many-body systems
M. Miorelli, S. Bacca, N. Barnea, G. Hagen, G. Orlandini, T. Papenbrock
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C. Ji, O. J. Hernandez, N. Nevo Dinur, S. Bacca, and N. Barnea,
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Few-Body System, DOI 10.1007/s00601-014-0809-3 (2014).

27. Electromagnetic Reactions and Few-Nucleon Dynamics
S. Bacca
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28. Coupling the Lorentz Integral Transform and the Coupled Cluster Methods: a way towards continuum spectra of "not so few-body systems"
G. Orlandini, S. Bacca, N. Barnea, G. Hagen, M. Miorelli and T. Papenbrock,
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S. Bacca
PoS(CD12) **119** (2013).

30. Electromagnetic Observables in Few-Nucleon System
S. Bacca
Few-Body Systems **54**, 903-909 (2013).

31. The isoscalar monopole resonance of ^{4}He
G. Orlandini, S. Bacca, N. Barnea, W. Leidemann
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Experimental Proposal

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C. Agodi, M. Bondì, F. Cappuzzello, D. Carbone, M. Cavallaro, A. Cunsolo, M. De Napoli, A. Foti, D. Nicolosi, S. Tropea, S. Bacca, G. Orlandini, L. Chamon, J.R.B. Oliveira, J.Lubian, R.Linares, M. L. Bouhssa, A. Khouaja, J. Inchaouh, A. Morsad, H. Chakir
Spokeperson: F. Cappuzzello
Co-spokesperson: S. Bacca
Proposal to the PAC at the Laboratory Nazionali del Sud, March 2013.

P.G. Blunden

1. N. L. Hall, P. G. Blunden, W. Melnitchouk, A. W. Thomas and R. D. Young, *Quark-hadron duality constraints on γZ box corrections to parity-violating elastic scattering,* Phys. Lett. **B753**, 221 (2016).

2. J. Benesch *et al.*, *The MOLLER experiment: An ultra-precise measurement of the weak mixing angle using Møller scattering,* arXiv:1411.4088 (2014).

3. N. L. Hall, P. G. Blunden, W. Melnitchouk, A. W. Thomas and R. D. Young, *Hadronic γZ box corrections in Møller scattering,* Phys. Lett. B **731**, 287 (2014); *Erratum*, Phys. Lett. B **733**, 380 (2014).

4. A. Sibirtsev and P. G. Blunden, *Q^2 evolution of the electric and magnetic polarizabilities of the proton,* Phys. Rev. C **88**, 065202 (2013).

5. N. L. Hall, P. G. Blunden, W. Melnitchouk, A. W. Thomas and R. D. Young, *Constrained γZ interference corrections to parity-violating electron scattering,* Phys. Rev. D **88**, 013011 (2013).

6. P. G. Blunden, W. Melnitchouk and A. W. Thomas, *γZ box corrections to weak charges of heavy nuclei in atomic parity violation,* Phys. Rev. Lett. **109**, 262301 (2012).

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7. P.G. Blunden, *Box diagrams in parity-violating electron scattering,* PAVI-14: From parity-violation to hadronic structure, Skaneatles, NY, July 14-18, 2014. To be published in the IOP Journal of Physics: Conference Series.

8. N. L. Hall, P. G. Blunden, W. Melnitchouk, A. W. Thomas and R. D. Young, *Constrained γZ corrections to parity-violating electron scattering,* AIP Conf. Proc. **1563**, 94 (2013).

Presentations

9. *From $\mathcal{A}_{PV} \to Q_W^p \to \sin^2\hat{\theta}_W(0)$*, QWEAK Collaboration Meeting, Jefferson Lab, Newport News, VA, November 15, 2016.

10. *Two-boson exchange effects in parity-violating electron-proton scattering: recent progress*, **Invited talk**, ECT Workshop on Precision Measurements with Parity-Violating Electron Scattering, Trento, Italy, August 3, 2016.

11. *Hadronic effects in parity-violating electron-proton scattering*, **Invited talk**, Workshop on Precision for New Discoveries, TRIUMF, Vancouver, BC, June 9, 2016.

12. *Two-boson exchange for parity-violating electron scattering*, **Invited talk**, Precision Radiative Corrections for New Experiments, Jefferson Lab, Newport News, VA, May 16, 2016.

13. *Overview of recent advances in calculations of two-photon exchange effects*, **Invited talk**, Intense Electron Beams Workshop, Cornell, NY, June 18, 2015.

14. *Hadronic effects in parity-violating electron-proton scattering*, **Invited talk**, Theory Canada 10, Calgary, AB, June 12, 2015.

15. *Hadronic effects in precision electroweak physics*, Colloquium, Department of Physics, University of Winnipeg, Winnipeg, MB, September 26, 2014.

16. *Boxes in parity-violating electron scattering,* **Invited talk**, PAVI-14 From Parity Violation to Hadronic Structure, Skaneateles, NY, July 18, 2014.

17. *Constrained γZ interference corrections to parity-violating electron scattering,* **Invited talk**, γZ Box(ing): Workshop on Radiative Corrections to Parity-Violating Electron Scattering, Jefferson Lab, December 16, 2013.

18. *Constrained γZ interference corrections to parity-violating electron scattering,* **Invited talk**, MITP program on Low Energy Precision Physics, Mainz, Germany, September 25, 2013.

19. *Comments on two-photon exchange in electron scattering,* **Invited talk**, ECT Workshop on the Proton Radius Puzzle, Trento, Italy, October 31, 2012.

20. *Hadronic effects in precision electroweak physics,* Colloquium, Department of Physics and Astronomy, University of Manitoba, Winnipeg, MB, September 21, 2012.

21. *Electroweak corrections to the weak charge of the nucleon,* Qweak Collaboration Meeting, TRIUMF, Vancouver, BC, August 1, 2012.

M. E. Carrington

Journal Articles

1. *Dynamical gap generation in graphene with frequency dependent renormalization effects,* M.E. Carrington, C.S. Fischer, L. von Smekal, M.H. Thoma, Phys. Rev. **B94**, 125102 (2016).

2. *The 2PI effective action at four loop order in φ^4 theory,* M.E. Carrington, B.A. Meggison, D. Pickering, Phys. Rev. **D94**, 025018 (2016).

3. *Gradient Flow in the Ginzburg-Landau Model of Superconductivity,* P. Mikula, M.E. Carrington and G. Kunstatter, Phys. Rev. **B94**, 184501 (2016).

4. *Energy Loss in Unstable Quark-Gluon Plasma,* M.E. Carrington, K. Deja and S. Mrówczyński, Phys. Rev. **C92**, 044914 (2015).

5. *On the geometric measure of entanglement for pure states,* M.E. Carrington, G. Kunstatter, J. Perron, S. Plosker, J. Phys. A: Math. Theor. 48 (2015) 435302.

6. *Renormalization group methods and the 2PI effective action,* M.E. Carrington, Wei-Jie Fu, D. Pickering, and J.W. Pulver, Phys. Rev. **D91**, 025003 (2015) .

7. *Plasmons in Anisotropic Quark-Gluon Plasma,* M.E. Carrington, K. Deja, S. Mrówczyński, Phys. Rev. **C90**, 034913 (2014).

8. *4-point vertices from the 2PI and 4PI Effective Actions,* M.E. Carrington, Wei-Jie Fu, P. Mikula, D. Pickering, Phys. Rev. **D89**, 025013 (2014).

9. *Bethe-Salpeter Equations from the 4PI effective action,* M.E. Carrington, WeiJie Fu, T. Fugleberg, D. Pickering, I. Russell, Phys. Rev. **D88**, 085024 (2013).

10. *Preliminary results from the 4PI Effective Action,* M. E. Carrington, Wei-Jie Fu, Eur. Phys. J. C, **73**, 2399 (2013).

11. *Thermal field theory at next-to-leading order in the hard thermal loop expansion,* A. Mirza and M.E. Carrington, Phys. Rev. **D87**, 065008 (2013).

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13. *A New Method to Calculate the n-Particle Irreducible Effective Action,* M.E. Carrington and Yun Guo, Phys. Rev. **D85**, 076008 (2012).

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15. *Smooth and sharp creation of a pointlike source for a* $(3+1)$*-dimensional quantum field,* L.J. Zhou, Margaret E. Carrington, Gabor Kunstatter, Jorma Louko, arXiv:1610.08455.

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16. *Frequency dependence in dynamical gap generation in graphene,* M.E. Carrington, Acta Physica Polonica B. Critical Point and Onset of Deconfinement 2016, Wroclaw, Poland, May 30 - June 4, 2016.

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20. *Energy loss in unstable quark-gluon plasma with extremely prolate momentum distribution,* M.E. Carrington, K. Deja, S. Mrówczyński, Acta Phys. Polon. Supp. 6 (2013) 545-550.

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22. *Renormalization group flow equations from the 4PI equations of motion,* M.E. Carrington, Acta Phys. Polon. Supp. 7 (2014) 1, 91-97.

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T. Chakraborty

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1. T. Chakraborty, A. Manaselyan, & M. Barseghyan J. Phys.: Condens. Matter 29, 075605 (2016)
2. Wenchen Luo & T. Chakraborty Phys. Rev. B 94, 161101 (R) (Rapid Commun.) (2016)
3. T. Chakraborty, A. Manaselyan, & M. Barseghyan arXiv:1606.04554 (2016)
4. S. Avetisyan, T. Chakraborty & P. Pietilinen Physica E 81, 334 (2016)
5. A. Ghazaryan, A. Manaselyan, & T. Chakraborty Phys. Rev. B 93, 245108 (2016)
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J. Fiege

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3. Rumble, D.; Hatchell, J., et al., MNRAS. 448(2): 1551-1573, The JCMT Gould Belt Survey: Evidence for radiative heating in Serpens MWC 297 and its influence on local star formation

4. Hull, Charles L.H.; Plambeck, R., et al., ApjS. 213(1): 13, TADPOL: A 1.3 mm Survey of Dust Polarization in Star-forming Cores and Regions

5. Danos, R. J., Fiege, J. D., & Shalchi, A. 2013, Ap.J., 772, 35, Numerical Analysis of the Fokker-Planck Equation with Adiabatic Focusing: Isotropic Pitch-angle Scattering

6. Hull, C. L. H., Plambeck, R. L., Bolatto, A. D., et al. 2013, Ap.J., 768, 159, Misalignment of Magnetic Fields and Outflows in Protostellar Cores. ApJ.

7. Rogers, A. and Fiege, J. D., 2011, Ap.J., 743, 68, Strong Gravitational Lens Modeling with Spatially Variant Point Spread Functions

Proceedings

8. McIntosh, B. Fiege, J. Pistorius, S. Goertzen, A.M10-79 Rapid Automated PET Detector Optimization with a Genetic Algorithm. IEEE Xplore Digital Library. IEEE Nuclear Science Symposium, Seattle, WA, , 2014-11-08. IEEE Xplore Digital Library

9. Masen Lamb ; David R. Andersen ; Jean-Pierre Vran ; Carlos Correia ; Glen Herriot ; Matthias Rosensteiner ; Jason Fiege. (2014). Non-common path aberration corrections for current and future AO systems. Proceedings of the SPIE, Volume 9148. Proceedings of the SPIE, Volume 9148, Adaptive Optics Systems IV, id. 914857 13 pp. (2014), Montreal, , 2014-06-22 (1-13)

Talks & Colloquia

10. "Modeling molecular cloud cores and turbulent magnetic fields using submillimetre polarization", Fiege, J., Franzmann, E., Ramacieri, G., Au, K., Srinivason, S., 2015, Colloquium, DRAO, Penticton, Canada

11. "Rapid Automated PET Detector Optimization with a Genetic Algorithm", McIntosh, B. Fiege, J. Pistorius, S. Goertzen, A., 2014, IEEE Nuclear Science Symposium, Seattle, United States

A. R. Frey

Refereed Publications

1. N. Deppe, A. Kolly, A. R. Frey and G. Kunstatter, "Black Hole Formation in AdS Einstein-Gauss-Bonnet Gravity," JHEP **1610**, 087 (2016) [arXiv:1608.05402 [hep-th]].

2. N. Deppe and A. R. Frey, "Classes of Stable Initial Data for Massless and Massive Scalars in Anti-de Sitter Spacetime," JHEP **1512**, 004 (2015) [arXiv:1508.02709 [hep-th]].

3. N. Deppe, A. Kolly, A. Frey and G. Kunstatter, "Stability of Anti-de Sitter in Einstein Gauss Bonnet Gravity," Phys. Rev. Lett. **114**, 071102 (2015) [arXiv:1410.1869 [hep-th]].

4. J. M. Cline and A. R. Frey, "Consistency of dark matter interpretations of the 3.5 keV x-ray line," Phys. Rev. D **90**, no. 12, 123537 (2014) [arXiv:1410.7766 [astro-ph.CO]].

5. J. M. Cline and A. R. Frey, "Nonabelian dark matter models for 3.5 keV X-rays," JCAP **1410**, no. 10, 013 (2014) [arXiv:1408.0233 [hep-ph]].

6. A. R. Frey and J. Roberts, "The Dimensional Reduction and Kähler Metric of Forms In Flux and Warping," JHEP **1310**, 021 (2013) [arXiv:1308.0323 [hep-th]].

7. A. R. Frey and N. B. Reid, "Cosmic Microwave Background Constraints on Dark Matter Models of the Galactic Center 511 keV Signal," Phys. Rev. D **87**, 103508 (2013) [arXiv:1301.0819 [hep-ph]].

8. J. M. Cline, A. R. Frey and G. D. Moore, "Composite magnetic dark matter and the 130 GeV line," Phys. Rev. D **86**, 115013 (2012) [arXiv:1208.2685 [hep-ph]].

9. J. M. Cline and A. R. Frey, "Abelian dark matter models for 511 keV gamma rays and direct detection," Annalen Phys. **524**, 579-590 (2012) [arXiv:1204.1965 [hep-ph]].

10. R. J. Danos, A. R. Frey and Y. Wang, "Canny Algorithm: A New Estimator for Primordial Non-Gaussianities," Phys. Rev. D **86**, 043526 (2012) [arXiv:1108.2265 [astro-ph.CO]].

11. J. M. Cline and A. R. Frey, "Light dark matter versus astrophysical constraints," Phys. Lett. B **706**, 384 (2012) [arXiv:1109.4639 [hep-ph]].

Media Appearances

2016 newspaper interview for *PROFile* in The Uniter, University of Winnipeg, 21 Jan 2016.

12. CJOB radio *morning news*, 7 Oct 2014, discussing the 2014 Nobel Prize in Physics.

13. CJOB radio *Charles Adler's morning broadcast*, 11 Sept 2014, discussing Stephen Hawking's comments on the Higgs boson and the end of the universe.

14. CKUW radio *Dark Matter, Defined* science talk show, 17 Oct 2013 (with G. Chernitsky, J. Enns, and N. Reid).

15. CTV Winnipeg news segment, 14 March 2013.

Talks

16. "Talk Back" discussion of physics with Rebecca Danos and Vesna Milosevic-Zdjelar and actors for performance of *Constellations* by Nick Payne by Theatre by the River, Winnipeg, 2016.

17. "Black Hole Formation in Anti-de Sitter Spacetime (And What It Means)," Winnipeg Institute for Theoretical Physics & University of Manitoba, 2016.

18. "Dynamics of Gravitational Collapse in AdS Space-Time," 2015 CAP Congress hosted by University of Alberta, 2015.

19. "Gravitational Collapse and Far-From-Equilibrium Dynamics in AdS/CFT," University of Alberta, 2015.

20. "Stringy Corrections from (Almost) Classical Supergravity," Canadian Conference on General Relativity and Relativistic Astrophysics (at Univ of Winnipeg), McGill University, 2014, & University of Alberta, 2015.

21. "Learning by Cosmosis" panel discussion with Ken Freeman, Jayanne English, and Chris O'Dea, Tallest Poppy restaurant, Winnipeg, 2014.

22. "The Astounding Universe of String Theory," public lecture at University of Manitoba "Dream Big" event, 2014.

23. "Not-So-Dark Matter," York University & University of North Dakota, 2013.

24. "What is String Theory?" public lecture at the Millennium Library, Winnipeg, 2012; Fred Douglas Place, Winnipeg, 2014; Wellington Retirement Residence, Winnipeg, 2015; Charleswood Senior Centre & Portsmouth Retirement Residence, Winnipeg, 2016.

25. "Gamma Rays at 130 GeV and How They Might Come from Dark Matter," McGill, 2012, & Perimeter Institute, 2013.

26. "Warped Dimensional Reduction," McGill University, Canadian Conference on General Relativity and Relativistic Astrophysics hosted by Memorial University, 2012.

T. D. Fugleberg

No update provided for this report

1. M. E. Carrington, W. Fu, T. Fugleberg, D. Pickering and I. Russell, "Bethe-Salpeter Equations from the 4PI effective action," Phys. Rev. D **88**, 085024 (2013)

D. Krepski

No update provided for this report
Refereed publications

1. Prequantization of the moduli space of flat $PU(p)$-bundles with prescribed boundary holonomies, Symmetry, Integrability and Geometry: Methods and Applications, 10 (2014), 109, 13 pages.

2. (with R. Goldin, M. Harada, and D. Johannsen) The inertia groups of a toric DM stack, fake weighted projective stacks, and labelled sheared simplices, to appear in Rocky Mountain Journal of Mathematics.

3. (with M. Harada) Global quotients among toric Deligne-Mumford stacks, Osaka Journal of Mathematics, 52 (2014), no. 1, pp. 236-269.

4. (with E. Meinrenken) On the Verlinde formulas for $SO(3)$, Quarterly Journal of Mathematics, 64 (2013), no. 1, pp. 235-252.

G. Kunstatter

1. J. Ziprick, J. Gegenberg and G. Kunstatter, "Polymer Quantization of a Self-Gravitating Thin Shell", to appear in PRD, accepted Nov. 14 2016 [arXiv:1609.06665]

2. P. Mikula, M.E. Carrington, G. Kunstatter, "Gradient Flow in the Ginzburg-Landau Model of Superconductivity". Phys. Rev. B 94, 184501 Published 3 November 2016 [arXiv:1511.03714]

3. Nils Deppe, Allison Kolly, Andrew R. Frey, Gabor Kunstatter, "Black Hole Formation in AdS Einstein-Gauss-Bonnet Gravity", JHEP, to appear (accepted Oct. 6, 2016) [arXiv:1608.05402].

4. G. Kunstatter, H. Maeda and T. Taves, "New 2D dilaton gravity for nonsingular black holes" Classical and Quantum Gravity, 102342.R1 2016 [arXiv:1509.06746].

5. M.E. Carrington, G. Kunstatter, J. Perron and S. Plosker,"On the geometric measure of entanglement for pure states", Journal of Physics A: Mathematical and Theoretical, 48, 435302, 2015.

6. Nils Deppe, Allison Kolly, Andrew Frey and Gabor Kunstatter, " Antide Sitter Space in Einstein Gauss Bonnet Stability of Einstein-Gauss-Bonnet Gravity", Phys. Rev. Lett. 114, 071102 ; arXiv:1410.1869.

7. Tim Taves and Gabor Kunstatter, "Modelling the evaporation of nonsingular black holes ",Phys. Rev. D 90, 124062 (2014) ; arXiv:1408.1444.

8. Gabor Kunstatter and Hideki Maeda, "Throat quantization of the SchwarzschildTangherlini(-AdS) black hole " Class. Quantum Grav. 31 115009 (2014).

9. G. Kunstatter, H. Maeda and T. Taves, "Hamiltonian dynamics of Lovelock black holes with spherical symmetry", Class. Qu. Grav. **30** 065002 (2013) ; arXiv:1210.1566.

10. N. Deppe, C. D. Leonard, T. Taves, G. Kunstatter and R. B. Mann, "Critical Collapse in Einstein-Gauss-Bonnet Gravity in Five and Six Dimensions",

    Phys. Rev. D 86, 104011 (2012); arXiv:1208.5250.

11. G. Kunstatter and J. Louko, "Polymer quantization on the half line", J. Phys. A. 422651/PAP/8788 (2012).

12. G.Kunstatter and T. Taves and H. Maeda, "Geometrodynamics of spherically symmetric Lovelock gravity", Class. Quantum Grav. 29 (2012) 092001 (Fast Track Communication); arXiv:1201.4904

13. J. Gegenberg and G. Kunstatter, "Local hamiltonian for spherical collapse: geometrodynamics approach" Phys. Rev. D 85, 084011 (2012); arXiv:1112.3301.

14. J. Gegenberg, G. Kunstatter and T. Taves, "Singularity Resolution Inside Radiating 2-D Black Holes", Phys. Rev. **D85** 024025 (2012); arXiv:1111.279 .

Chapters in Books

15. J. Gegenberg and G. Kunstatter, "Midi-superspace models for quantum black holes", **(invited)** *Recent Research in Quantum Gravity*, (Nova Scientific, 2012) ed. A. Dasgupta.

Invited papers presented at meetings

16. G. Kunstatter, "Birth and Death of Regular Black Holes", CAP Congress, Ottawa, 2016.

17. G. Kunstatter, "Polymer quantized spherical thin shell collapse", Theory Canada, Carleton University, Ottawa, June 2016.

18. G. Kunstatter, "Formation and Evaporation of Regular Black Holes in New 2D Gravity", **Invited** BIRS Workshop on Black Holes: New Horizons, Oaxaca, Mexico, May 2016.

19. G. Kunstatter, "Non-singular black holes from new 2D gravity" **invited**, Mann Fest, University of Waterloo, December 2015.

20. G. Kunstatter, "(In-)stability of AdS Space-time in Einstein-Gauss-Bonnet Gravity", **Invited**, Focus Week on Black Hole Stability, Fields Institute, Toronto, June 2015.

21. G. Kunstatter, "(In-)stability of AdS Space-time in Einstein-Gauss-Bonnet Gravity", **Invited**, Atlantic Meeting on General Relativity, University of Fredericton, May 2015.

22. G. Kunstatter, "Spherically Symmetric Black Hole Formation in Lovelock Gravity"**Invited**, Black Holes IX, Saskatoon, May, 2013.

23. "Boundary Conditions for Quantum Mechanics on the Discretized Half Line" **Invited**, CAP Congress, Montreal, May, 2013.

24. G. Kunstatter, "Lovelock gravity: geometrodynamics and quantum mechanics", **Invited**, CAP Congress, U. Calgary, June, 2012.

25. G. Kunstatter, "Quantum Mechanics on the Discretized Half Line"

    Invited, CMS Meeting, Regina, June 2012.

    Invited Lectures

26. "Formation and Evaporation of Nonsingular Black Holes in New 2D Gravity",

    - CECS, Chile, January 2016
    - Simon Fraser University, February 2016
    - University of Lethbridge, March 2016
    - University of Victoria, March 2016;
    - University of Calgary, March 2016

27. "Black hole information loss: is there light at the end of the tunnel?", University of Lethbridge, March 2016.

28. "Black hole information loss: is there light at the end of the tunnel?"Canadian Association of Physicists 2015 Lecture Tour, March 2-5, 2015 given at:

    - University of Guelph
    - University of Waterloo
    - McMaster University
    - University of Western Ontario.

29. "Black hole information loss: is there light at the end of the tunnel?", UWinnipeg, October, 2014; SFU, October, 2014.

30. "Stability of AdS Spacetime in Einstein-Gauss-Bonnet Gravity", SFU, October, 2014.

31. "Black hole information loss: let's lose the singularity instead of the information", UNB, July, 2014.

32. "Quantum Mechanics of the Interior of Radiating 2D Black Holes", Rykkyo University, Tokyo, June, 2013.

33. "Lovelock Gravity: Geometrodynamics and Quantum Mechanics", Univerite de Montreal, March 2012.

34. "Singularity resolution inside radiating black holes", McGill University, March, 2012.

P.D. Loly

No update provided for this report

1. Ian Cameron, Adam Rogers & Peter Loly, "Signatura of magic and Latin integer squares: isentropic clans and indexing", Discussiones Mathematicae Probability and Statistics, xx (xxxx) 129, online c. December 2013, in paper 2014.

   Talks

2. Peter Loly (speaker), with Ian Cameron and Adam Rogers, "Shannon entropy of small matrices for physicists", Colloquium, 7 Nov. 2014, Department of Physics and Astronomy, University of Manitoba.

3. Peter Loly (speaker), with Adam Rogers and Ian Cameron, "Knut Vik Designs are Multimagic"", CMS Summer 2014, 7 June, Winnipeg.

4. Peter Loly (presenter) "Board Games on a square grid - Sudoku, chess, and magic squares - from refereed papers to personal web pages or vice versa", at the August 2012 University of Iceland - University of Manitoba 2012 Partnership Conference, on "Origins", Reykjavik.

5. Ian Cameron, Adam Rogers & Peter Loly (all presenters) Bewedlo, "Signatura of magic and Latin integer squares: isentropic clans and indexing", IWMS21 and LINSTAT2012 conferences at Bedlewo, Poland.

C. O'Dea

Refereed Articles

1. **C. P. O'Dea**, "The infrared properties of the GPS and CSS radio sources," *Astronomische Nachrichten*, 337, 141-147 (2016)

2. **C. P. O'Dea** & A. Siemiginowska, "Summary," *Astronomische Nachrichten*, 337, 205-208 (2016)

3. S. Vaddi, **C. P. O'Dea**, S. A. Baum, S. Whitmore, R. Ahmed, K. Pierce, S. Leary, "Constraints on Feedback in the Local Universe: The Relation between Star Formation and AGN Activity in Early-type Galaxies," *Astrophysical Journal*, 818, 182-200 (2016)

4. H. R. Russell, B. R. McNamara, A. C. Fabian, P. E. J. Nulsen, A. C. Edge, F. Combes, N. W. Murray, I. J. Parrish, P. Salomé, J. S. Sanders, S. A. Baum, M. Donahue, R. A. Main, R. W. O'Connell, **C. P. O'Dea**, J. B. R. Oonk, G. Tremblay, A. N. Vantyghem, G. M. Voit, "ALMA observations of cold molecular gas filaments trailing rising radio bubbles in PKS 0745-191," *Monthly Notices of the Royal Astronomical Society*, 458, 3134-3149 (2016)

5. G. R. Tremblay, J. B.R. Oonk, F. Combes, P. Salomé, **C. P. O'Dea**, S. A. Baum, G. M. Voit, M. Donahue, B. R. McNamara, T. A. Davis, M. A. McDonald, A. C. Edge, T. E. Clarke, R. Galván-Madrid, M. Maury, H. R. Russell, A. C. Quillen, C. M. Urry, J. S. Sanders, M. W. Wise, "Cold, clumpy accretion onto an active supermassive black hole," *Nature*, 534, 218-221 (2016)

6. J. P. Kotayla, M. Chiaberge, S. A. Baum, A. Capetti, B. Hilbert, F. D. Macchetto, G. K. Miley, **C. P. O'Dea**, E. S. Perlman, W. B. Sparks, G. R. Tremblay, "The Environment of $z > 1$ 3CR Radio Galaxies and QSOs: From Proto-Clusters to Clusters of Galaxies?" *Astrophysical Journal*, 826, 46-58 (2016)

7. B. Hilbert, M. Chiaberge, J. P. Kotayla, G. R. Tremblay, C. Stanghellini, W. B. Sparks, S. A. Baum, A. Capetti, F. D. Macchetto, G. K. Miley, **C. P. O'Dea**, E. S. Perlman, A. C. Quillen, "Powerful Activity in the Bright Ages. I. A Visible/IR Survey of High Redshift 3C Radio Galaxies and Quasars," *Astrophysical Journal Supplements*, 225, 12-28 (2016)

8. B. Punsly, C. Reynolds, P. Marziani, **C. P. O'Dea**, "The Extreme Ultraviolet Spectra of Low Redshift Radio Loud Quasars," *Monthly Notices of the Royal Astronomical Society*, 459, 4233-4239 (2016)

9. A. Maselli, F. Massaro, G. Cusumano, V. La Parola, D. E. Harris, A. Paggi, E. Liuzzo, G. R. Tremblay, S. A. Baum, **C. P. O'Dea**, "Swift observations of unidentified radio sources in the revised Third Cambridge Catalogue," *Monthly Notices of the Royal Astronomical Society*, 460, 3829-3837 (2016)

10. J. F. Gallimore, M. Elitzur, R. Maiolino, A. Marconi, **C P. O'Dea**, D. Lutz, S. A. Baum, R. Nikutta, C. M. V. Impellizzeri, R. Davies, Amy E. Kimball, and E. Sani "High-velocity Bipolar Molecular Emission from an AGN Torus," *Astrophysical Journal Letters*, 829, 7-12 (2016)

11. B. Punsly, P. Marziani, S. Zhang, S. Muzahid, and **C. P. O'Dea** "The Extreme Ultraviolet Variability of Quasars," *Astrophysical Journal*, 830, 104-123 (2016)

12. D. Sales, A. Robinson, D. Axon, J. Gallimore, P. Kharb, R. Curran, **C. O'Dea**, S. Baum, M. Elitzur, and R. Mittal, "An embedded active nucleus in the OH megamaser galaxy IRAS16399-0937," *Astrophysical Journal*, 799, 25-53 (2015)

13. E. C. Stanley, P. Kharb, M.L. Lister, H. L. Marshall, **C. O'Dea**, S. Baum, "A Multiwavelength Study of Three Hybrid Blazars," *Astrophysical Journal*, 807, 48-59 (2015)

14. G. R. Tremblay, **C. P. ODea**, S. A. Baum, R. Mittal, M. A. McDonald, F. Combes, Y. Li, B. R. McNamara, M. N. Bremer, T. E. Clarke, M. Donahue, A. C. Edge, A. C. Fabian, S. L. Hamer, M. T. Hogan, J. B. R. Oonk, A. C. Quillen, J. S. Sanders, P. Salom, and G. M. Voit, "Far Ultraviolet Morphology of Star Forming Filaments in Cool Core Brightest Cluster Galaxies," *Monthly Notices of the Royal Astronomical Society*, 451, 3768-3800 (2015)

15. F. Massaro, D. E. Harris, E. Liuzzo, M. Orienti, R. Paladino, A. Paggi, G. R. Tremblay, B. J. Wilkes, J. Kuraszkiewicz, S. A. Baum, & **C. P. ODea**, "The Chandra survey of extragalactic sources in the 3CR catalog: X-ray emission from nuclei, jets and hotspots in the Chandra archival observations," *Astrophysical Journal Supplements*, 220, 5-19 (2015)

16. B. Punsly, P. Marziani, P. Kharb,**C. P. O'Dea**, & M. Vestergaard, "The Extreme Ultraviolet Deficit: Jet Connection in the Quasar 1442+101," *Astrophysical Journal*, 812, 79-88 (2015)

17. J. A. White, R. E. A. Canning, L. J. King, B. E. Lee, H. R. Russell, S. A. Baum, D. I. Clowe, J. E. Coleman, M. Donahue, A. C. Edge, A. C. Fabian, R. M. Johnstone, B. R. McNamara, **C. P. O'Dea**, J. S. Sanders, "Dynamical analysis of galaxy cluster merger Abell 2146," *Monthly Notices of the Royal Astronomical Society*, 453, 2718-2730 (2015)

18. S. L. Hamer, A. C. Edge, A. M. Swinbank, J. B. R. Oonk, R. Mittal, B. R. McNamara, H. R. Russell, M. N. Bremer, F. Combes, A. C. Fabian, N. P. H. Nesvadba, **C. P. O'Dea**, S. A. Baum, P. Salom, G. Tremblay, M. Donahue, G. J. Ferland, C. L. Sarazin, "Cold gas dynamics in Hydra-A: evidence for a rotating disk," *Monthly Notices of the Royal Astronomical Society*, 437, 862-878 (2014)

19. A. Bogdan, R. J. van Weeren, R. P. Kraft, W. R. Forman, S. Randall, S. Giacintucci, E. Churazov, **C. P. O'Dea**, S. A. Baum, J. Noel-Storr, and C. Jones "Young AGN Outburst Running Over Older X-ray Cavities," *Astrophysical Journal Letters*, 782, L19-24 (2014)

20. H.R. Russell, B.R. McNamara, A.C. Edge, P.E.J. Nulsen, R.A. Main, A.N. Vantyghem, F. Combes, A.C. Fabian, N. Murray, P. Salome, R.J. Wilman, S.A. Baum, M. Donahue, **C.P. O'Dea**, J.B.R. Oonk, G.R. Tremblay, G.M. Voit "Massive molecular gas flows in the Abell 1664 brightest cluster galaxy," *Astrophysical Journal*, 784, 78-86 (2014)

21. B. R. McNamara, H.R. Russell, P. E. J. Nulsen, A. C. Edge, N. W. Murray, R. A. Main, A. N. Vantyghem, F. Combes, A. C. Fabian, P. Salome, C.C. Kirkpatrick, S. A. Baum, J. N. Bregman, M. Donahue, E. Egami, S. Hamer, **C. P. O'Dea**, J.B.R. Oonk, G. Tremblay, G.M. Voit "A Ten Billion Solar Mass Outflow of Molecular Gas Launched by Radio Bubbles in the Abell 1835 Brightest Cluster Galaxy," *Astrophysical Journal*, 785, 44-53 (2014)

22. P. Kharb, **C. P. O'Dea**, S. A. Baum, M. J. Hardcastle, D. Dicken, J. H. Croston, B. Mingo, J. Noel-Storr, "VLBA Observations of Mrk 6: Probing the Jet-Lobe Connection," *Monthly Notices of the Royal Astronomical Society*, 440, 2976-2987 (2014)

23. G. Tremblay, M. D. Gladders, S. A. Baum, **C. P. O'Dea**, M. B. Bayliss, K. C. Cooke, H. Dahle, T. A. Davis, M. Florian, J. R. Rigby, K. Sharon, E. Soto, E. Wuyts, "A Thirty Kiloparsec Chain of "Beads on a String" Star Formation between Two Merging Early Type Galaxies in the Core of a Strong Lensing Galaxy Cluster," *Astrophysical Journal Letters*, 790, L26-31 (2014)

24. H. R. Russell, A. C. Fabian, B. R. McNamara, A. C.Edge, J. S. Sanders, P. E. J. Nulsen, S. A. Baum, M. Donahue, **C. P. O'Dea**, "The bow shock, cold fronts and disintegrating cool core in the merging galaxy group RX J0751.3+5012," *Monthly Notices of the Royal Astronomical Society*, 444, 629-641 (2014)

25. D. J. E. Floyd, J. S. Dunlop, M. J. Kukula, M. J. I. Brown, R. J. McLure, S. A. Baum, **C. P. O'Dea**, "Star Formation in Luminous Quasar Host Galaxies at Z=1-2," *Monthly Notices of the Royal Astronomical Society*, 429, 2-19 (2013)

26. **C. P. O'Dea**, S. A. Baum, G. R. Tremblay, P. Kharb, W. Cotton, R. Perley, "Hubble Space Telescope Observations of Dusty Filaments in Hercules A: Evidence for Entrainment," *Astrophysical Journal*, 771, 38-49 (2013)

27. M. Cara, E. S. Perlman, Y. Uchiyama, C. C. Cheung, P. S. Coppi, M. Georganopoulos, D. M. Worrall, M. Birkinshaw, W. B. Sparks, H. L. Marshall, L. Stawarz, M. C. Begelman, **C. P. O'Dea**, S. A. Baum, "Polarimetry and the High-energy Emission Mechanisms in Quasar Jets: The Case of PKS 1136−135," *Astrophysical Journal*, 773, 186-199 (2013)

28. C. Reynolds, B. Punsly, **C. P. O'Dea**, "Misalignment of the Jet and the Normal to the Dusty Torus in the Broad Absorption Line QSO FIRST J155633.8+351758," *Astrophysical Journal Letters*, 773, 10-15 (2013)

29. C. Reynolds, B. Punsly, **C. P. O'Dea**, N. Hurley-Walker, J. Wrobel, "A Blazar-Like Radio Flare in Mrk 231," *Astrophysical Journal Letters*, 776, 21-27 (2013)

30. G. C. Privon, S. A. Baum, **C. P. O'Dea**, J. Gallimore, J. Noel-Storr, D. J. Axon, A. Robinson, "Modeling the Infrared Emission in Cygnus A," *Astrophysical Journal*, 747, 46 - 58 (2012)

31. H. R. Russell, B. R. McNamara, J. S. Sanders, A. C. Fabian, P. E. J. Nulsen, R. E. A. Canning, S. A. Baum, M. Donahue, A. C. Edge, L. J. King, **C. P. O'Dea**, "Shock fronts, electron-ion equilibration and ICM transport processes in the merging cluster Abell 2146," *Monthly Notices of the Royal Astronomical Society*, 423, 236 - 255 (2012)

32. P. Kharb, **C. P. O'Dea**, A. Tilak, S. A. Baum, E. Haynes, J. Noel- Storr, C. Fallon, K. Christiansen, "VLBA and Chandra observations of jets in FRI radio galaxies: Constraints on jet evolution," *Astrophysical Journal*, 754, 1 - 17 (2012)

33. R. A. Daly, T. B. Sprinkle, **C. P. O'Dea**, P. Kharb, S. A. Baum, "The Relationship between Beam Power and Radio Power for Classical Double Radio Sources," *Monthly Notices of the Royal Astronomical Society*, 423, 2498 - 2502 (2012)

34. G. R. Tremblay, **C. P. O'Dea**, S. A. Baum, T. E. Clarke, C. L. Sarazin, J. N. Bregman, F. Combes, M. Donahue, A. C. Edge, A. C. Fabian, G. J. Ferland, B. R. McNamara, R. Mittal, J. B. R. Oonk, A. C. Quillen, H. R. Russell, J. S. Sanders, P. Salome, G. M. Voit, R. J. Wilman, M. W. Wise, "Multiphase Signatures of AGN Feedback in Abell 2597," *Monthly Notices of the Royal Astronomical Society*, 424, 1026 - 1041 (2012)

35. G. R. Tremblay, **C. P. O'Dea**, S. A. Baum, T. E. Clarke, C. L. Sarazin, J. N. Bregman, F. Combes, M. Donahue, A. C. Edge, A. C. Fabian, G. J. Ferland, B. R. McNamara, R. Mittal, J. B. R. Oonk, A. C. Quillen, H. R. Russell, J. S. Sanders, P. Salome, G. M. Voit, R. J. Wilman, M. W. Wise, "Residual Cooling and Persistent Star Formation amid AGN Feedback in Abell 2597," *Monthly Notices of the Royal Astronomical Society*, 424, 1042 - 1060 (2012)

36. M. J. Hardcastle, F. Massaro, D. E. Harris, S. A. Baum, S. Bianchi, M. Chiaberge, R. Morganti, **C. P. O'Dea**, A. Siemiginowska, "The Nature of the Jet-Driven Outflow in the Radio Galaxy 3C305," *Monthly Notices of the Royal Astronomical Society*,424, 1774 - 1789 (2012)

37. B. Balmaverde, A. Capetti, P. Grandi, E. Torresi, M. Chiaberge, J. Rodriguez Zaurin, G. R. Tremblay, D. J. Axon, S. A. Baum, G. Giovannini, P. Kharb, F. D. Macchetto, **C. P. O'Dea**, W. Sparks, "Extended Soft X-ray Emission in 3CR Radio Galaxies at $z < 0.3$: High Excitation and Broad Line Galaxies," *Astronomy and Astrophysics*, 545, 143 - 158 (2012)

38. R. Mittal, J. B. R. Oonk, G. Ferland, A. C. Edge, **C. P. ODea**, S. A. Baum, J. T. Whelan, R. M. Johnstone, F. Combes, P. Salome, A. C. Fabian, G. R. Tremblay, M. Donahue, and H. Russell, "Herschel observations of extended atomic gas in the core of the Perseus cluster", *Monthly Notices of the Royal Astronomical Society*, 426, 2957 -2977 (2012)

39. F. Massaro, G. R. Tremblay, D. E. Harris, P. Kharb, D. Axon, B. Balmaverde, S. A. Baum, A. Capetti, M. Chiaberge, R. Gilli, G. Giovannini, P. Grandi, F. D. Macchetto, **C. P. O'Dea**, G. Risaliti, W. Sparks, E. Torresi, "Chandra Observations of 3C Radio Sources with $z < 0.3$ II: Completing the Snapshot Survey," *Astrophysical Journal Supplements*, 203, 31-48 (2012)

40. A. Bogdan, R. P. Kraft, W. R. Forman, C. Jones, S. W. Randall, M. Sun, **C. P. O'Dea**, E. Churazov, S. A. Baum, "Chandra and ROSAT Observations of A194: Detection of an X-Ray Cavity and Mapping the Dynamics of the Cluster," *Astrophysical Journal*, 743, 59 - 70 (2011)

41. R. Mittal, **C. P. O'Dea**, J. B. R. Oonk, A. C. Edge, R. E. A. Canning, H. Russell, S. A. Baum, H. Boehringer, F. Combes, M. Donahue, A. C. Fabian, N. A. Hatch, A. Hoffer, R. Johnstone, B. R. McNamara, P. Salone, G. Tremblay, "Herschel Observations of the Centarus Cluster - the Dynamics of Cold Gas in a Cool Core," *Monthly Notices of the Royal Astronomical Society*, 418, 2386 - 2402 (2011)

T.A. Osborn

No update provided for this report

1. Karl-Peter Marzlin and T. A.Osborn, "Quantum Collapse Bell Inequalities", Phys. Rev. A 89, 032123, (2014)

Talks

2. T. A.Osborn, New and Old Bell Inequalities, Department of Physics and Astronomy Colloquium, November, 20th, 2015.

3. T. A.Osborn, Aharonov-Bohm Effect without Potentials, Theory Canada 7, Lethbridge, AB, June 9, 2012 (Invited talk).

S. Plosker

Peer-Reviewed Journal Articles

1. D. Farenick, M. J. Kozdron, and S. Plosker. *Spectra and variance of quantum random variables*. Journal of Mathematical Analysis and Applications **434**, pp. 1106-1122, 2016.

2. M. E. Carrington, G. Kunstatter, J. Perron, and S. Plosker. *On the geometric measure of entanglement for pure states*. Journal of Physics A: Mathematical and Theoretical, **48**, 435302, 2015.

3. J. Li, R. Pereira and S. Plosker. *Some geometric interpretations of quantum fidelity.* Linear Algebra and its Applications, **487**, pp. 158-171, 2015.

4. R. Pereira and S. Plosker. *Extending a characterization of majorization to infinite dimensions.* Linear Algebra and its Applications, **468**, pp. 80-86, 2015.

5. T. Jochym-O'Connor, D. W. Kribs, R. Laflamme, and S. Plosker. *Quantum subsystems: Exploring the complementarity of quantum privacy and error correction.* Physical Review A, **90**, 032305, 2014.

6. D. W. Kribs and S. Plosker. *Private quantum codes: introduction and connection with higher rank numerical ranges.* Linear and Multilinear Algebra, **62**, pp. 639-647, 2014.

7. T. Jochym-O'Connor, D. W. Kribs, R. Laflamme, and S. Plosker. *Private quantum subsystems.* Physical Review Letters, **111**, 030502, 2013.

8. R. Pereira and S. Plosker. *Dirichlet polynomials, majorization, and trumping.* Journal of Physics A: Mathematical and Theoretical, **46**, 225302, 2013.

9. D. Farenick, R. Floricel, and S. Plosker. *Approximately clean quantum probability measures.* Journal of Mathematical Physics, **54**, Issue 5, 052201, 2013.

10. D. W. Kribs, R. Pereira, and S. Plosker. *Trumping and power majorization.* Linear and Multilinear Algebra, **61**, pp. 1455-1463, 2013.

11. D. Farenick, S. Plosker, and J. Smith. *Classical and nonclassical randomness in quantum measurements.* Journal of Mathematical Physics, **52**, Issue 12, 122204, 2011.

Invited Lectures

12. *Spectra and variance of quantum random variables*, Workshop on Quantum Marginals and Numerical Ranges, Guelph, Ontario Aug. 17–21, 2015

13. *Spectra and variance of quantum random variables*, Workshop on Matrices and Operators (MAO), Shaanxi Normal University, Xian, China Jul. 19–21, 2015

14. *Some geometric interpretations of quantum fidelity*, Summer Research Workshop on Quantum Information Science, Sanya, Hainan, China Jul. 13–17, 2015

15. *Quantum fidelity*, three part lecture series, University of Regina, June 29–Jul. 3, 2015

16. *Private quantum subsystems and error correction*, Operator Algebra Seminar Series, University of Regina, Sept. 26, 2014

17. *The majorization and trumping orders in quantum information*, Math Colloquium, University of Regina, Sept. 26, 2014

18. *On the problem of entanglement transformations: characterizing trumping*, Minisymposium on Quantum Information and Computing, 19th Conference of the International Linear Algebra Society (ILAS), Seoul, South Korea, Aug. 6–9, 2014

19. *Quantum expectations: a matricial range perspective*, The Twelveth Workshop on Numerical Ranges and Numerical Radii, Sanya, Hainan, China, Jul. 28 – Aug. 1, 2014

20. *Using vector spaces of matrices to study quantum measurements*, Workshop on Matrices and Operators, Haikou, Hainan, China, Jul. 24–27, 2014

21. *The majorization and trumping orders in quantum information* (co-presenter Rajesh Pereira, three lectures), 14th Canadian Summer School on Quantum Information, Guelph, ON, Jun. 16–20, 2014

22. *On majorization and trumping*, Winnipeg Institute for Theoretical Physics (WITP), University of Manitoba, Mar. 20, 2014

23. *Trumping and power majorization*, Minisymposium on Linear Algebra Problems in Quantum Computation, 18th Conference of the International Linear Algebra Society (ILAS), Providence, Rhode Island, USA, Jun. 3, 2013.

24. *Private quantum codes*, Operator Theory and Operator Algebras Session, CMS Winter Meeting, Montreal, PQ, Dec. 8, 2012.

25. *On complementarity in quantum error correction and quantum cryptography*, Operator Algebra Seminar Series, University of Regina, Regina, SK, Apr. 18, 2012.

A. Prymak

1. K. A. Kopotun, D. Leviatan, A. Prymak, I. A. Shevchuk, *Yet another look at positive linear operators, q-monotonicity and applications*, Journal of Approximation Theory, **210** (2016), 1–22.
`http://arxiv.org/abs/1109.0968`

2. Z. Ditzian, A. Prymak, *On Nikol'skii inequalities for domains in R^d*, Constructive Approximation, **44** (2016), 23–51.
`http://arxiv.org/abs/1409.5397`

3. O. Maizlish, A. Prymak, *Convex polynomial approximation in R^d with Freud weights*, Journal of Approximation Theory, **192** (2015), 60–68.

4. Z. Ditzian, A. Prymak, *Discrete d-dimensional moduli of smoothness*, Proc. Amer. Math. Soc., **142** (2014), no. 10, 3553–3559.
`http://arxiv.org/abs/1404.0063`

5. A. Bondarenko, A. Prymak, D. Radchenko, *On concentrators and related approximation constants*, J. Math. Anal. Appl., **402** (2013), 234–241.
`http://arxiv.org/abs/1404.2161`

6. A. Bondarenko, D. Leviatan, A. Prymak, *Pointwise estimates for 3-monotone approximation*, *Journal of Approximation Theory*, **164** (2012) 1205–1232.

S. Safi-Harb

Refereed Journal Articles

1. Rogers, A. & Safi-Harb, S. 2017, Monthly Notices of the Royal Astronomical Society (MNRAS), vol. 465, issue 1, pp. 383-393 (arXiv:1610.04685)

2. West, J. L., Safi-Harb, S. & Ferrand, G. 2017, accepted for publication in Astronomy&Astrophysics (arXiv:1609.02887)

3. Rogers, A. 2017, Monthly Notices of the Royal Astronomical Society, vol. 465, issue 2, pp. 2151-2159 (arXiv:1611.01269)

4. Miceli, M., Bamba, A., Orlando, S., Zhou, P., Safi-Harb, S., Chen, Y. & Bocchino, F. 2017, Accepted for publication in Astronomy&Astrophysics (arXiv:1612.01923)

5. Zhou, Ping, Chen, Yang, Safi-Harb, Samar, Zhou, Xin, Sun, Ming, Zhang, Zhi-Yu & Zhang, Gao-Yuan 2016, The Astrophysical Journal, Volume 831, Issue 2, article id. 192, 17 pp. (2016).

6. The Hitomi Collaboration, including Safi-Harb, S. 2016, Nature, Volume 535, Issue 7610, pp. 117-121 (2016).

7. The Hitomi Collaboration, including Safi-Harb, S. 2016, Submitted to the Astrophysical Journal Letters (arXiv:1607.07420)

8. Zhou, Ping, Chen, Yang, Zhang, Zhi-Yu, Li, Xiang-Dong, Safi-Harb, Samar, Zhou, Xin & Zhang, Xiao 2016, The Astrophysical Journal, Volume 826, Issue 1, article id. 34, 7 pp. (2016).

9. Matheson, H., Safi-Harb, S. & Kothes, R. 2016, The Astrophysical Journal, Volume 825, Issue 2, article id. 134, 10 pp. (2016).

10. Rogers, A. & Safi-Harb, S. 2016, Monthly Notices of the Royal Astronomical Society, Volume 457, Issue 2, p.1180-1189 (arXiv:1601.00949).

11. West, J. L., Safi-Harb, S., Jaffe, T., Kothes, R., Landecker, T. L., Foster, T. 2015, Astronomy & Astrophysics, Volume 587, id.A148, 20 pp. (arXiv:1510.08536).

12. Coti Zelati, F., Rea, N., Campana, S., De Martino, D., Papitto, A., Safi-Harb, S., Torres, D. F. 2015, Monthly Notices of the Royal Astronomical Society, Volume 456, Issue 2, p.1913-1923 (arXiv:1510.04431).

13. Bamba, Aya, Terada, Yukikatsu, Hewitt, John, Petre, Robert, Angelini, Lorella, Safi-Harb, Samar, Zhou, Ping, Bocchino, Fabrizio & Sawada, Makoto 2016, The Astrophysical Journal, Volume 818, Issue 1, article id. 63, 11 pp. (arXiv:1601.02715).

14. Rogers, A. 2015, Monthly Notices of the Royal Astronomical Society, Volume 451, Issue 1, p.17-25.

15. Yamaguchi, H., Badenes, C., Petre, R., Nakano, T., Castro, D., Enoto, T., Hiraga, J. S., Hughes, J. P., Maeda, Y., Nobukawa, M., Safi-Harb, S., Slane, P. O., Smith, R. K., Uchida, H. 2014, The Astrophysical Journal (ApJ) Letters, 785, L27.

16. Zhou, P., Chen, Y., Li, X.-D., Safi-Harb, S., Mendez, M., Terada, Y., Sun, W., Ge, M.-Y. 2014, ApJ (Letters), 781, L16.

17. Jackson, M., Safi-Harb, S., & Kothes, R. 2014, MNRAS, 444, 2228.

18. Ferrand, G., Danos, R., Shalchi, A., Safi-Harb, S., Edmon, P. & Mendygral, P. 2014, ApJ, 792, 133.

19. Kosenko, D., Ferrand, G., Decourchelle, A. 2014, MNRAS, 443, 1390.

20. Ferrand, G., Decourchelle, A., Safi-Harb, S. 2014, ApJ, 789, 49.

21. Zhou, P., Safi-Harb, S., Chen, Y., Zhang,X., Jiang, B. Ferrand, G. 2014, ApJ, 791, 87.

22. Kumar, H. S., Safi-Harb, S., Slane, P., & Gothelf, E. V. 2014, ApJ, 781, 41.

23. Matheson, H., Safi-Harb, S., & Kothes, R. 2013, ApJ, 774, 33.

24. Ferrand, G., Decourchelle, A., & Safi-Harb, S. 2012, ApJ, 760, 34.

25. Kumar, H. S., Safi-Harb, S., & Gonzalez, M. E. 2012, ApJ, 754, 96.

26. Ferrand, G., & Safi-Harb, S. 2012, Advances in Space Research, 49, 1313.

Proceedings

27. Safi-Harb, S. 2017; Gamma2016: Highlights and Summary of Galactic Science (invited rapporteur talk), 6th International Symposium on High-Energy Gamma-Ray Astronomy (Gamma 2016), Heidelberg (Germany), 11–15 July (2016). To be published by AIP in 2017.

28. Cherenkov Telescope Array (CTA) consortium, in: 6th International Symposium on High-Energy Gamma-Ray Astronomy (Gamma 2016), Heidelberg (Germany), 11–15 July (2016) (arXiv:1610.05151).

29. Takahashi (Hitomi collaboration) et al., including Safi-Harb, S. 2016, Proceedings of the SPIE, Volume 9905, id. 99050U 17 pp. (2016).

30. Safi-Harb, S. 2016 (invited review) in: Supernova Remnants: An Odyssey in Space after Stellar Death, Proceedings of the Conference held 6-11 June 2016, in Chania, Greece; 2016sros.confE..49S.

31. Ferrand, G. & Safi-Harb, S. 2016; in Supernova Remnants: An Odyssey in Space after Stellar Death, Proceedings of the Conference held 6-11 June 2016, in Chania, Greece; arXiv:1609.03264 (2016)

32. West, J., Safi-Harb, S., Jaffe, T., Ferrand, G., Kothes, R., Landecker, T., Foster, T. 2016, in: Supernova Remnants: An Odyssey in Space after Stellar Death, Proceedings of the Conference held 6-11 June 2016, in Chania, Greece; 2016sros.confE..83W (2016)

33. Safi-Harb, S. & Rogers, A. 2016, in: Supernova Remnants: An Odyssey in Space after Stellar Death, Proceedings of the Conference held 6-11 June 2016, in Chania, Greece; 2016sros.confE..66S

34. Guest, B. & Safi-Harb, S. 2016 in: Supernova Remnants: An Odyssey in Space after Stellar Death, Proceedings of the Conference held 6-11 June 2016, in Chania, Greece; 2016sros.confE..52G

35. Zhou, Ping, Chen, Yang, Zhang, Zhi-Yu, Li, Xiang-Dong, Safi-Harb, Samar, Zhou, Xin & Zhang, Xiao 2016 in: Supernova Remnants: An Odyssey in Space after Stellar Death, Proceedings of the Conference held 6-11 June 2016, in Chania, Greece; 2016sros.confE.130Z.

36. Safi-Harb, S. 2015, International Astronomical Union Assembly, 2015IAUGA..2251633S (invited), submitted to the American Astronomical Society, 01 Nov. (2015).

37. Reichardt, I., Terrier, R., West, J., Safi-Harb, S., de Ona-Wilhelmi, E., Rico, J. 2014, Fermi Symposium proceedings - eConf C14102.1; arXiv:1502.03053 (2015).

38. Takahashi, T. et al. (for the ASTRO-H team) 2014, Proceedings of the SPIE, Volume 9144, id. 914425 24 pp; arXiv:1412.1356 (2014).

39. Ferrand, G. & Safi-Harb, S., Cosmic Rays and the Interstellar Medium (CRISM 2014), Proceedings of Science, paper I on the simulations (3D simulations of the multi-wavelength emission from young SNRs including efficient particle acceleration), CRISM 2014, 24-27 June, Montpellier, France (2014).

40. Ferrand, G. & Safi-Harb, S., Cosmic Rays and the Interstellar Medium (CRISM 2014), Proceedings of Science, paper II on the SNR catalogue (An updated Catalogue of High-Energy Observations of Galactic Supernova Remnants), CRISM 2014, 24-27 June, Montpellier, France (2014).

41. Zhou, P., Safi-Harb, S. et al., Proceedings of the IAU Symposium, Cambridge U. Press, Volume 296, 360 (2014).

42. Kumar, H. S., Safi-Harb, S., Slane, P., & Gotthelf, E. V., Proceeding of the IAU Symposium, Cambridge U. Press, Volume 296, 235 (2014).

43. Safi-Harb, S., Ferrand, G., & Matheson, H. 2013, Proceedings of the IAU Symposium, 291, 483, Cambridge U. Press; arXiv:1210.5264 (2013).

44. Safi-Harb, S., & Kumar, H. S. 2013, Proceedings of the IAU Symposium, 291, 480, Cambridge U. Press; arXiv:1210.5261 (2013).

45. Safi-Harb, S. 2013, Proceedings of the IAU Symposium, 291, 251, Cambridge U. Press; arXiv:1211.0852 (invited review. 2013).

46. Takahashi, T., Mitsuda, K., Kelley, R.,... Safi-Harb et al. 2012, Proceedings of the SPIE, Proc. SPIE, 8443, 22pp.; arXiv:1210.4378 (2012).

47. Safi-Harb, S. 2012, American Institute of Physics Conference Series, 1505, 13; arXiv:1210.5406 (invited review, 2012).

Theses

48. Jennifer West, PhD thesis: The connection between supernova remnants and the Galactic magnetic field; completed 24 Aug. (2016).

49. Chelsea Braun, MSc thesis: Study of the Supernova Remnant RCW 103 (G332.4-0.4) with the Chandra X-ray Observatory; completed 31 March (2016).

50. Heather Matheson, PhD thesis: X-ray observations of the young pulsar wind nebula G21.5–0.9 and the evolved pulsar wind nebulae CTB 87 (G74.9+1.2) and G63.7+1.1, completed 21 Dec. (2014).

51. Harsha S. Kumar, PhD thesis: X-ray studies of highly magnetized neutron stars and their environs, defended May (2013); recipient of the 2014 UofM's Governor General's Gold Medal.

52. Recent Honours undergraduate theses: Benson Guest and Chelsea Braun (2013), Kelvin Au (2015), and Yichen Zhan (2016).

White Papers

- Young Supernova Remnants by Hughes, Safi-Harb et al., ASTRO-H White Paper, arXiv:1412.1169 (2014).
- Older Supernova Remnants and Pulsar Wind Nebulae by Long et al., ASTRO-H White Paper, arXiv:1412.1166 (2014).
- Accreting Pulsars, Magnetars, and Related Sources by Kitamoto, Enoto, Safi-Harb et al., ASTRO-H White Paper, arXiv:1412.1165 (2014).
- *plus* 13 other white papers for the ASTRO-H team members (all posted on the arXiv on 03 Dec 2014): arXiv:14121190, 1412.1179, 1412:1177, 1412:1176, 1412:1175, 1412:1174, 1412:1173, 1412:1172, 1412:1171, 1412:1170, 1412:1164, 1412:1163, 1412:1162 (2014).

Conference Presentations

- X-ray Observations of the Supernova Remnant G21.5–0.9 by Guest, B. & Safi-Harb, S., Hitomi Collaboration meeting at NASA's Goddard Space Flight Centre, Greenbelt, MD, Sep. (2016).

- Rapporteur Summary at the 6th International Symposium of Gamma-Ray Astronomy , Heidelberg, Germany, 11-15 July (2016).

- **Six** Presentations given by Safi-Harb and group members at the Supernova Remnants Conference entitled: Supernova Remnants: An Odyssey in Space after Stellar Death, Conference held 6-11 June 2016, in Chania, Greece (2016).

- **Six** Presentations given by Safi-Harb's group at the annual CASCA meeting held in Winnipeg, May 30-June 2 (2016).

- Peering deeper into the Plerionic Supernova Remnant G21.5–0.9, Guest, B. & Safi-Harb, S., WITP Symposium, 25 Aug. (2016).

- Spin-Down Mechanisms in Neutron Stars with Anomalous Magnetic Fields, Rogers, A., Safi-Harb, S., International Astronomical Union (IAU) General Assembly, Meeting #29, id.#2257636, Aug. (2015).

- Autonomous Modelling of X-ray Spectra Using Robust Global Optimization Methods, Rogers, A., Safi-Harb, S. & Fiege, J., International Astronomical Union (IAU) General Assembly, Meeting #29, id.#2257588, Aug. (2015).

- 3D Simulations of the Emission from Young Supernova Remnants Including Efficient Particle Acceleration, Ferrand, G., Safi-Harb, S., Decourchelle, A. IAU General Assembly, Meeting #29, id.#2257717, Aug. (2015).

- Bilateral symmetry in supernova remnants and the connection to the Galactic magnetic field, West, J. L., Safi-Harb, S.,Jaffe, T., Kothes, R., Foster, T., Landecker, T., IAU General Assembly, Meeting #29, id.#2257592, Aug. (2015).

- Molecular environment and X-ray study of the metal-rich thermal composite supernova remnant Kes 79, Zhou, P., Chen, Y., Safi-Harb, S., Sun, IAU General Assembly, Meeting #29, id.#2255046, Aug. (2015).

- Multi-D SNR Simulations with Particle Acceleration, Ferrand. G. in collaboration with Safi-Harb and Decourchelle, 2015, Particle Astrophysics and Cosmology Including Fundamental InteraCtions (PACIFIC) workshop, Sep. (2015).

- Modelling Supernova Remnants with Bilateral Morphology, Jennifer West's PhD project presentation at the WITP symposium, UofM, Aug. (2015).

- A Chandra X-ray Study of a Supernova Remnant Hosting a Peculiar Compact Object, Kelvin Au, undergraduate thesis project presentation at WITP, UofM, Aug. (2015).

- Study of the Very High Energy Emission from the Galactic Supernova Remnant Population with H.E.S.S., Hahn, J., Fernandez, D., Casanova, S., Chaves, R., Marandon, V., Renaud, M., Safi-Harb, S., Vink, J., International Cosmic Ray Conference, ICRC 2015-I/686, The Hague, The Netherlands, 30 July–06 Aug. (2015).

- Autonomous Modelling of X-ray Spectra Using Robust Global Optimization Methods, Rogers, A., Safi-Harb, S. & Fiege, CASCA 2015, Hamilton, ON, May (2015).

- High-Energy Studies of the Supernova Remnant CTB 37B, Kumar, H. S. & Safi-Harb, S., Fermi Summer School, Delaware, 26 May – 05 June (2015).

- Studying Young and Old Supernova Remnants with the Upcoming X-ray Mission, Safi-Harb, S., for the ASTRO-H team, American Astronomical Society Meeting #225, id.#338.33, Seattle, 4–8 Jan. (2015).

- Prospects with ASTRO-H on New Sciences of Accreting Pulsars, Magnetars, & Related Sources by Kitamoto, Enoto, Safi-Harb et al. for the ASTRO-H team, American Astronomical Society Meeting #225, id.#345.22, Seattle, 4-8 Jan. (2015).

- Fermi/LAT Study of the Cygnus Loop Supernova Remnant: Discovery of a Point-like Source and of Spectral Differences in its gamma-ray emission, 2014 Fifth International Fermi Symposium, Nagoya U, Japan, 20–24 Oct. (2014).

- Hughes, J. P., Safi-Harb, S. et al. (for the ASTRO-H team), 40th COSPAR Scientific Assembly; Moscow, Russia, E1.4-20-14., Aug. (2014).

- Zhou, P., Chen, Y., Safi-Harb, S. & Ming, S., 40th COSPAR Scientific Assembly; Moscow, Russia, Abstract E1.16-41-14, Aug. (2014).

- Zhou, P. et al., 40th COSPAR Scientific Assembly; Moscow, Russia, Abstract E1.12-20-14., Aug. (2014).

- 3D simulations (poster) and SNRcat (talk), Ferrand, G. with Safi-Harb at CTA workshop in Paris, 30 June (2014).

- 3D simulations, Ferrand, G. at the RAMSES Users meeting, Saclay, 26 June (2014).

- A talk on SNRcat and a poster the 3D simulations, Ferrand, G. with Safi-Harb at the CRISM conference in Montpellier, 24–27 June (2014).

- Three Presentations on PV phase targets for ASTRO-H; Young and Old SNRs, and Compact Objects, in collaboration with the ASTRO-H team, ASTRO-H SM13 meeting, Metropolitan U., Japan, March (2014)

- Pulsar Wind Nebulae with ASTRO-H, Guest, B. & Safi-Harb, S., ASTRO-H Summer School, Paris, July (2014). (one of the winners for a poster presentation)

- Three presentations on white papers for Young and Old SNRs, Pulsar Wind Nebulae and Compact Objects, in collaboration with the ASTRO-H team, ASTRO-H's SM12, Matsuyama, Japan, Feb. (2014)

- Using Supernova Remnants to Probe Magnetars, Safi-Harb, Suzaku/Maxi 2014 conference, Matsuyama, Japan, Feb (2014).

- Supernova remnants as astrophysical laboratories for the formation of the elements, Braun, C. & Safi-Harb, S., WITP, Winnipeg, Aug. (2013)

- A new galactic pulsar candidate revealed by the Chandra X-ray Observatory, Guest, B. & Safi-Harb, S., WITP, Winnipeg, Aug. (2013)

- Young Supernova Remnants with Astro-H, Safi-Harb for the ASTRO-H Science Working Group on Young SNRs, Yale U. (2013)

- Magnetars and High-Mass X-ray Binaries with Astro-H, Kitamoto et al., ASTRO-H Science Working Group on compact objects, Yale U., Jul (2013)

- Old Supernova Remnants and Pulsar Wind Nebulae with Astro-H, Long et al., ASTRO-H Science Working Group on Old SNRs and PWNe, Yale U., Jul (2013)

- Bilateral Symmetry in Supernova Remnants and the Connection to the Galactic Magnetic Field, West, J., Safi-Harb, S. Jaffe, T., Kothes, R., Landecker, T., & Foster, T., Seventh NAIC/NRAO Single-Dish Summer School, Puerto Rico, July (2013).

- The Astro-H X-ray Mission, Safi-Harb, S., Gallo, L., McNamara, B. et al., CASCA, U. of British Columbia, May (2013).

- Applications of Global Optimization Methods in High-Energy Astrophysics, Rogers, A., Safi-Harb, S., & Fiege, J., CASCA, U. of British Columbia, May (2013).

- Modelling polarized radio emission from supernova remnants, West, J., Safi-Harb, S. Jaffe, T., Kothes, R., Landecker, T., & Foster, T., CASCA, U. of British Columbia, May (2013).

- Modelling polarized radio emission from supernova remnants, West, J., Safi-Harb, S. Jaffe, T., Kothes, R., Landecker, T., Foster, T., S, & Landecker, T. 2010, International EMU/POSSUM/GALFACTS Meeting, British Columbia, May (2013).

- Prospects for Astro-H studies of Young SNRs, Old SNRs and PWNe, and High-Mass X-ray Binaries+Magnetars; a total of 9 posters total for the ASTRO-H Science Working Group Meeting, Tsukuba, Japan, Feb. (2013).

- An XMM-Newton study of the mixed?-morphology supernova remnant W28, Zhou, P., Safi-Harb, S. et al., Supernova Environmental Impacts, IAU Symposium No. 296, Calcutta, India, Jan. (2013).

- X-ray imaging and spectroscopic study of the SNR Kes 73 hosting the magnetar 1E 1841–045, Kumar, H. S., Safi-Harb, S., Slane, P., & Gotthelf, E. V., Supernova Environmental Impacts, IAU Symposium No. 296, Calcutta, India, Jan. (2013).

- Pulsar Wind Nebulae, Kumar delivered on behalf of Safi-Harb, Supernova Environmental Impacts, IAU Symposium No. 296, Calcutta, India, Jan. (2013).

- Pulsar Wind Nebulae: On their growing diversity and association with highly magnetized neutron stars, Safi-Harb, S., IAU Symposium 291: Neutron Stars and Pulsars: Challenges and Opportunities after 80 years, Beijing, China, 20–31 Aug. (2012).

- A high-energy catalogue of galactic SNRs and PWNe, Safi-Harb, S., Ferrand, G., & Matheson, H. 2013, IAU Symposium 291: Neutron Stars and Pulsars: Challenges and Opportunities after 80 years, Beijing, China, 20–31 Aug. (2012).

- On the environments and progenitors of supernova remnants associated with highly magnetized neutron stars, Safi-Harb, S. & Kumar, H. S., IAU Symposium 291: Neutron Stars and Pulsars: Challenges and Opportunities after 80 years, Beijing, China, 20–31 Aug. (2012).

- 3D simulations of the emission from young supernova remnants including particle acceleration, Ferrand, G., Safi-Harb, S., The Cosmic Kaleidoscope, Pulsars and their Nebulae, Supernova Remnants and More, Kruger Park, S. Africa, 13–17 Aug. (2012).

- An X-ray study of the pulsar wind nebula G63.7+1.1 with Chandra and XMM-Newton, Matheson, S., Safi-Harb, S., & Kothes, R., The Cosmic Kaleidoscope, Pulsars and their Nebulae, Supernova Remnants and More, Kruger Park, S. Africa, 13–17 Aug. (2012).

- A Census of High-Energy Observations of Galactic Supernova Remnants and Pulsar Wind Nebulae, Ferrand, G., Safi-Harb, S., & Matheson, H., The Cosmic Kaleidoscope, Pulsars and their Nebulae, Supernova Remnants and More, Kruger Park, S. Africa, 13–17 Aug. (2012).

- An XMM-Newton Study of the Mixed-?Morphology Supernova Remnant W28, Zhou, P., Safi-Harb, S. et al.. The Cosmic Kaleidoscope, Pulsars and their Nebulae, Supernova Remnants and More, Kruger Park, S. Africa, 13–17 Aug. (2012).

- Plerionic Supernova Remnants, Safi-Harb, S., the 5th Symposium on Gamma-Ray Astronomy, Heidelberg, Germany, 9–13 Jul. (2012).

- SNR Plasmas White Paper Task Force, Hughes, J., Safi-Harb, S. et al., Astro-H Science Working Group (SWG) meeting, Cambridge, U.K., 9–11 Jul. (2012).

- Magnetars/High-Mass-X-ray Binaries White Paper Task Force, Enoto, Kitamoto, Safi-Harb, S. et al., Astro-H SWG meeting, Cambridge, U.K., 9–11 Jul. (2012).

- SNR Dynamics White Paper Task Force, Long, K. et al. including Safi-Harb, S., Astro-H SWG meeting, Cambridge, U.K., 9–11 Jul. (2012).

- The Astro-H X-ray Observatory: The mission, science, and Canadian participation, Gallo, L., Safi-Harb, S. (presenter), McNamara, B., on behalf of the Astro-H team, Canadian Astronomical Society Meeting (CASCA), U. of Calgary, 4–7 June (2012).

- 3D simulations of the emission from young supernova remnants including particle acceleration, Ferrand, G., Safi-Harb, S., Decourchelle, A., Pomarede, D., Canadian Astronomical Society Meeting (CASCA), U. of Calgary, 4–7 June (2012).

Invited Talks

- Presentation at the UofM Faculty of Science Homecoming event, 19 Sep. (2016)

- Keynote Lecture on 'High-Energy Astrophysics: A Window into a Violent and Extreme Universe; Women in Physics Conference, U. of Saskatchewan, 27 July (2016)

- Review on 'Future X-ray Studies of Pulsar Wind Nebulae' at the 'Modelling Nebulae' workshop, 5th session of the Sant Cugat Forum in Astrophysics, Barcelona, Spain, June 14-17 (2016)

- Review on 'High-Energy Observations of Pulsar Wind Nebulae' at the Supernova Remnants Conference 'An Odyssey in Space After Stellar Death', Crete Island, Greece, June 6-11 (2016)

- Rapporteur talk on Galactic Science, Gamma2016, Heidelberg, Germany, 11–15 July (2016)

- An X-ray View of the Zoo of Compact Objects and Associated Supernova Remnants, International Astronomical Union (IAU) General Assembly, Meeting #29, id.#2251633 Honolulu, Hawaii, 10 Aug. (2015)

- The Different Faces of Neutron Stars, U. of Tokyo in celebration of Prof. Makishima's Japan Academy Prize Award and his retirement from the U. of Tokyo, 01 Aug. (2015)

- The Beauty in the Extreme: Supernova Remnants and Associated Compact Objects, Max Planck Institute for Nuclear Physics (MPIK), Heidelberg, Germany, 08 June (2015)

- The Beauty in the Extreme: Supernova Remnants and Associated Compact Objects, National Research Council of Canada, Dominion Radio Astrophysical Observatory, Penticton, B.C., 20 May (2015)

- Supernova Remnants and Associated Beasts: A violent, hot and dynamic Universe: A Public Lecture at the U. of Toronto's Astronomy and Space Exploration (ASX) Society's Symposium, 23 Jan. (2015)

- Supernova Remnants: An Astrophysical Factory for High-Energy and Exotic Phenomena, Colloquium at the U. of Alberta, 13 Nov. (2014)

- Supernova Remnants, ASTRO-H 5th Summer School, Paris (France), July (2014)
- Pulsar Wind Nebulae and Neutron Stars, ASTRO-H 5th Summer School, Paris (France), July (2014)
- Neutron Stars, CCGRA15, U. of Winnipeg, 21-23 May (2014)
- Pulsar Wind Nebulae and Magnetars, ASTRO-H HXI/SGD Workshop at Hiroshima U. (Japan), 24-25 Feb. (2014)
- Pulsar Wind Nebula – Supernova Remnant Interaction, International Astronomical Union Symposium entitled 'Supernova Environmental Impacts', Calcutta, India, 6–11 Jan. (2013).
- Neutron Stars and Supernova Remnants, International Astronomical Union Symposium 291 entitled 'Neutron Stars and Pulsars: Challenges and Opportunities after 80 years', Beijing, China, 20–31 Aug. (2012).
- Supernova Remnants as Cosmic Laboratories for Studying the Physics of the Extreme and our Origins, Women in Physics Conference, University of British Columbia, Vancouver, Canada, 2–4 Aug. (2012).
- Plerionic Supernova Remnants, 5th International Symposium on High-Energy Gamma-Ray Astronomy dedicated to a centenary of cosmic ray research, Heidelberg, Germany, 9–13 July (2012).
- Supernova Remnants and Neutron Stars in X-rays, Colloquium at St. Mary's University, Halifax, Canada, 30 March. (2012).

Media and Press Releases

- Expanding molecular bubble unveils the mysterious origin of Tycho?s supernova; UofM press release (and others including ESA), 19 July (2016).
- Hitomi press releases: **several** press releases and interviews highlighting the pre- and post-launch of the X-ray mission, ASTRO-H (renamed to Hitomi), including interviews with Safi-Harb on Discovery Channel, CBC, Manitoba news and others; Feb.–Mar. (2016).
- PhD student Jennifer West's 1-min NSERC, Science Action video, runner-up, Featured in UofM Today: http://news.umanitoba.ca/winners-in-science-action/ (Apr. 2015).
- CSA Ottawa based Neptec Design Group built precision optics technology for Japan's Next Generation Space Observatory, Canadian Space Agency's press release, Longueuil, Quebec 19 Mar. (2015)
- 'Future of Canadian astronomy research is looking up', UofM Press release, 19 Mar. (2015).

- NASA/Chandra image release on the SNR Kes 73, 21 Oct. (2014).
- Iron 'Fingerprints' Point Astronomers to Supernova Suspects, NASA press release, NASA press release, 02 Jul. (2014).
- Government of Canada Awards Contract for Canada's Contribution to Japan's Next Generation Space Observatory, 24 Apr. (2014).
- 'Canada Partners on Upcoming Japanese X-ray Space Observatory', Canadian Space Agency Press Release, 28 Jan. (2014).
- Serendipitous discovery of star playing 'Now you see me?', U. of Manitoba press release on the XMM-Newton discovery of a transient magnetar (Dec. 2013). Led also to COSPAR and XMM-Newton press releases during 2013–2014.
- NASA/Chandra image release on the SNR 3C 397, 28 Oct. (2013)
- 'Travels Through Space': Interview and article featuring Safi-Harb's group's research in the International Innovation magazine published by ResearchMedia, July (2013).
- '3D Simulations of Supernova Remnants', U. of Manitoba and CEA/Saclay Press Release, Nov. (2012).
- UofM's Research Life interview and feature article, Jan. (2012).
- 'Canadian stellar sleuth seeks to unravel mysteries of exploding stars', Radio Canada International (RCI) interview, The Link. Broadcast replayed as one of their 'Best of 2011' shows during the holiday period (Dec. 2011).

Recent Conference Organization

- Scientific Organizing Committee member for the International Astronomical Union (IAU) Symposium 331 on 'SN1987A, 30 years later', to take place in Reunion Island, France, Feb. (2017).
- Scientific Organizing Committee member for Gamma2016, Heidelberg, Germany (2016).
- Organizing Committee member for CASCA 2016, Winnipeg (May 30-June 2, 2016).
- ASTRO-H SNR Workshop co-organizer, Tokyo Metropolitan U., July (2015).

High-energy missions membership and other activities

- Science working group member for the proposed ESA's Athena X-ray mission (since Apr. 2015)
- Full Member of the Cherenkov Telescope Array (CTA) future gamma-ray mission; co-applicant with Andreas Shalchi (since Dec. 2014)

- Associate member of the H.E.S.S. gamma-ray collaboration (since Oct. 2011)
- Science working group member and SNR team co-leader for the ASTRO-H X-ray mission launched in Feb. 2016 (since Aug. 2011), renamed to Hitomi. The mission was lost in Mar. (2016) but scientific activities continue with the data taken during the early phase of the mission.
- Chair of the CSA high-energy astrophysics Diffuse Emission Subcommittee
- Member of NASA's Chandra Users Committee
- Member of the Canadian Time Allocation Committee
- Member of the ACURA Advisory Committee for the Square Kilometre Array (AACS)
- Referee for astronomy and astrophysics journals, NASA and NSERC

E. Schippers

Publications

1. Schippers, E.; Staubach, W. "Harmonic reflection in quasicircles and well-posedness of a Riemann-Hilbert problem on quasidisks.", to appear in Journal of Mathematical Analysis and Applications.
2. Schippers, E.; Staubach, W. "Well-posedness of a Riemann-Hilbert problem on d-regular quasidisks.", to appear in Annales Academiae Scientiarum Fennicae.
3. Schippers, E.; Staubach, W. "Riemann boundary value problem on quasidisks, Faber isomorphism and Grunsky operator.", Complex Analysis and Operator Theory. 9 (2015) no. 8, 1663 – 1679.
4. Radnell, D.; Schippers, E.; Staubach, W. "Dirichlet problem and Sokhotski-Plemelj jump formula on Weil-Petersson class quasidisks." Annales Academiae Scientiarum Fennicae. 41 (2016), 1–9.
5. Radnell, D.; Schippers, E.; and Staubach, W. "Convergence of the Weil-Petersson metric on the Teichmueller space of bordered Riemann surfaces", Communications in Contemporary Mathematics 19, No. 01, 1650025 (2017).
6. Radnell, D.; Schippers, E.; and Staubach, W. "Quasiconformal maps of bordered Riemann surfaces with L^2 Beltrami differentials." to appear in Journal d'Analyse Mathématique.
7. Radnell, D.; Schippers, E.; and Staubach, W. "Weil-Petersson class non-overlapping mappings into a Riemann surface." Commun. Contemp. Math. 18, 1550060 (2016).
8. Schippers, E.; and Staubach, W. "A symplectic functional analytic proof of the conformal welding theorem." Proceedings of the American Mathematical Society **143** (2015), 265 – 278.

9. Radnell, D.; Schippers, E.; and Staubach, W. "A Hilbert manifold structure on the Weil-Petersson class Teichmueller space of bordered Riemann surfaces. Communications in Contemporary Mathematics **17** no 4, 1550016 (2015).

10. Reimer, K.; and Schippers, E. "Grunsky inequalities for mappings into a compact Riemann surface" Complex Analysis and Operator Theory **9**, Issue 8 (2014), 1663 –1826

11. Penfound, B.; Schippers, E. "Power matrices for Faber polynomials and conformal welding." Complex Variables and Elliptic Equations. **58** no 9 (2013), 1247–1259.

12. Radnell, D.; and Schippers, E. "The semigroup of rigged annuli and the Teichmueller space of the annulus." Journal of the London Mathematical Society **86** no 2 (2012), 321–342.

Refereed Conference Proceedings

13. Schippers, E. "Quadratic differentials and conformal invariants". To appear in the Journal of Analysis.

14. Radnell, D.; Schippers, E; Staubach, W. "Quasiconformal Teichmuller theory as an analytic foundation for two-dimensional conformal field theory." to appear in Contemporary Mathematics.

Research Presentations

15. CMS Winter Meeting, Special Session on Complex Analysis and Applications, Niagara Falls ON, December 2016.

16. Workshop on Probabilistic Methods in Spectral Geometry and Partial Differential Equations, Centre de Récherche Mathématique, Montréal, QC. August 2016.

17. Analysis Seminar, University of Bergen, Bergen, Norway, April 2016.

18. Analysis and Geometry Seminar, Aalto University, Helsinki, Finland, April 2016.

19. CMS winter meeting, Special Session on Complex Analysis and Operator Theory, Montréal QC, December 2015.

20. Conference on Trends in Contemporary Complex Analysis, University of Cincinnati, Cincinnati, OH, May 2015.

21. Rutgers University Lie Groups/Quantum Mathematics seminar, April 2014.

22. American Mathematical Society Sectional Meeting, special session on Complex Function Theory and Special Functions, Texas Tech University, Lubbock, TX, April 2014.

23. Workshop on infinite-dimensional geometry, MSRI (Mathematical Sciences Research Institute), Berkeley, December 2013.

24. McGill University analysis seminar, February 2013.

25. CMS winter meeting, special session on complex analysis and operator theory, Montreal, QC. December 2012.

26. University of Western Ontario, Colloquium. London, ON. November 2012.

27. CMS summer meeting, special session on complex geometry and related fields, Regina SK. June 2012.

28. Uppsala Universitet analysis seminar, Uppsala, Sweden. April 2012.

29. HCAA 2012, (Harmonic and Complex Analysis and its Applications), Tenerife, Spain, March 2012.

A. Shalchi

1. Lasuik, J., Fiege, J. D., & Shalchi, A., Numerical Analysis of the Fokker-Planck Equation with Adiabatic Focusing: Realistic Pitch-Angle Scattering, 2016, Advances in Space Research, in press

2. Shalchi, A., The implicit contribution of slab modes to the perpendicular diffusion coefficient of particles interacting with two-component turbulence, The Astrophysical Journal **830**, 2 (2016)

3. Shalchi, A., The influence of the Kubo number on the transport of energetic particles, New Journal of Physics **18**, 085010 (2016)

4. Heusen, M. & Shalchi, A., Simulations of energetic particles interacting with nonlinear anisotropic dynamical turbulence, Astrophysics and Space Science **361**, 308 (2016)

5. Shalchi, A., Negrea, M., & Petrisor, I., Stochastic field-line wandering in magnetic turbulence with shear, 1. Quasi-linear theory, Physics of Plasmas **23**, 072306 (2016)

6. Qin G. & Shalchi, A., Numerical test of different approximations used in the transport theory of energetic particles, The Astrophysical Journal **823**, 23 (2016)

7. Tautz, R. C., Bolte, J. & Shalchi, A., Monte Carlo simulations of intensity profiles for energetic particle propagation, Astronomy & Astrophysics **586**, A118 (2016)

8. Hussein, M. & Shalchi, A., Simulating parallel and perpendicular diffusion of energetic particles in dynamical turbulence, The Astrophysical Journal **817**, 136 (2016)

9. Reimer A. & Shalchi, A., Parallel Diffusion of Energetic Particles Interacting with Noisy Reduced MHD Turbulence, Monthly Notices of the Royal Astronomical Society **456**, 3803 (2016)

10. Shalchi, A., Finite Gyroradius corrections in the theory of perpendicular diffusion, 2. Strong velocity diffusion, Advances in Space Research **57**, 431 (2016).

11. Shalchi, A., Finite Gyroradius corrections in the theory of perpendicular diffusion, 1. Suppressed velocity diffusion, Advances in Space Research **56**, 1264 (2015).

12. Hussein, M., Tautz, R., and Shalchi, A., The Influence of Different Turbulence Models on the Diffusion Coefficients of Energetic Particles, Journal of Geophysical Research **120**, 4095 (2015).

13. Shalchi, A., Analytic Forms of the Perpendicular Diffusion Coefficient in NRMHD Turbulence, The Astrophysical Journal **799**, 232 (2015).

14. Shalchi, A., Perpendicular Diffusion of Energetic Particles in Collisionless Plasmas, Physics of Plasmas Letters **22**, 010704 (2015).

15. Qin, G. and Shalchi, A., Perpendicular Diffusion of Energetic Particles: Numerical Test of the Theorem on Reduced Dimensionality, Physics of Plasmas **22**, 012905 (2015).

16. Shalchi, A. and Hussein, M., Erratum: "Benchmarking the unified nonlinear transport theory for Goldreich-Sridhar turbulence" [Astrophys Space Sci (2013) 344:187-191], Astrophysics and Space Science **355**, 234 (2015).

17. Tautz, R. C., Shalchi, A., and Dosch, A., Pitch-angle scattering of energetic particles with adiabatic focusing, The Astrophysical Journal **794**S, 138 (2014).

18. Shalchi, A. and Hussein, M., Perpendicular Diffusion of Energetic Particles in Noisy Reduced Magnetohydrodynamic Turbulence, The Astrophysical Journal **794**, 56 (2014).

19. Hussein, M. and Shalchi, A., Parallel and perpendicular diffusion coefficients of energetic particles interacting with Shear Alfvén waves, Monthly Notices of the Royal Astronomical Society **444**, 2676 (2014).

20. Ferrand, G., Danos, R., Shalchi, A., Safi-Harb, S., Edmon, P., and Mendygral, P., Cosmic Ray Acceleration at Perpendicular Shocks in Supernova Remnants, The Astrophysical Journal **792**, 133 (2014).

21. Qin, G. and Shalchi, A., Detailed numerical investigation of 90° scattering of energetic particles interacting with magnetic turbulence, Physics of Plasmas **21**, 042906 (2014).

22. Hussein, M. and Shalchi, A., Detailed numerical investigation of the Bohm limit in cosmic ray diffusion theory, The Astrophysical Journal **785**, 31 (2014).

23. Srinivasan, S. and Shalchi, A., The different transport regimes of pitch-angle scattering of energetic particles, Astrophysics and Space Science **350**, 197 (2014).

24. Shalchi, A., On the Universality of Asymptotic Limits in the Theory of Field Line Diffusion and Perpendicular Transport of Energetic Particles, Advances in Space Research **53**, 1024 (2014).

25. Qin, G. and Shalchi, A., Pitch-Angle Dependent Perpendicular Diffusion of Energetic Particles Interacting with Magnetic Turbulence, Applied Physics Research **6**, 1 (2014).

26. Shalchi, A., Simple Analytical Forms of the Perpendicular Diffusion Coefficient for Two-Component Turbulence, II. Dynamical Turbulence with Constant Correlation Time, The Astrophysical Journal **780**, 138 (2014).

27. Qin, G. and Shalchi, A., The Role of the Kubo Number in Two-Component Turbulence, Physics of Plasmas **20**, 092302 (2013).

28. Shalchi, A., Simple Analytical Forms of the Perpendicular Diffusion Coefficient for Two-Component Turbulence, I. Magnetotstatic Turbulence, The Astrophysical Journal **774**, 7 (2013).

29. Dosch, A., Shalchi, A., and Zank, G. P., Perpendicular Transport of Charged Particles: Results for the Unified Nonlinear Transport theory derived from the Newton-Lorentz equation, Advances in Space Research **52**, 936 (2013).

30. Danos, R. J., Fiege, J. D., and Shalchi, A., Numerical Analysis of the Fokker-Planck Equation with Adiabatic Focusing: Isotropic Pitch-Angle Scattering, The Astrophysical Journal **772**, 35 (2013).

31. Tautz, R. C. and Shalchi, A., Simulated Energetic Particle Transport in the Interplanetary Space: The Palmer Consensus Revisited, Journal of Geophysical Research **118**, 642 (2013).

32. Shalchi, A. and Kolly, A., Analytical description of field line random walk in Goldreich-Sridhar Turbulence, Monthly Notices of the Royal Astronomical Society **431**, 1923 (2013).

33. Shalchi, A., Perpendicular Diffusion in Magnetostatic Slab Turbulence: The Theorem on Reduced Dimensionality and Microscopic Diffusion, Journal of Atmospheric and Solar-Terrestrial Physics **97**, 37 (2013).

34. Shalchi, A. and Danos, R. J., On the different results for the parallel diffusion coefficient of cosmic particles with adiabatic focusing, The Astrophysical Journal **765**, 153 (2013).

35. Shalchi, A., Benchmarking the unified nonlinear transport theory for Goldreich-Sridhar turbulence, Astrophysics and Space Science **344**, 187 (2013).

36. Buffie, K., Heesen, V., and Shalchi, A., Theoretical Explanation of the Cosmic Ray Perpendicular Diffusion Coefficient in the Nearby Starbust Galaxy NGC 253, The Astrophysical Journal **764**, 37 (2013).

37. Shalchi, A., Analytical description of nonlinear particle transport in slab turbulence: High particle energies and stochastic acceleration, Physics of Plasmas **19**, 102901 (2012).

38. Shalchi, A., Fitting Analytical Forms of Spatial and Temporal Correlation Functions to Spacecraft Data, Astrophys. Space Sci. Trans. **8**, 35 (2012).

39. Shalchi, A., Gyrophase Diffusion of Charged Particles in Random Magnetic Fields, Monthly Notices of the Royal Astronomical Society **426**, 880 (2012).

40. Buffie, K. and Shalchi, A., Compound Diffusion of Energetic Particles: A Kappa Model for the Parallel Distribution Function, Astrophysics and Space Science **340**, 351 (2012).

41. Shalchi, A., Webb, G. M., and le Roux, J. A., Parallel transport of cosmic rays for non-diffusive pitch-angle scattering. I. Using the standard Fokker-Planck equation, Physica Scripta **85**, 065901 (2012).

42. Qin, G. and Shalchi, A., Numerical investigation of the influence of large turbulence scales on the parallel and perpendicular transport of Cosmic Rays, Advances in Space Research **49**, 1643 (2012).

43. Guest, B. and Shalchi, A., Random Walk of Magnetic Field Lines in Dynamical Turbulence: A Field Line Tracing Method, II. Two Dimensional Turbulence, Physics of Plasmas **19**, 032902 (2012).

44. Li, G., Shalchi, A., Ao, X., Zank, G. P., and Verkhoglyadova, O. P., Particle acceleration and transport at an oblique CME-driven shock, Advances in Space Research **49**, 1067 (2012).

45. Shalchi, A., Dosch, A., le Roux, J. A., Webb, G. M., and Zank, G. P., Magnetic Field Line Random Walk in Turbulence: A Two-point Correlation Function Description, Physical Review E **85**, 026411 (2012).

46. Tautz, R. C. and Shalchi, A., Drift coefficients of charged particles in turbulent magnetic fields, The Astrophysical Journal **744**, 125 (2012).

Khodr M. Shamseddine

Refereed Journal Publications

1. A local mean value theorem for functions on non-Archimedean field extensions of the real numbers, *Khodr Shamseddine and Gidon Bookatz*, ***p*-Adic Numbers, Ultrametric Analysis, and Applications**, Volume 8 # 2, 2016, pp. 160-175.

2. On the solutions of linear ordinary differential equations and Bessel-type special functions on the Levi-Civita field, *Alpár Mészáros and Khodr Shamseddine*, **Journal of Contemporary Mathematical Analysis**, Volume 50 # 2, 2015, pp. 53-62.

3. Inner product on B*-algebras of operators on a Free Banach space over the Levi-Civita field, *José Aguayo, Miguel Nova and Khodr Shamseddine*, **Indagationes Mathematicae**, in press (to appear in Volume 26 # 1, January 2015, Pages 191–205.)

4. Characterization of compact and self-adjoint operators on Free Banach spaces of countable type over the complex Levi-Civita field, *José Aguayo, Miguel Nova and Khodr Shamseddine*, **Journal of Mathematical Physics**, Volume 54 # 2, 2013.

5. New results on integration on the Levi-Civita field, *K. Shamseddine*, **Indagationes Mathematicae**, Volume 24 # 1, 2013, pp. 199-211.

6. One-variable and multi-variable calculus on a non-Archimedean field extension of the real numbers, *Khodr Shamseddine*, ***p*-Adic Numbers, Ultrametric Analysis, and Applications**, Volume 5 # 2, 2013, pp. 160-175.

7. On locally uniformly differentiable functions on a complete non-Archimedean ordered field extension of the real numbers, *Khodr Shamseddine and Todd Sierens*, **ISRN Mathematical Analysis**, Volume 2012, Article ID 387053, 20 pages.

8. Preliminary notes on Fourier Series for functions on the Levi-Civita field, *Khodr Shamseddine and William Grafton*, **International Journal of Mathematical Analysis**, Volume 6, 2012, # 19, pp. 941-950.

Edited Proceedings

9. Advances in Ultrametric Analysis, Proceedings of the Fourteenth International Conference on *p*-Adic Functional Analysis, *Alain Escassut, Cristina Perez-Garcia and Khodr Shamseddine, editors*, **Contemporary Mathematics, American Mathematical Society**, in preparation.

10. Advances in Non-Archimedean Analysis, Proceedings of the Thirteenth International Conference on p-Adic Functional Analysis, *Helge Glockner, Alain Escassut and Khodr Shamseddine, editors*, **Contemporary Mathematics, American Mathematical Society**, Volume 665, 2016, ISBN 978-1-4704-1988-2.

11. Advances in Ultrametric Analysis, Proceedings of the Twelfth International Conference on *p*-Adic Functional Analysis, *Khodr Shamseddine, editor*, **Contemporary Mathematics, American Mathematical Society**, Volume 596, 2013, ISBN-13: 978-0-8218-9142-1.

Refereed Conference Proceedings

12. Calculus on a non-Archimedean field extension of the real numbers: inverse function theorem, intermediate value theorem and mean value theorem, *Gidon Bookatz and Khodr Shamseddine*, **Contemporary Mathematics, American Mathematical Society**, accepted.

13. Measure theory and Lebesgue-like integration in two and three dimensions over the Levi-Civita field, *Khodr Shamseddine and Darren Flynn*, **Contemporary Mathematics, American Mathematical Society**, Volume 665 (Advances in Non-Archimedean Analysis), 2016, pp. 289- 325.

14. Analysis on the Levi-Civita field and computational applications, *Khodr Shamseddine*, **Applied Mathematics and Computation**, Volume # 255, 2015, pp. 44-57.

15. A brief survey of the study of power series and analytic functions on the Levi-Civita fields, *Khodr Shamseddine*, **Contemporary Mathematics, American Mathematical Society**, Volume 596 (Advances in Ultrametric Analysis), 2013, pp. 269-280.

Invited Talks at Conferences

16. Calculus on a non-Archimedean field extension of the real numbers: The intermediate value theorem, mean value theorem, inverse function theorem and implicit function theorem. 14th International Conference on p-adic Functional Analysis, Aurillac, France, June 30-July 5, 2016.

17. On the Levi-Civita fields: introduction and survey of recent research. 14th International Conference on p-adic Functional Analysis, Aurillac, France, June 30-July 5, 2016.

18. One-variable and multi-variable integral calculus over the Levi-Civita field and applications. NUMTA2016 (Numerical Computations: Theory and Applications) International Conference and Summer School, Pizzo Calabro, Italy, June 19-25, 2016.

19. Characterization of compact and self-adjoint operators, and study of positive operators on a Banach space over a non-Archimedean field, International Conference on p-Adic Mathematical Physics and its Aplications, Belgrade, Serbia, September 7-12, 2015.

20. New results on the Lebesgue-like measure and integration theory on the Levi-Civita field and applications, 13th International Conference on p-Adic Functional Analysis, Paderborn, Germany, August 12-16, 2014.

21. On positive operators on a Banach space over the complex Levi-Civita field, The Seventh Conference on Function Spaces, Southern Illinois University- Edwardsville, Illinois, USA, May 20-24, 2014.

22. Preliminaries in non-Archimedean Functional Analysis, The Seventh Conference on Function Spaces, Southern Illinois University- Edwardsville, Illinois, USA, May 20-24, 2014.

23. Analysis on non-Archimedean ordered field extensions of the real numbers and applications, NUMTA2013 (Numerical Computations: Theory and Applications) International Conference and Summer School, Falerna, Italy, June 16-23, 2013

24. B*-algebras of operators and study of positive operators on a free Banach space of countable type over the complex Levi-Civita field, 12th International Conference on p-Adic Functional Analysis, University of Manitoba, Winnipeg, Canada, July 2-6, 2012.

25. (Co-author, talk given by Jose Aguayo) Characterization of Compact and self-adjoint operators on free Banach spaces of countable type over the complex Levi-Civita field, 12th International Conference on p-Adic Functional Analysis, University of Manitoba, Winnipeg, Canada, July 2-6, 2012.

26. (Co-author, talk given by Todd Sierens) On locally uniformly differentiable functions: the Inverse Function Theorem and the Implicit Function Theorem in a non-Archimedean setting, 12th International Conference on p-Adic Functional Analysis, University of Manitoba, Winnipeg, Canada, July 2-6, 2012.

Seminars and Colloquia at Universities

27. Numerical Calculus Laboratory, University of Calabria, Rende, Italy, June 28, 2016.

28. Department of Mathematics, American University of Beirut, Beirut, Lebanon, July 22, 2015.

29. Department of Mathematics (Functional Analysis seminar, part II), University of Manitoba, March 17, 2015.

30. Department of Mathematics (Functional Analysis seminar, part I), University of Manitoba, March 10, 2015.

31. Department of Mathematics, University of Manitoba, March 21, 2014.

32. Department of Physics, University of Regina, March 7, 2014.

33. Department of Physics and Engineering Physics, University of Saskatchewan, March 6, 2014.

34. Department of Mathematics & Statistics (Algebra seminar), University of Saskatchewan, March 6, 2014.

35. Department of Physics and Astronomy and Winnipeg Institute for Theoretical Physics (joint colloquium), University of Manitoba, April 10, 2013.

36. Science Department, Texas A & M University in Qatar, October 23, 2012.

37. Department of Mathematics, Western Illinois University, August 31, 2012.

38. Departments of Mathematics (Joint Mathematics Colloquium), Universidad del Bio-Bio and Universidad de Concepcion, Concepcion, Chile, December 5, 2011.

Conference Organization

- Member of the International Scientific Committee, 15th International Conference on p- Adic Functional Analysis, Poland (July 2018)
- Member of the International Scientific Committee, 14th International Conference on p- Adic Functional Analysis, France (July 2016)
- Member of the International Scientific Committee, NUMTA2016: Numerical Computations: Theory and Algorithms, Italy (June 2016)
- Organizer, Winnipeg Institute of Theoretical Physics Summer Symposium, U of Manitoba (August 2015)

- Member of the Scientific Advisory Board, 13th International Conference on p-Adic Functional Analysis, Germany (August 2014)
- Organizer of a special session on Non-Archimedean Functional Analysis, The Seventh Conference on Function Spaces, USA (May 2014)
- Co-organizer, Winnipeg Institute of Theoretical Physics Summer Symposium, U. of Manitoba (August 2013)
- Member of the International Scientific Committee, NUMTA2013: Numerical Computations: Theory and Algorithms, Italy (June 2013)
- Organizer and Chair of the International Scientific Committee, 12th Internaional Conference on p-Adic Functional Analysis, U. of Manitoba (July 2012).

J. Sirker

1. T. Enss, F. Andraschko, J. Sirker, "Many-body localization in infinite chains", arXiv: 1608.05733 (2016).
2. D. Morath, N. Sedlmayr, J. Sirker, S. Eggert, "Conductance in inhomogeneous quantum wires: Luttinger liquid predictions and quantum Monte Carlo results", Phys. Rev. B **94**, 115162 (2016).
3. Y. Zhao, F. Andraschko, J. Sirker, "Entanglement entropy of disordered quantum chains following a global quench", Phys. Rev. B **93**, 205146 (2016).
4. M. Harder, L. Bai, C. Match, J. Sirker, C.-M. Hu, "Study of the cavity-magnon-polariton transmission line shape", Sci. China Phys. Mech. Astron. **59**, 117511 (2016).
5. C. Karrasch, R. G. Pereira, J. Sirker, "Low temperature dynamics of nonlinear Luttinger liquids", New J. Phys. **17**, 103003 (2015).
6. F. Andraschko, J. Sirker, "Propagation of a single hole defect in the one-dimensional Bose-Hubbard model", Phys. Rev. B **91**, 235132 (2015).
7. F. Andraschko, T. Enss, J. Sirker, "Purification and many-body localization in cold atomic gases", Phys. Rev. Lett. **113**, 217201 (2014).
8. J. Sirker, M. Maiti, N.P. Konstantinidis, N. Sedlmayr, "Boundary Fidelity and Entanglement in the symmetry protected topological phase of the SSH model", J. Stat. Mech. P10032 (2014).
9. R. G. Pereira, V. Pasquier, J. Sirker, I. Affleck, "Exactly conserved quasilocal operators for the XXZ spin chain", J. Stat. Mech. P09037 (2014).
10. J. Sirker, N.P. Konstantinidis, F. Andraschko, N. Sedlmayr, "Locality and Thermalization in Closed Quantum Systems", Phys. Rev. A **89**, 042104 (2014).

11. F. Andraschko, J. Sirker, "Dynamical quantum phase transitions and the Loschmidt echo: A transfer matrix approach", Phys. Rev. B **89**, 125120 (2014).

12. N. Sedlmayr, D. Morath, J. Sirker, S. Eggert, I. Affleck, "Conducting fixed points for inhomogeneous quantum wires: a conformally invariant boundary theory", Phys. Rev. B **89**, 045133 (2014).

13. N. Sedlmayr, P. Korell, J. Sirker "Two-Band Luttinger Liquid with Spin-Orbit Coupling: Applications to Monatomic Chains on Surfaces", Phys. Rev. B **88**, 195113 (2013).

14. N. Sedlmayr, J. Ren, F. Gebhard, J. Sirker, "Closed and Open System Dynamics in a Fermionic Chain with a Microscopically Specified Bath: Relaxation and Thermalization", Phys. Rev. Lett. **110**, 100406 (2013).

15. N. Sedlmayr, P. Adam, J. Sirker, "Theory of the conductance of interacting quantum wires with good contacts and applications to carbon nanotubes", Phys. Rev. B **87**, 035439 (2013).

16. J. Sirker, "Entanglement measures and the quantum to classical mapping", J. Stat. Mech. P12012 (2012).

17. N. Sedlmayr, J. Ohst, I. Affleck, J. Sirker, S. Eggert, "Transport and scattering in inhomogeneous quantum wires", Phys. Rev. B **86**, 121302(R) (2012).

18. J. Ren and J. Sirker, "Spinons and helimagnons in the frustrated Heisenberg chain", Phys. Rev. B **85**, 140410(R) (2012).

19. F. Gebhard, K. zu Muenster, J. Ren, N. Sedlmayr, J. Sirker, B. Ziebarth, "Particle injection into a chain: decoherence versus relaxation for Hermitian and non-Hermitian dynamics", Ann. Phys. **524**, 286 (2012).

20. J. Sirker, "The Luttinger liquid and integrable models", Int. J. Mod. Phys. B. **26**, 1244009 (2012).

21. T. Enss and J. Sirker, "Lightcone renormalization and quantum quenches in one-dimensional Hubbard models", New J. Phys. **14**, 023008 (2012).

Talks

22. "Dynamical respomse in low-dimensional quantum models", Conference: Low-dimensional quantum systems: Models and Materials, Bad Honnef, Germany, November 2016.

23. "Low temperature dynamics of nonlinear Luttinger liquids", Conference: Boundary degrees of freedom and thermodynamics of integrable models, Natal, Brazil, August 2016.

24. "Dynamics in integrable quantum systems", CAP congress, Ottawa, Canada, June 2016.

25. "Entanglement entropy in quantum critical glasses and MBL phases" Conference: Quantum non-equilibrium phenomena, Natal, Brazil, June 2016.

26. "Low temperature dynamics of nonlinear Luttinger liquids", Conference: Correlation days, Dresden, September 2015.

27. "Many-body localization", Theory colloquium, TU Kaiserslautern, July 2015.

28. "Low temperature dynamics of nonlinear Luttinger liquids", International Workshop, 'Beyond Integrability', CRM, Montréal, July 2015.

29. "Many-Body Localization and possible realizations in cold atomic gases", CAP Congress, Edmonton, June 2015.

30. "Many-Body Localization", Theory seminar, University of British Columbia, April 2015.

31. "Purification and Many-Body Localization in cold atomic gases", Conference, Rotorua (New Zealand), February 2015 .

32. "Correlated quantum systems out of equilibrium", Colloquium, U of Alberta and U of Saskatchewan, January 2015.

33. "Magnetic frustration and spin liquids: From one to two dimensions", Condensed Matter Seminar, U of Manitoba, November 2014.

34. "Dynamical quantum phase transitions and the Loschmidt echo. Quantum Integrability", Conference: Conformal Field Theory and Topological Quantum Computation, Natal, Brazil, 2014.

35. "Thermalization in quantum systems: Conservation laws and effective baths", Colloquium, Bonn, Germany (2014).

36. "Transport in one-dimensional quantum systems and conservation laws", Conference: Correlation days 2013, Dresden, Germany (2013).

37. "When is a bath a bath? Hermitian and Non-Hermitian relaxation dynamics in a toy model", Conference: Quantum Many-body systems out of equilibrium, Dresden, Germany (2013).

38. "Thermalization in quantum systems: Conservation laws and effective baths. Amsterdam", Summer Workshop on Low-D Quantum Condensed Matter, Amsterdam, Netherlands (2013).

39. "Thermalization in quantum systems: Conservation laws and effective baths", Colloquium, Physics Department, Heidelberg, Heidelberg, Germany (2013).

40. "Some thoughts and numerical experiments on thermalization in quantum systems", Frontiers of quantum condensed matter physics: light, matter and unusual devices out of equilibrium, New York, United States (2013).

41. "Entanglement measures and the quantum-to-classical mapping", APS March Meeting 2013, Baltimore, United States (2013).

42. "Non-equilibrium dynamics in one-dimensional quantum models", Condensed Matter Seminar, University of British Columbia, Vancouver, Canada (2012).

43. "Non-equilibrium dynamics in one-dimensional quantum models" Condensed Matter Seminar, Simon Fraser University, Vancouver, Canada (2012).

44. "Dephasing, relaxation and thermalization in one-dimensional quantum systems", Colloquium, Physics Department, U Sao Paulo in Sao Carlos, Sao Carlos, Brazil (2012).

45. "Dephasing, relaxation and thermalization in one-dimensional quantum systems", Conference: The beauty of Integrability, Natal, Brazil (2012).

46. "Conservation laws: Consequences for thermalization and transport", Theory Colloquium, U Dortmund, Dortmund, Germany (2012).

47. "Transport in quantum wires and conservation laws", GGI Workshop: New quantum states of matter in and out of equilibrium, Florence, Italy (2012).

48. "New aspects of transport in spin chains", 504. WEH-Seminar: Quantum Magnetism in Low Spatial Dimensions, Bad Honnef, Germany (2012).

49. "Decoherence, relaxation and thermalization in one-dimensional quantum models", Theory colloquium U Hannover, Hannover, Germany (2012).

50. "Lightcone renormalization and quantum quenches in one-dimensional Hubbard models", APS March Meeting 2012, Boston, United States (2012).

51. "Decoherence, relaxation and thermalization in one-dimensional quantum models", Theory seminar Max-Planck Institute for Solid State Research, Stuttgart, Germany (2012).

B.W. Southern

Refereed Publications

1. Bassel Alkadour, J. I. Mercer, J. P. Whitehead, B. W. Southern, and J. van Lierop, "Dipolar ferromagnetism in three-dimensional superlattices of nanoparticles", Phys. Rev. B (revision requested) (2016)

2. Bassel Alkadour, J. I. Mercer, J. P. Whitehead, J. van Lierop and B. W. Southern, "Surface vacancy mediated pinning of the magnetization in $\gamma - Fe_2O_3$ nanoparticles: A micromagnetic simulation study", Phys. Rev. B **93**, 140411(R) (2016)

3. M. S. Holden, M. L. Plumer, I. Saika-Voivod and B. W. Southern, "Monte Carlo simulations of a kagome lattice with magnetic dipolar interactions", Phys. Rev. B **91**, 224425 (2015)

4. M.D. LeBlanc, B.W. Southern, M.L. Plumer and J.P. Whitehead, "Spin Waves in the Anisotropic FCC Kagome Antiferromagnet" Phys. Rev. B **90**, 144403 (2014)

5. P. Hyde, Lihui Bai, D.M.J. Kumar, B.W. Southern, C.-M. Hu, S.Y. Huang, B.F. Miao and C.L. Chien, "Electrical Detection of Direct and Alternating Spin Current Injected from a Ferromagnetic Insulator into a Ferromagnetic Metal" Phys. Rev. B **89**, 180404(R) (2014)

6. E. Skoropata, R.D. Desautels, B.W. Southern and J. van Lierop, Comment on "Colossal reduction in Curie temperature due to finite-size effects in CoFe2O4 nanoparticles", Chemistry of Materials **25**, 1898 (2013)

7. M. D. LeBlanc, M. L. Plumer, J. P. Whitehead, and B. W. Southern, "Monte Carlo simulations of the fcc kagome lattice: Competition between triangular frustration and cubic anisotropy", Phys. Rev. B**88**, 094406 (2013).

8. N. H. G. Grenda, P. A. Hyde, Y. S. Gui, M. P. Wismayer, J. D. A. Jung, C. M. Hu, B. W. Southern, and K. W. Lin, "Angular dependence of ferromagnetic resonance measurements in exchange coupled $NiFe_{20}$/NiO bilayers" , J. Phys. D: Applied Physics **46**, 205002 (2013)

9. V. Hemmati, M. L. Plumer, J. P. Whitehead, and B.W. Southern, "Monte Carlo simulations of magnetic ordering in the fcc kagome lattice" , Phys. Rev. B. **86**, 104419(1:8) (2012)

10. B.W. Southern, "Triangular Antiferromagnets and Universality", Invited review in "Frustrated Magnetism", Physics in Canada **68**, no 2, 83 87 (2012)

11. M.P. Wismayer, B.W. Southern, X. L. Fan, Y.S. Gui, C. M. Hu and R. E. Camley , "Nonlinear Behavior for the Uniform Mode and Horizontal Standing Spin Wave Modes in Metallic Ferromagnetic Microstrips: Experiment and Theory", Phys. Rev. B **85**, 064411(1:7) (2012)

Conference Contributions

12. B. Alkadour, J. P. Whitehead, J. I. Mercer, J. van Lierop, B. W. Southern, "Surface vacancy mediated pinning of the magnetization in $\gamma - Fe_2O_3$ nanoparticles: A micromagnetic simulation study", CAP Congress, Ottawa, Canada (2016)

13. John Whitehead, Bassel Alkadour, J. van Lierop, B. W. Southern, "Micromagnetic simulations of maghemite nanoparticles in FCC arrays", Magnetic North V, Colorado Springs, United States (2016)

14. Martin Plumer, Mark Holden, Andrew Way, Ivan Saika-Voivod, B. W. Southern, "Monte Carlo simulations of kagome lattices with magnetic dipolar interactions", APS March meeting, Baltimore, United States (2016)

15. Can-Ming Hu, Lihui Bai, P. Hyde, B.W. Southern, C.L. Chien, "Electrical detection of dynamically generated DC and AC currents", Canadian Association of Physicists Congress Sudbury (2014)

16. B. Alkadour, J. P. Whitehead, and B. W. Southern. "Simulation of the Magnetic Properties of Close Packed Arrays of Maghemite Nanospheres", Canadian Association of Physicists Congress Montreal (2013)

17. B. Alkadour, J.P. Whitehead, J.I. Mercer, B.W. Southern, "Simulation of Maghemite Nanospheres on a triangular lattice", Canadian Association of Physicists (CAP) Congress Calgary (2012)

18. B. Alkadour, J.P. Whitehead, J.I. Mercer, B.W. Southern, "Simulation of Maghemite Nanospheres on a triangular lattice", Magnetic North III, Banff (2012)

19. B.W. Southern, "Angular dependence of FMR measurements in exchange coupled NiFe/NiO bilayers: Experiment and Theory", invited talk, Magnetic North III, Banff (2012)

20. M.P. Wismayer, B.W. Southern, X. L. Fan, Y.S. Gui, C. M. Hu and R. E. Camley, "Nonlinear Behavior for the Uniform Mode and Horizontal Standing Spin Wave Modes in Metallic Ferromagnetic Microstrips: Experiment and Theory", APS March Meeting (2012)

21. V. Hemmati, M. L. Plumer, J. P. Whitehead, and B.W. Southern, "Monte Carlo simulations of the fcc Kagome lattice", APS March Meeting (2012)

Seminars and Colloquia

22. B. W. Southern, "Monte Carlo Studies of the FCC Kagome Lattice", Department of Physics and Astronomy, University of Manitoba, March 8, (2013).

J.P. Svenne

No update provided for this report

1. A multichannel model for clusters of an α and select N = Z nuclei, K. Amos, L. Canton, P. R. Fraser, S. Karataglidis, J. P. Svenne, and D. van der Knijff. Submitted to Physical Review C, October 27, 2014; **Reviewed; in revision.**

2. Conditional charge symmetry for nuclear mirror systems n+^{14}C and p+^{14}O, P. R. Fraser, K. Amos, L. Canton, S. Karataglidis, D. van der Knijff, J. P. Svenne. Submitted to Physics Letters B, September, 2014; **Reviewed; in revision.**

3. Comparing coupled-channel spectra with no-core multi-$\hbar\omega$ shell-model results for carbon isotopes and mirror nuclei, S. Karataglidis, K. Amos, L. Canton, P.R. Fraser, J.P. Svenne and D. van der Knijff, Revised version submitted to European Physical Journal A, November, 2013, 22 pp. **In revision**

4. Reactivity Impact of ^{2}H and ^{16}O Elastic Scattering Nuclear Data for Critical System with Heavy Water, D. Roubtsov, K.S. Kozier, J.C.Chow, A.J.M. Plompen, S. Kopecky, J.P. Svenne, and L. Canton, Nuclear Data Sheets **118**, 414-417 (2014).

5. The angular distribution of neutrons scattered from deuterium below 2 MeV, N. Nankov, A.J.M. Plompen, S. Kopecky, K.S. Kozier, D. Roubtsov, R. Rao, R. Beyer, E. Grosse R. Hannaske, A.R. Junghans, R. Massarczyk, R. Schwenger, D. Yakorev, A. Wagner, M. Stanoiu, L. Canton, R. Nolte, S. Rötger, J. Beyer, and J.P. Svenne, Nuclear Data Sheets **119**, 98-103 (2014).

6. Coupling to two target-state bands in the study of the $n+^{22}$Ne system at low energy, P. R. Fraser, L. Canton, K. Amos, S. Karataglidis, J. P. Svenne, and D. van der Knijff, Phys. Rev. **90**, 024616[1-13 pp.] (2014)

7. Modelling scattering and resonances of weakly-bound radioactive nuclei, P. R. Fraser, L. Canton, R. Fossion, K. Amos, S. Karataglidis, J. P. Svenne, and D. van der Knijff, Heavy Ion Accelerator Symposium on Fundamental and Applied Science, Canberra, Australia, 8-12 April 2013. EPJ Web of conferences, published online: 19 December 2013. DOI: http://dx.doi.org/10.1051/epjconf/20136302010

8. Analysis of a coupled-channel continuum approach for spectra of mass-17 compound systems, K. Amos, L. Canton, P.R. Fraser, S. Karataglidis, J. P. Svenne, and D. van der Knijff. Nuclear Physics, **A912**, 7-17 (2013).

9. Linking the exotic structure of ^{17}C to its unbound mirror ^{17}Na, K. Amos, L. Canton, P.R. Fraser, S. Karataglidis, J. P. Svenne, and D. van der Knijff, Nuclear Physics **A879**, 132-145 (2012).

10. Linking nuclear masses with nucleon-removal thresholds and the mass of the proton-emitter ^{17}Na, K. Amos, D. van der Knijff, L. Canton, P.R. Fraser, S. Karataglidis, and J. P. Svenne. European Physics Letters, **99**, 12001 (2012).

11. The case for a return to nuclear power, J.P. Svenne, The Environmentalist, **32**, 346-352 (2012). DOI 10.1007/s10669-011-9358-1

Refereed Conference Proceedings

12. Comparison of multi-$\hbar\omega$ shell-model results with MCAS, J.P. Svenne, S. Karataglidis, K. Amos, L. Canton, P.R. Fraser, Dirk van der Knijff, INPC 2013, International Nuclear Physics Conference, Florence, Italy, June 2-7, 2013. Accepted for publication on-line by EPJ Web of Conferences.

13. Investigating the astrophysical ^{22}Ne$(p,\gamma)^{23}$Na and ^{22}Mg$(p,\gamma)^{23}$Al reactions with a multi-channel scattering formalism. International Nuclear Physics Conference, Florence, Italy, June 2-7, 2013. Submitted for publication on-line by EPJ Web of Conferences, in review.

14. Exploring exotic nuclei with MCAS, S. Karataglidis [*et al*], invited talk presented at the first International African Symposium on Exotic Nuclei, Somerset West, South Africa, December 2013.

15. Aspects of the structure of heavy carbon isotopes, S. Karataglidis, K. Amos, J. P. Svenne, L. Canton, P. R. Fraser, and D. van der Knijff, talk presented at the 58th

Annual Conference of the South African Institute of Physics, SAIP2013, Richards Bay, South Africa, July 2013, Proceedings to be published.

16. Recent developments in Multi-Channel Algebraic Scattering calculations, L. Canton, K. Amos, S. Karataglidis, P.R. Fraser, J.P. Svenne, and D. van der Knijff, invited parallel talk at the 10th Latin American Symposium on Nuclear Physics and Applications held on December 1-6, 2013 in Montevideo, Uruguay. Proceedings of Science 047.

17. Medium-light nuclei beyond the drip line: the proton-emitter ^{17}Na, P.R. Fraser, L. Canton, K. Amos, S. Karataglidis, J.P. Svenne and D. van der Knijff; Villa Monastero, Varenna, Italy June 11-17, 2012. CERN Proceedings 2012, 243-249 (2012)

18. Neutron scattering from deuterium and oxygen: New theoretical results, J.P. Svenne and L. Canton, WINS 2012, Workshop on (In) elastic Neutron Scattering, Boston, Ma, U.S.A., September 17-19, 2012. Invited paper, published on-line.

19. Structure of medium-light nuclei near the proton drip line, J.P. Svenne, K. Amos, D. van der Knijff, L. Canton, P.R. Fraser, S. Karataglidis; contributed paper (poster) at NS2012, Nuclear Structure 2012 Conference August 13-17, 2012, Argonne National Laboratory, Illinois, U.S.A. Papers published on-line.

20. Systematics of nuclear masses and nucleon-removal thresholds, J.P. Svenne, K. Amos, D. van der Knijff, L. Canton, G. Pisent, P.R. Fraser, S. Karataglidis; contributed paper at the Canadian Association of Physicists Annual Congress, June 11-15, 2012, Calgary, AB, Canada. Abstract on-line.

G.C. Tabisz

No update provided for this report

Last Refereed Publications

1. A. Senchuk and G. C. Tabisz, "General expression for the depolarization ratio for first order collision induced light scattering", Journal of Raman Spectroscopy, 42, 1046 1048 (2011).

2. A. Senchuk and G. C. Tabisz, "Second order collision induced light scattering: a spherical tensor approach", Journal of Raman Spectroscopy, 42, 1049 1054 (2011).

J.M. Vail

No update provided for this report

Last Refereed Publication

1. Vail, J. M., Haroon, T., Hernandez-Melgar, J., Chevrier., D. K, and Pandey, R., "Nitrogen Vacancy and Oxygen Impurity in AlN: Spintronic Quantum Dots", Radiation Effects and Defects in Solids, 164, 585-591 (2009).

M. Whitmore

Refereed Publications

1. Mark D. Whitmore, Gary S. Grest, Jack F. Douglas, M. S. Kent and Tongchuan Suo, *End–Anchored Polymers in Good Solvents from the Single Chain Limit to High Anchoring Densities*, J. Chem. Phys.**145**, 174904-1 to 11 (2016); doi: 10.1063/1.4966576

2. Tongchuan Suo and Mark D. Whitmore, *Self-consistent Field Theory of Tethered Polymers: One Dimensional, Three Dimensional, and High Stretching Theories*, J. Chem. Phys. **140**, 114901-1 to 14 (2014)

3. Tongchuan Suo and Mark D. Whitmore, *Controlling Microtube Permeability via Grafted Polymers and Solvent Quality*, J. Chem. Phys. **140**, 114902-1 to 7 (2014)

4. Tongchuan Suo and Mark D. Whitmore, *Doubly Self-Consistent Field Theory of Grafted Polymers Under Simple Shear in Steady State*, J. Chem. Phys. **140**, 114901-1 to 14 (2014)

5. Mark D. Whitmore, Jeffrey D. Vavasour, John G. Spiro and Mitchell A. Winnik, *On Cylindrical PS-b-PMMA in Moderate and Weak Segregation,* Macromolecules **46**, 9045–9054 (2013)

6. Tongchuan Suo and Mark D. Whitmore, *Grafted Polymers inside Cylindrical Tubes: Chain Stretching vs Layer Thickness,* J. Chem. Phys. **138**, 164907: 1–11 (2013)

7. Tongchuan Suo, Tyler N. Shendruk, Owen A. Hickey, Gary W. Slater and Mark D. Whitmore, *Controlling Grafted Polymers Inside Cylindrical Tubes,* Macromolecules **46**, 1221–1230 (2013)

8. John G. Spiro, Nicolas Illy, Mitchell A. Winnik, Jeffrey D. Vavasour and Mark D. Whitmore, *Theory of Lamellar Superstructure from a Mixture of Two Cylindrical PS-PMMA Block Copolymers,* Macromolecules **45**, 4289 – 4294 (2012)

Invited Talk

1. M. D. Whitmore and Tongchuan Suo, *Self-consistent Theory of Liquids Flowing Through Capillaries with End-anchored Polymers,* II International Symposium on Profiling, Lisbon, Portugal (2015)

J.G. Williams

No update provided for this report

1. T.A. Harriott and J.G. Williams, "Solutions for the null-surface formulation of general relativity," in Proceedings of the 14th Marcel Grossmann Meeting on General Relativity, edited by M. Bianchi, R.T. Jantzen and R. Ruffini (World Scientific, Singapore), to appear 2016.

2. T.A. Harriott and J.G. Williams, "Solutions in the 2+1 null-surface formulation," in Relativity and Gravitation, Springer Proceedings in Physics 157, edited by J. Bicak and T. Ledvinka, (Springer, New york), pp. 283–286 (2014).

3. T.A. Harriott and J.G. Williams, "Solution for the null-surface formulation of general relativity in 2+1 dimensions," in General Relativity and Gravitation, **46**, 1666 (2014).

4. T.A. Harriott and J.G. Williams, "Exact positive curvature solution for the null surface formulation in 2+1 dimensions," in Essays on Mathematics and Statistics: Volume 4, edited by V. Akis (Atiner, Athens), pp. 3–10 (2013).

5. T.A. Harriott and J.G. Williams, "Light cone cut solution in the 2+1 null surface formulation," in Proceedings of the 12th Marcel Grossmann Meeting on General Relativity, edited by T. Damour, R.T. Jantzen and R. Ruffini (World Scientific, Singapore), pp. 1896–1898 (2012).

5 Financial

5.1 Statement of Income and Expenditures

Income

Income Source	Amount
UWinnipeg Dean of Science & VP Research	$1600.00
UManitoba Dean of Science	$1600.00
Brandon Univ VP Research	$1000.00
Total Income	$4200.00

Expenditures

Activity	Amount Spent
Contribution to CASCA2016	$2000
Contribution to CCGRRA-16	$500
Summer Student Symposium	$436
Visit by Nicholas Sedlmayr	$300
Visit by Hideki Maeda	$300
Visit by Jorma Louko	$300
Refreshments for all WITP seminars	$21
The DTP/WITP Thesis Prize	$261
Total Expenditures	$4118

The income listed above represents commitments to WITP funding from the three major universities in Manitoba from which the WITP draws its members. For the five-year period 2013-17, the University of Winnipeg and University of Manitoba have each committed $1600 per annum, and Brandon University has committed $1000 per annum.

In addition to the supporting funds indicated above, it should be pointed out that the members of the Institute use their individual NSERC discovery grants to subsidize Institute activities. As of January 2013, the members from the three universities drew upon more than $600,000 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 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.

An estimated annual budget for the current five-year period follows:

- Conference support: $1700
  This support advertises theoretical physics in Manitoba throughout Canada, promotes research collaborations and dissemination of results, and provides opportunity to recruit graduate students.
- Summer Symposium for (graduate and undergraduate) student researchers: $500
- Visitor Support: $1800
  - Prominent visiting scientist for public lecture: $2000 twice in five years
    Outreach to the public, as well as scientific discussion
  - Support for other WITP visitors: $1000
    The WITP visitor program is primarily funded by Members; this funding is to allow visits that individual Members may not otherwise be able to afford or to increase the length of time that visitors can stay in Manitoba.

- Contribution to the DTP/WITP PhD Thesis Prize: $250
- Miscellaneous: $250
  Printing, advertising of study opportunities at Canadian Undergraduate Physics Conference only

Total: $4500 per annum

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 the three universities in 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 WITP membership includes all of the theoretical physicists in the province. Hence its growth relies upon the Associate and Student Members that it can attract (i.e. graduate students, post- doctoral fellows, and research associates), along with occasional new faculty hires. Another area of potential growth is identifying new Permanent Members at UM, UW, and Brandon University among current faculty members in related fields. For example, experimental physicists who work closely with theorists may be candidate members, as may mathematicians whose research is closely related to mathematical physics. The WITP has recently added members that fit these criteria; for example, three colleagues from the Department of Mathematics at U of M became permanent members of WITP in 2015.

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.

1 Appendix: Supplementary Material

2016 Annual Meeting of the Canadian Astronomical Society (CASCA)

CASCA MANITOBA 2016

HOME | LOCATION | PROGRAM | REGISTRATION | ACCOMMODATIONS | CONTACT

Join us in Winnipeg, Manitoba, **May 30 – June 2, 2016** for the annual meeting of the Canadian Astronomical Society (CASCA).

We are excited to announce that the winner of the 2015 Nobel Prize in Physics, **Dr. Art McDonald** will be giving our public lecture: *The Sudbury Neutrino Observatory: Observing the Sun from 2 km Underground,* on the evening of June, 1, 2016.

See our **list of confirmed invited speakers** and the **conference schedule**.

Registration is now closed.

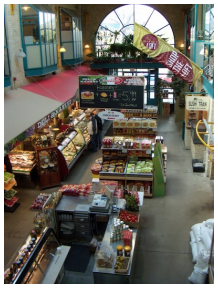
Conference program in now available!

Banquet Speaker: Wilfred Buck on First Nations Astronomy

The meeting will be held at the historic Fort Garry Hotel, located in the heart of Winnipeg, within easy walking distance of many attractions such as The Forks and the Canadian Museum for Human Rights.

Canadian Human Rights Museum (V.Pahkala)

The Fort Garry Hotel



Forks Market (Ccyyrree)

Languages

English
Français

Hosted by:

University of Manitoba

And our partners:

The University of Winnipeg

Brandon University

Contact Us
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Thank you to our sponsors!

University of Manitoba — faculty of SCIENCE discover the unknown + invent the future

The University of Winnipeg

WITP Winnipeg Institute for Theoretical Physics

Royal Astronomical Society of Canada Winnipeg Centre

Canadian Astronomical Society / Société canadienne d'astronomie

2016 Summer Symposium Schedule

WITP Summer Student Symposium 2016

August 25, 2016, Room 3M69, University of Winnipeg

9:00 - 9:15	*Coffee/Refreshments*	
9:15 - 9:30	Dr. Danny Blair	Welcome Address
9:30 - 9:55	Philipp Jaeger	*Measuring Topological Invariants: Lohschmidt Echo in the SSH-Model*
9:55 - 10:20	Ben Guest	*Peering Deeper into the Plerionic Supernova Remnant G21.5-0.9*
10:20 - 10:40	*Coffee Break*	
10:40 - 11:05	L.J. Zhou	*Firewall Creation in Curved Space-Time under Spherical Symmetry*
11:05 - 11:30	Paul Mikula	*Gradient Flow in the Ginzburg-Landau model for Superconductivity*
11:30 – 11:55	Donovan Allum	*Modeling the Formation of non-Singular Black Holes in Spherical Symmetry*
11:55 – 13:00	*Lunch*	
13:00 - 13:25	Darren Flynn	*Non-Archimedean Fields: A Laboratory for the Infinite and the Infinitesimal*
13:25 - 13:50	Will Grafton	*On the Convergence and Analytical Properties of Power Series on non-Archimedean Field Extensions of the Real Numbers*
13:50 – 14:15	Brett Meggison	*Renormalization of Scalar nPI Effective Theories in 4 Dimensions*
14:15 – 14:45	*Snack Break*	
14:45 – 15:10	Brad Cownden	*Modelling Gravitational Collapse in Anti-de Sitter Space*
15:10 – 15:35	Raphael Hoult	*Black Hole Formation in AdS_4 with Varying Boundary Conditions*

16th Canadian Conference on General Relativity and Relativistic Astrophysics