The Winnipeg Institute for Theoretical Physics Annual Report

September 2017 – August 2018

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

Contents

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 28th 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. This year, the WITP also helped organize an international workshop at the University of Manitoba on April 23-24, 2018. The workshop attracted a number of high-profile theoreticians from the US and Europe and was attended by around 40 participants. Several of our graduate students presented posters. The WITP organized its annual graduate student workshop at Brandon University on August 27, 2018. This workshop was attended by about 15 participants and included talks by 7 of our graduate students. In order to emphasize the strong base of theoretical physics in Manitoba throughout the rest of Canada, the WITP also continues to co-sponsor a new PhD thesis prize in conjunction with the Canadian Association of Physicists Division of Theoretical Physics.

For the 2017-2018 academic year, the list of visitors is found in section 4.1, invited speakers in section 4.2, a description of the WITP workshop in 4.3, the cumulative list of graduate degrees awarded appears in section 4.6, and the published research work of members is found in section 4.7. 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, the promotion of postgraduate and postdoctoral research, and the organization of our yearly WITP workshop.

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 December 31, 2018, consists of the Director, J. Sirker (Manitoba), the Director-Elect, A. R. Frey (Winnipeg), and the Past-Director, K.Shamseddine (Winnipeg). K. Shamseddine was the director from January 1, 2015 to December 31, 2016 and J. Sirker became the new director as of January 1, 2017.

Jesko Sirker (Director, WITP)

2 Current List of Members (2017-18)

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, 19-20]
- 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)* [Director, 17-18]
- R. Stamps[1], *Ph.D. (Colorado State University)*
- D.W. Vincent[2], *Ph.D. (Toronto)* [Director, 94-95]
- 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]
- M. Whitmore[1], *Ph.D. (McMaster)*
- 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)
- Michelle Boyce (O'Dea)

Postdoctoral Fellows

- Bijaya Acharya (Mainz) (Bacca)
- Nir Nevo Dinur (TRIUMF) (Bacca)
- Yjan Gordon (O'Dea)
- Vadim Lenkiy (Mainz) (Bacca)
- Wenchen Luo (Chakraborty)
- Amin Naseri (Chakraborty/Sirker)
- Chris Ramsey (Plosker)
- Adam Rogers (Safi-Harb)
- Johannes Simonis (Mainz) (Bacca)
- Adrian Vantyghem (O'Dea)
- Jennifer Vaughan (PIMS postdoctoral fellow) (Krepski/Schippers)
- Dr. Seth Wolbert (PIMS postdoctoral fellow) (Krepski)
- Sarka Wykes (O'Dea)

2.3 Graduate Students

- V. Arendt (Ph.D.) (Shalchi)
- 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)
- 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)
- Dinamo Djounvona (Ph.D.) (Krepski)
- Chetna Dugal (Ph.D.) (O'Dea)
- Darren Flynn (Ph.D.) (Shamseddine)
- Erica Franzmann (Ph.D.) (Fiege)
- Robert Gleisinger (M.Sc.) (O'Dea)
- William Grafton (M.Sc.) (Shamseddine)
- Javier Hernandez-Melgar (PhD) (Bacca)
- Md. Ismail Hossain (M.Sc.) (Krepski)
- P. Jäger (Ph.D.) (Sirker)
- M. Kiefer (Ph.D.) (Sirker)
- Jordan Lasuik (M.Sc.) (Shalchi)
- Cameron Lawlor-Forsyth (M.Sc.) (O'Dea)
- Daniel Maciel (M.Sc.) (Southern)
- Brett Meggison (M.Sc.) (Carrington/Frey)
- Paul Mikula (Ph.D.) (Carrington/Kunstatter)
- Mirko Miorelli (Ph.D.) (Bacca)
- Shirin Moein (Ph.D.) (Plosker)

- Kyle Monkman (Ph.D.) (Sirker)
- 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)
- Mainak Singha (Ph.D.) (O'Dea)
- Cole Treyturik (M.Sc.) (Safi-Harb)
- Andrew Urichuk (Ph.D.) (Sirker)
- Olena Usoltseva (Ph.D.) (Prymak)
- Dennis Wagner (Ph.D.) (Sirker)
- Xiaohong Zhang (Ph.D.) (Plosker, co-supervised with S. Kirkland, Manitoba)
- L.J. Zhou (Ph.D.) (Carrington/Kunstatter)

2.4 Undergraduate Research Students 2017-18

- Neil Doerksen (Safi-Harb)
- Seth Friesen (Carrington)
- Michael Gammon (Shalchi)
- Taylor Hanson (Alexander)
- Sebastian Horvat (Bacca)
- Raphael Hoult (Frey)
- Marcin Kalinowki (Bacca)
- Tejhas Kapoor (Frey)
- Brock Klippenstein (Safi-Harb)
- Cam Lawlor-Forsythe (O'Dea)
- Austin MacMaster (Safi-Harb)
- Darian McLaren (Plosker)
- Anna Poggialini (Bacca)
- Michael Ramsey (Safi-Harb)

- Christopher Phillips (Carrington)
- Samantha Taylor (Frey)
- Cole Treyturik (Safi-Harb)
- Anna Volotovska (High School) (Frey)
- Jakob Weirathmueller (Alexander)
- Brayden Yarish (High School) (Frey)

3 Research Interests of Members

M.E. Alexander

My principal research interests are:
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.

Close binary star systems. (1) I am 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).
(2) A model to explain anomalies in photometric measurements of exoplanet transits in the system Kepler-13, using data from the Kepler mission. The model proposes that the observed behaviour is the result of interaction of rotational and orbital motion causing resonance effects between the stellar precession and nutation and orbital motion of the transiting exoplanet. This work is based on earlier (1987-88) work on resonant rotational/orbital interactions in binary star systems, published in Monthly Notices of the Royal Astronomical Society.

Finally, with Dr P. Shivakumar (Professor Emeritus, Univ. Manitoba) and collaborators, I am finalizing a manuscript for publication as an undergraduate/graduate-level monograph, entitled "Mathematical Modeling of Some Major Human Diseases".

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 electromagnetic 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

A new project started in September 2016 has just been submitted to arXiv: 'Powers of doubly-affine square matrices with one non-zero eigenvalue' with Ian Cameron and Adam Rogers. While I identified 1EV magic squares more than a decade ago (see LAA2009), a colleague in Argentina drew my attention to this issue via a reference to a paper in the Fibonacci Quarterly. This arXiv will be followed shortly by another: 'Compounding Doubly Affine Matrices', by Rogers, Cameron and myself, which completes a study begun in 2004 for multiplying-up smaller Latin or magic squares to larger ones of multiplicative order. Combining results from the latter paper enables 'Powers' to generate 1EV square matrices to orders which are any multiples of orders 4,5 and 8. Next I plan to finish a project with Cameron on extending Frierson's algebraic compounding of the sole order 3 magic to orders 3^n, first presented in 2009 at Can. Math. Soc. in Windsor. These papers all make use of my 'singular value clan' concept given in Signatura of Magic and Latin Integer Squares: Isentropic Clans and Indexing', by Cameron. Rogers and Loly, in Discussiones Mathamaticae : Probability and Statistics, 33 (2013) 121-149.

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 quantum coherence, positive operator valued measures (POVMs), quantum fidelity (probability of state transfer), and various generalizations of majorization as they pertain to entanglement transformations and other problems in quantum information theory.

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 research program are targeted to understand the aftermath of a supernova explosion, the growing diversity of neutron stars (including magnetars), their relativistic outflows and magnetic field evolution, their evolution and interaction with their hosting supernova remnant shells, nucleosynthesis, 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 NuSTAR and ESA's XMM-Newton satellites, combined with modelling. I played a leadership role on the international, JAXA-led, ASTRO-H (renamed to Hitomi) X-ray satellite, serve on the science team for the future ESA-led ATHENA X-ray mission, and currently lead the neutron stars' science working group for the first Canadian X-ray telescope (Colibri) concept study approved by CSA in Sep. 2018. In radio, I serve on the ACURA Advisory Committee for the Square Kilometre Array (SKA). In optical, I was selected for the TMT International Science Development Team for the Milky Way & Nearby Galaxies. 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/computer scientists developing models to interpret and catalogue data, performing state-of-the-art numerical simulations to apply to data, and making use of a local CFI-funded computing cluster. Lastly, with the latest LIGO discovery of the Gravitational Wave Neutron Stars Merger event (aka kilonova), my research is branching out into this new direction.

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 infinitely 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, quantum 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 recent publication, on the properties of anionic site defects in AlN, a wide band-gap insulator.

My most recent published research has been 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.

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: 2014-2018

Date	Visitor	Institution	Host
Oct. 2018	Toka Diagana	University of Alabama in Huntsville	K. Shamseddine
Oct. 30-Nov. 3, 2017	Shirin Moein	Isfahan University of Technology	S. Plosker
July 17-21, 2017	Gilles Ferrand	RIKEN, Japan	S. Safi-Harb
May 23-26, 2017	Takaaki Tanaka	Kyoto, Japan	S. Safi-Harb
May 15-19, 2017	Rajesh Pereira	Universty of Guelph	S. Plosker
Apr 20-24, 2017	Shigehiro Nagataki	Riken, Japan	Safi-Harb
Feb. 13-17, 2017	Don Page	University of Alberta	G. Kunstatter
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

4.2 Seminars: 2014-2018

Date	Speaker	Title
Oct. 26. 2018	Toka Diagana	“Existence Results for some classes of Integro-Differential Equations of Gurtin-Pipkin Type”
July 20, 2017	G. Ferrand	“From the supernova to the supernova remnant”
May 25, 2017	T. Tanaka	“Shaping our Understanding of Supernova Remnants with the Fermi Large Area Telescope”
Feb. 16, 2017	D. Page	“Anthropic Estimates for ManyParameters of Physics and Astronomy”
Jan. 17, 2017	A. Nielson	“Binary Black Hole Mergers in the First Advanced LIGO Observing Run”
Jan. 13, 2107	J. Ziprick	“Quantum gravitational collapse of a thin shell”
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”

Scientific Program

Time	Sunday, April 22	Monday, April 23	Tuesday, April 24
8:45 – 9:00	Arrival	Opening	—
9:00 – 9:50		Rolf Haug	Jochen Mannhart
9:50 – 10:20		Coffee / Posters	
10:20 – 11:10		Peter Maksym	Herb Fertig
11:10 – 12:00		Rene Coté	Rudolf Roemer
12:00 – 14:00		Lunch	
14:00 – 14:50		Frank Marsiglio	Giovanni Vignale
14:50 – 15:40		Joseph Falson	Closing remarks
15:40 – 16:10		Coffee / Posters	—
16:10 – 17:00		Marco Ameduri	—
17:00 – 17:30		Posters	—
18:30		Conference Dinner	—

4.3 Workshop 'Physics at the Nanoscale'

The WITP co-sponsored and organized a two-day workshop (April 23 - April 24, 2018) on 'Physics at the Nanoscale'. The workshop in honour of the long-time WITP member and CRC chair Tapash Chakraborty included talks by 10 invited speakers from Germany, England, Quatar, USA, and Canada. A number of topics of current interest in nanoscale Physics ranging from devices with possibly dissipationless transport, Anderson localization in semiconductors, the optical properties of Graphene to topological insulators were discussed. The tist of invited speakers and the titles of the talks presented can be found in Appendix 1.

In addition, the workshop also gave our students the opportunity to showcase the world class research in theoretical physics that is being done in Manitoba by presenting their work during a poster session. Coffee and lunch was provided for all participants, giving the graduate students ample of time to interact with the invited lecturers.

4.4 Annual WITP student workshop

On August 27, 2018 our yearly student workshop was held at Brandon University. The event was attended by about 15 participants. Talks ranging from string theory and ADS/CFT to quantum state tranfer were given by 7 of our graduate students. The detailed program can be found in Appendix 2.

4.5 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:
  - Theory Canada 13 held in June 2018 at St. Francis Xavier University ($500).
  - 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).
- 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”.

4.6 Graduate Degrees Supervised

1. Victor Arendt (2018), "Numerical Test of Approximations used in Theories for Cosmic Ray Transport", M.Sc. thesis (Shalchi)
2. Angel Barria Comicheo (2018), "On X-normed spaces and operator theory on c_0 over a field with a Krull valuation of arbitrary rank", Ph.D. thesis Mathematics (Shamseddine)
3. Robert Gleisinger (2018), "Searching for Nucleus Obscuration in the Infrared Spectra of Nearby FR-I Radio Galaxies", M.Sc. thesis (O'Dea)
4. Md Ismail Hossain (2018), "Hamiltonian vector fields on a space of curves on the 3-sphere", M.Sc. thesis (Krepski)
5. Andrew Senchuk (2018), "On the Determination of Absolute Nuclear Charge Radii for Elements without Stable Isotopes via Precision X-Ray Spectroscopy of Lithium-Like Ions", Ph.D. thesis (Gwinner/Shamseddine)

4.7 Publications of Permanent Members

M.E. Alexander

1. Hagit Peretz-Soroka, Reuven Tirosh, Jolly Hipolito, Erwin Huebner, Murray Alexander, Jason Fiege, and Francis Lin. "A bioenergetic mechanism for amoeboid-like cell motility profiles tested in a microfluidic electrotaxis assay" Integrative Biology **9**(11): 839-896, 2017.
2. Ke Yang, Jiandong Wu, Guoqing Xu, Hagit Peretz-Soroka, Susy Santos, Murray Alexander, Ling Zhu, Michael Zhang, Yong Liu, Francis Lin. "A dual-docking microfluidic cell migration assay (D2-Chip) for testing neutrophil chemotaxis and the memory effect". Integrative Biology, **9**, 303-312, 2017.
3. S. Rathee, Nilam, M.E. Alexander. "Dynamics and control of glucose-insulin regulatory system in diabetics using vitamin D." Mathematics in Computer Science, (in press) Jul. 2017.
4. I. Halilovic, J. Wu, M. Alexander, F. Lin. "Neutrophil migration under spatially-varying chemoattractant gradient profiles". Biomed. Microdevices **17**, 57-63, 2015.
5. 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.
6. M.E. Alexander, M. Mercredi. "A model for cell migration in competing chemotactic fields." Canadian Applied Math Quarterly **21**(2): 121-144, (Summer 2013).

7. 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).

8. 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.

9. 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.

S. Bacca

Peer reviewed journal articles

1. Ab initio calculation of nuclear structure corrections in muonic atoms
   C. Ji, S. Bacca, N. Barnea, O.J. Hernandez, N. Nevo Dinur, J. Phys. G: Nucl. Part. Phys. **45** (2018) 093002, commisioned topical review.

2. Computing the dipole polarizability of ^{48}Ca with increased precision
   M. Miorelli, S. Bacca, G. Hagen, T. Papenbrock, Phys. Rev. C **98**, 014324 (2018).

3. The deuteron-radius puzzle is alive: A new analysis of nuclear structure uncertainties
   O.J. Hernandez, A. Ekström, N. Nevo Dinur, C. Ji, S. Bacca, and N. Barnea, Phys. Lett. B **778**, 377-383 (2018).

4. 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, Phys. Rev. Lett. **118**, 252501 (2017).

5. 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).

6. 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).

7. 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).

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

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

10. 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).

11. 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,
Phys. Rev. C **90**, 064619 (2014).

12. Electromagnetic Reactions on Light Nuclei
S. Bacca and S. Pastore, commissioned topical review, J. Phys. G: Nucl. Part. Phys. **41** 123002 (2014).

13. 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).

14. 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, Phys. Rev. Lett. **113**, 262504 (2014).

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

Refereed Conference Proceedings

1. Recent developments in nuclear structure theory: an outlook on the muonic atom program
O.J.Hernandez, S.Bacca, K.Wendt, PoS BORMIO2017 **041**, (2017); arXiv:1712.05187.

2. Electromagnetic reactions from coupled-cluster theory
S.Bacca, M.Miorelli and G. Hagen, Proceedings of the 12th International Spring Seminar on Nuclear Physics "Current Problems and Prospects for Nuclear Structure", Sant'Angelo d'Ischia, May 15 to 19, 2017; arXiv:1710.09741

3. Update on nuclear structure effects in light muonic atoms
O.J. Hernandez, N. Nevo Dinur, C. Ji, S.Bacca and N. Barnea, Hyperfine Interact **237**, 158 (2016).

4. 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).

5. Theory of electromagnetic reactions in light nuclei
T. Xu, M. Miorelli, S. Bacca and G. Hagen,
Proceedings of the 21st International Conference on Few-Body Problems in Physics, arXiv:1509.03681.

6. Is the isoscalar monopole resonance of the α-particle a "breathing" mode?
G. Orlandini, S. Bacca, N. Barnea and W. Leidemann,
Proceedings of the 21st International Conference on Few-Body Problems in Physics, arXiv:1510.02248.

7. Electric dipole polarizability: from few- to many-body systems
M. Miorelli, S. Bacca, N. Barnea, G. Hagen, G. Orlandini, T. Papenbrock
Proceedings of the 21st International Conference on Few-Body Problems in Physics, arXiv:1509.00265.

8. Understanding the proton radius puzzle: Nuclear structure effects in light muonic atoms
C. Ji, O. J. Hernandez, N. Nevo Dinur, S. Bacca, and N. Barnea,
Proceedings of the 21st International Conference on Few-Body Problems in Physics, arXiv:1509.01430.

9. Nuclear polarizability effects in muonic atoms
C. Ji, N. Nevo Dinur, S. Bacca, N. Barnea,
Few-Body System, DOI 10.1007/s00601-014-0809-3 (2014).

10. Electromagnetic Reactions and Few-Nucleon Dynamics
S. Bacca
EPJ Web of Conferences **66**, 01002 (2014).

Media and press releases

1. 2017, Appeared on the "Innovation150", celebrating 150 years of innovations in Canada:
Unravelling the proton-radius puzzle
`https://innovation150.ca/story/unraveling-proton-radius-puzzle`

2. 2015, Appeared on the "Research Highlights" of the TRIUMF web-page:
Computing the Heart of Matter
`http://www.triumf.ca/experimental-result/computing-heart-matter`

3. 2015, TRIUMF Press Release:
   Calcium Built From Scratch, Much Smaller than Expected
   http://www.triumf.ca/sites/default/files/NR-11-03-2015-Ca48-Nature.pdf

4. 2014, Appeared on the "Research Highlights" of the TRIUMF web-page:
   Unraveling the Proton-Radius Puzzle
   http://www.triumf.ca/research-highlights/experimental-result/unravelling-proton-radius-puzzle

5. 2014, Appeared on the "Research Highlights" of the TRIUMF web-page:
   Nuclear Structure Workshop at TRIUMF
   http://www.triumf.ca/research-highlights/workshops-conferences/nuclear-structure-workshop-triumf

Organized Workshops and Conferences

2018, *"Symmetry breaking summer school "*, Frauenchimsee, Germany.

2018, *"Fundamental physics with electroweak probes of light nuclei"*, Institute of Nuclear Theory program, USA.

2018, *"International conference of few-body problems in physics, FB22"*, Member of the Program Organizing Committee.

2017, *"Progress in ab-initio techniques in nuclear physics"*,
TRIUMF Theory Workshop, Organized with A. Calci, J. Holt and P. Navrátil.

2016, *"DNP October Meeting"*,
Vancouver, Oct 13-15 2016, Member of the Local Organizing Committee.

1. 2016, *"Progress in ab-initio techniques in nuclear physics"*,
   TRIUMF Theory Workshop.

2. 2016, American Physical Society April Meeting (Salt Lake City, USA),
   Member of the Program Committee for the Group Few-Body Session.

3. 2015, *"Theory for exploring experiments in light and medium-mass nuclei"*,
   Triumf Summer Institute.

4. 2015, *"6th International Symposium on Symmetries in Subatomic Physics"*,
   Member of the Local Organizing Committee.

5. 2015, *"Progress in ab-initio techniques in nuclear physics"*,
   TRIUMF Theory Workshop.

6. 2014, *"Nuclear Structure 2014 Conference"*,
   Member of the Local Organizing Committee.

7. 2014, *"Nuclear Structure and Reactions: Experimental and Ab-initio Theoretical Perspectives"*, TRIUMF workshop.

Invited talks and colloquia

1. *"Nuclear dipole response function by ab initio theory"*,
Talk in plenary session at the NN2018 conference, Tokyo, Japan, Dec. 6th, 2018.

2. *"Electromagnetic response in nuclei: from few- to many-body systems"*,
Talk at the NUSTAR workshop, Milano, Italy, Sept. 27th, 2018.

3. *"Electromagnetic response in nuclei: from few- to many-body systems"*,
Talk at the 53rd Zakopane Conference on Nuclear Physics, Zakopane, Poland, Aug 27th, 2018.

4. *"Electromagnetic nuclear responses"*,
Nuclear Seminar at the Institute for Theoretical Physcis of the Ruhr University of Bocum, Bochum, Germany, July 5th, 2018.

5. *"Electromagnetic sum rules in light nuclei"*,
Talk at the International few-body conference FB22, Caen, France, July 13th, 2018.

6. *"Electromagnetic nuclear responses"*,
Nuclear Seminar at the Physics Department of the University of Surrey, Guilford, UK, May 22nd, 2018.

7. *"Electromagnetic nuclear responses"*,
Talk at the ECT Workshop on Exploring the role of electro-weak currents in Atomic Nuclei, Trento, Italy, April 24th, 2018.

8. *"Electromagnetic observables from coupled-cluster theory"*,
Talk at the TRIUMF Theory Workshop, TRIUMF, Canada, March 1st, 2018.

9. *"Electromagnetic observables from coupled-cluster theory"*,
Talk at the Nuclear Theory Get Together, Oak Ridge National Laboratory, US, Dec. 6th, 2017.

10. *"Recent developments in nuclear theory"*,
Talk at the KHuH annual meeting, Bad Honneff, Germany, Dec. 1st, 2017.

11. *"Theory of electromagnetic interactions"*,
Talk at the workshop on "Physics of energy recovery linacs", Bad Honnef, Germany, Oct. 18, 2017.

12. *"Computing the heart of matter"*,
Seminar at the Istituto Nazionale di Fisica Nucleare, Sezione Napoli, Napoli, Italy, Oct. 10th, 2017.

13. *"Recent developments in nuclear structure theory: from few- to many-body systems"*,
Talk at the 2nd workshop of the SFB 1245, Budenheim, Germany, Oct. 4th, 2017.

14. *"Electromagnetic response in nuclei: from few- to many-body systems"*, Talk in plenary session at the ARIS Conference, Keystone (CO), US, May 28-June 2, 2017.

15. *"Electromagnetic response in nuclei: from few- to many-body systems"*, Talk at the 12th International Spring Seminar on Nuclear Physics, St'Angelo di Ischia, Italy, May 15-19, 2017.

16. *"Ab-initio calculation of the neutron-skin and the electric dipole response of nuclei"*, Talk at the DPG Conference, Münster, Germany, March 27-31, 2017.

17. *"Recent developments in nuclear structure theory"*, Talk at the 55th Intenational Winter Meeting on Nuclear Physics, Bormio, Italy, January 23-27, 2017.

18. *"Computing the heart of matter"*, Seminar at the Institute for Nuclear and Particle Physics, Ohio University, Athens, US, Nov. 8th, 2016.

19. *"Neutrino-antineutrino pair production by hadronic bremsstrahlung"*, Talk at the October DNP meeting, Vancouver, October 13-16, 2016.

20. *"Frontiers in ab-initio nuclear structure"*, Talk in plenary session at the International Nuclear Physics Conference (INPC), Adelaide, Australia, Sept. 11-16, 2016.

21. *"Few- and many-body systems"*, Introductory talk to low-energy session of Photonuclear Reactions Gordon Research Conference, Holderness, NH, USA, Aug. 11 2016.

22. *"Computing the heart of matter"*, Colloquium at the Physics Department, University of Trento, Italy, June 28th, 2016.

23. *"Precision physics with electroweak probes: what ab-initio nuclear theory can do"*, Colloquium at the Physics Department, Johannes-Gutenberg University, Mainz, Germany, July 15th, 2016.

24. *"Ab initio computations of the electric dipole polarizability"*, Talk at the NSKIN Workshop, MITP, Mainz, Germany, May 16-27, 2016.

25. *"A path to lepton-nucleus reactions from first principles"*, Talk at the TRIUMF Workshop on Double-beta decay, Vancouver, Canada, May 11-13, 2016.

26. *"Computing the heart of matter"*, Colloquium at the Physics Department, Washington University, USA, Feb 29th, 2016.

27. *"Computing the heart of matter"*, Colloquium at the Physics and Astronomy Department, Louisiana State University, USA, Feb 11th, 2016.

28. *"Computing the heart of matter"*,
Physics Seminar at Argonne National Laboratory, Physics Division, USA, Jan 25th, 2016.

29. *"Coupled-cluster computations of electroweak observables"*,
Talk at the Fall meeting of the APS Division of Nuclear Physics, Workshop on Theory and Computations for Neutrinos and Fundamental Symmetries, Santa Fe, USA, Oct 28-31, 2015.

30. *"Neutron distribution in* ^{48}*Ca"*,
Talk for the ADVISORY COMMITTEE ON TRIUMF, 5th October 2015.

31. *"Electromagnetic strengths in ab initio approaches"*,
Talk in plenary session at COMEX 2015, Collective motions in nuclei under extreme conditions, Krakow, Poland, Sept 14-18, 2015.

32. *"From neutron-rich nuclei to stars"*,
Winnipeg Institute of Theoretical Physics Seminar at the Physics & Astronomy Department, University of Manitoba, Winnipeg, Canada, Aug 13th, 2015.

33. *"Structure Models: from shell model to ab-initio methods"*,
Summer School Exotic 2015: Rewriting nuclear physics textbooks, July 20-24 2015, Pisa, Italy.

34. *"Towards an ab-initio description of electroweak response functions"*,
Talk at the TRIUMF T2K WORKSHOP, Vancouver, Canada, July 10th, 2015.

35. *"Towards a unified description of electroweak reactions"*,
Seminar at the Cyclotron Institute, Texas A&M University, College Station, USA, July 8th, 2015.

36. *"From Nuclear Forces to Nuclei and Stars"*,
Colloquium at the Physics Department of the Texas A&M University, College Station, USA, July 7th, 2015.

37. *"Emission of neutrino-antineutrino pairs by hadronic bremsstrahlung processes"*,
Talk at the international conference on NUCLEUS NUCLEUS COLLISIONS, Catania, Italy, June 22- 26, 2015.

38. *"Theory of electromagnetic reactions in light nuclei"*,
Talk at the international FEW-BODY CONFERENCE, FB21, Chicago, US, May 18-22, 2015.

39. *"Towards ab-initio calculations of dipole strengths in exotic nuclei"*,
Talk at the INT program on REACTION AND STRUCTURE OF EXOTIC NUCLEI, INT, Seattle, US, March 1- 6, 2015.

40. *"Electromagnatic Reactions in Few- and Many-Body Systems"*,
Nuclear Science seminar at the Physics Department of the Michigan State University, East Lansing, USA, Jan 21st, 2015.

41. *"Nuclear giant dipole resonance"*,
Talk at Gordon Research Conference on PHOTONUCLEAR REACTIONS: FROM QUARKS TO NUCLEI, Holderness School, Holderness, NH, USA, Aug 10- 15, 2014.

42. *"Towards first principle description of electromagnetic reactions in medium-mass nuclei"*,
Talk at the XIII Elba workshop on ELECTRON-NUCLEUS SCATTERING, Marciana Marina, Italy, June 23- 27, 2014.

43. *"Understanding the proton radius puzzle: nuclear structure corrections in muonic atoms"*,
Talk at the INT program on UNIVERSALITY IN FEW-BODY SYSTEMS: THEORETICAL CHALLENGES AND NEW DIRECTIONS, Seattle, USA, March 10- May 16, 2014.

44. *"Towards ab-initio calculations for electromagnetic reactions in medium-mass nuclei"*,
Talk at the FUSTIPEN workshop on UNDERSTANDING NUCLEAR STRUCTURE AND REACTIONS MICROSCOPICALLY, INCLUDING THE CONTINUUM, GANIL, France, March 17-21, 2014.

45. *"Towards ab-initio calculations for electromagnetic observables of stable and unstable nuclei"*,
Talk at the workshop on THRESHOLD PHYSICS AT THE NEUTRON DRIP LINE, EMMI Institute, GSI, Darmstadt, Germany, Feb 02-07, 2014.

Other talks

1. *"Theoretical Nuclear Physics"*,
Talk at the SFB CRC 1044 MEETING, Mainz, September 25th, 2018.

2. *"Project N2: Theoretical nuclear physics from first principles"*,
talk for the ADVISORY COMMITTEE ON CRC 1044, 19th November 2018, Mainz, Germany.

3. *"Theoretical nuclear physics from first principles"*,
talk for the ADVISORY COMMITTEE ON CRC 1044, 9th November 2017, Mainz, Germany.

4. *"Coulomb sum rule from coupled-cluster theory"*,
Talk at the TRIUMF THEORY DEPARTMENT MEETING, June 7, 2017.

5. *"Coupled-cluster computations of the nuclear electric dipole polarizability"*,
Talk at the APS APRIL MEETING, Salt Lake City, April 17th, 2016.

6. *"Neutrino-nucleus interactions"*,
Talk at the TRIUMF THEORY DEPARTMENT MEETING, Oct 14, 2015.

7. *"Neutrino-pair production in supernova from hadronic collisions"*,
   Talk at the TRIUMF THEORY DEPARTMENT MEETING, Jan 14, 2015.

8. *"Towards a first principle description of photo-nuclear reactions in medium mass nuclei"*,
   Talk at the TRIUMF THEORY GROUP MEETING, February 12, 2014.

P.G. Blunden

No update provided for this report

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 M oller 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).

Conference Proceedings

6. 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.

Presentations

7. *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.

8. *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.

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

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

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

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

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

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

M. E. Carrington

Journal Articles

1. " Smooth and sharp creation of a spherical shell for a (3+1) dimensional quantum field," M.E. Carrington, G. Kunstatter, J. Louko and L.J. Zhou, Phys. Rev. **D98**, 024035 (2018).

2. "*The 2PI effective theory at next-to-leading order using the functional renormalization group,*" M.E. Carrington, S.A. Friesen, B.A. Meggison, C.D. Phillips, D. Pickering and K. Sohrabi, Phys. Rev. **D97**, 036005 (2018).

3. "*The role of frequency dependence in dynamical gap generation in graphene,*" M.E. Carrington, C.S. Fischer, L. von Smekal and M.H. Thoma, Phys. Rev. **97**, 115411 (2018).

4. "*Momentum broadening in unstable quark-gluon plasma,*" M.E. Carrington, St. Mrówczyński, B. Schenke, Phys. Rev. **C95**, 024906 (2017).

5. "*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, Phys. Rev. **D95**, 085007 (2017).

6. "*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).

7. "*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).

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

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

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

11. “*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) .

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

13. “*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).

- **Papers in Refereed Proceedings**

14. “*Next-to-leading order scalar ϕ^4 theory using the functional renormalization group,*” M.E. Carrington and C.D. Phillips, submitted to the proceedings of the 7th International Conference on New Frontiers in Physics (ICNFP 2018), Kolymbari, Crete, July 04 - 12, 2018.

15. “*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.

16. “*Techniques for calculations with nPI effective actions,*” M.E. Carrington, EPJ Web of Conferences 95, 04013 (2015).

17. “*Energy loss in unstable quark-gluon plasma,*”M.E. Carrington, K. Deja and S. Mrówczyński, Conference: C14-03-22, p.337-340, (2014).

18. “*Energy Loss in Unstable QGP - the Upper Cut-off Dependence,*”M.E. Carrington, K. Deja and S. Mrówczyński, Acta Phys. Polon. Supp. 7 (2014) 1, 209-214.

19. “*Energy loss in unstable QGP - problem of the upper cut-off,*”M.E. Carrington, K. Deja, S. Mrówczyński, EPJ Web Conf. 71 (2014) 00095.

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

T. Chakraborty

No update provided for this report

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)

6. Wenchen Luo & T. Chakraborty Phys. Rev. B 93, 161103 (R) (Rapid Commun.) (2016)
7. P. K. Pyatkovskiy & T. Chakraborty Phys. Rev. B 93, 085145 (2016)
8. A. Ghazaryan & T. Chakraborty Phys. Rev. B 92, 235404 (2015)
9. Wenchen Luo & T. Chakraborty J. Phys.: Condens. Matter 28, 015801 (2015)
10. Wenchen Luo & T. Chakraborty Phys. Rev. B 92, 155123 (2015)
11. A. Ghazaryan & T. Chakraborty , Phys. Rev. B 92, 165409 (2015)
12. V.M. Apalkov & T. Chakraborty, Phys. Rev. B 91, 235447 (2015)
13. A. Ghazaryan & T. Chakraborty, Phys. Rev. B 92, 115138 (2015)
14. A. Ghazaryan & T. Chakraborty, Phys. Rev. B 91, 125131 (2015)
15. A. Ghazaryan, T. Chakraborty & P. Pietiläinen, J. Phys.: Condens. Matter 27, 183501 (2015)
16. T. Chakraborty & Vadym M. Apalkov, IET Circuits, Devices & Systems (Invited article) 9, 19 (2015)
17. V. Apalkov & T. Chakraborty, Phys. Rev. B90, 245108 (2014)
18. A. Ghazaryan, A. Manaselyan, & T. Chakraborty, Physica E66, 157 (2014)
19. T. Chakraborty & V. Apalkov, IET Circuits, Devices & Systems (2014)
20. V. Apalkov & T. Chakraborty, J.Phys. Condensed Matter 26, 475302 (2014)
21. V. Apalkov & T. Chakraborty, Phys. Rev. Lett. 112, 176401 (2014)
22. T. Chakraborty & V. Apalkov, Solid State Commun. 175-176, 123 (2013)
23. T. Chakraborty & V. Apalkov, chapter in Physics of Graphene, H. Aoki & M. Dresselhaus (Eds), Springer (2013)
24. M. Zarenia, B. Partoens, T. Chakraborty, & F.M. Peeters, Phys. Rev. B88, 245432 (2013)
25. A. Manaelyan, A. Ghazaryan, & T. Chakraborty, Solid State Commun. 181, 34 (2013)
26. S. Avetisyan, P. Pietiläinen, & T. Chakraborty, Phys. Rev. B88, 205310 (2013)
27. V. Apalkov & T. Chakraborty, Solid State Commun. 177, 128 (2013)

J. Fiege

No update provided for this report

1. Pattle, K.; Ward-Thompson, D., et al., MNRAS. 450(1): 1094-1122, The JCMT Gould Belt Survey: first results from the SCUBA-2 observations of the Ophiuchus molecular cloud and a virial analysis of its prestellar core population

2. Salji, C. J.; Richer, J. S., et al., MNRAS. 449(2): 1769-1781, The JCMT Gould Belt Survey: constraints on prestellar core properties in Orion A North

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.

Proceedings

7. 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

8. 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

9. “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

10. “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

Preprints

1. B. Cownden, N. Deppe and A. R. Frey, "Phase Diagram of Stability for Massive Scalars in Anti-de Sitter Spacetime," arXiv:1711.00454 [hep-th].

Refereed Publications

1. B. Cownden and A. R. Frey, "Variations on the Dirac string," Phys. Rev. D **98**, no. 10, 105013 (2018) [arXiv:1807.07401 [hep-th]].

2. B. Cownden, A. R. Frey, M. C. D. Marsh and B. Underwood, "Dimensional Reduction for D3-brane Moduli," JHEP **1612**, 139 (2016) [arXiv:1609.05904 [hep-th]].

3. 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]].

4. 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]].

5. 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]].

6. 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]].

7. 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]].

Media Appearances

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

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

9. 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.

Talks

1. "A New Interpretation for the Dirac String," McGill University & Perimeter Institute, 2018.

2. "Phases of Gravitational Collapse in AdS," McGill University & Perimeter Institute, 2018.

3. "Question and Answer" at the performance of *How the Heavens Go* at Prairie Theatre Exchange, Winnipeg, 2018.

4. "Gravitational Collapse in AdS," WITP Workshop at UManitoba, 2017.

5. "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.

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

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

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

9. "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.

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

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

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

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

Refereed publications

1. Basic equivariant gerbes on non-simply connected compact simple Lie groups. Journal of Geometry and Physics, 133 (2018), pp. 30-41.

2. (with J. Watts) Differential cocycles and Dixmier-Douady bundles. Journal of Geometry and Physics, 130 (2018), pp. 168–183.

3. Groupoid equivariant prequantization, Communications in Mathematical Physics, 360 (2018), no. 1, pp. 169–195.

4. 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.

5. (with R. Goldin, M. Harada, and D. Johannsen) Inertia groups of a toric DM stack, fake weighted projective stacks, and labelled sheared simplices, Rocky Mountain Journal of Mathematics, 46, no. 2 (2016), pp. 481-517.

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

G. Kunstatter

No update provided for this report

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).

Invited papers presented at meetings

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

10. G. Kunstatter, “Polymer quantized spherical thin shell collapse”, Theory Canada, Carleton University, Ottawa, June 2016.
11. 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.
12. G. Kunstatter, “Non-singular black holes from new 2D gravity” **invited**, Mann Fest, University of Waterloo, December 2015.
13. 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.
14. G. Kunstatter, “(In-)stability of AdS Space-time in Einstein-Gauss-Bonnet Gravity”, **Invited**, Atlantic Meeting on General Relativity, University of Fredericton, May 2015.

Invited Lectures

15. ”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
16. “Black hole information loss: is there light at the end of the tunnel?”, University of Lethbridge, March 2016.
17. “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.
18. “Black hole information loss: is there light at the end of the tunnel?”, UWinnipeg, October, 2014; SFU, October, 2014.
19. “Stability of AdS Spacetime in Einstein-Gauss-Bonnet Gravity”, SFU, October, 2014.
20. “Black hole information loss: let’s lose the singularity instead of the information”, UNB, July, 2014.

P.D. Loly

1. Peter Loly, Ian Cameron & Adam Rogers, ”Powers of doubly-affine integer square matrices with one non-zero eigenvalue”, arXiv:1712.03393[math.HO] (2017).

2. Adam Rogers, Ian Cameron and Peter Loly, “Compounding Doubly Affine Matrices”, arXiv:1711.11084 (2017).

3. Ian Cameron, Adam Rogers & Peter Loly, ”Signatura of magic and Latin integer squares: isentropic clans and indexing”, Discussiones Mathematicae Probability and Statistics, online c. December 2013, in paper 2014.

   Talks

4. Peter Loly (speaker) ”Perspectives in Physics: Eigenspectra from magnons to magic” 4 April 2018.

5. Peter Loly (speaker) ”Quantum angular momentum matrices – eigenvalues and SVs”, at WCLAM2016 14-15 May.

6. Peter Loly (speaker) ”Shannon entropy of small matrices for physicists”, Department Colloquium, 7 Nov. 2014.

7. Peter Loly (speaker) ”Knut-Vik Designs are Multimagic”, CMS Summer Meeting 7 June 2014.

C. O’Dea

Refereed Articles

1. F. Massaro, V. Missaglia, C. Stuardi, D. E. Harris, R. P. Kraft, A. Paggi, E. Liuzzo, G. R. Tremblay, S. A. Baum, C. P. O’Dea, B. J. Wilkes, J. Kuraszkiewicz, W. R. Forman, “The 3CR Chandra snapshot survey: extragalactic radio sources with $0.5 < z < 1.0$,” Astrophysical Journal Supplements, 234, 7 - 32 (2018)

2. C. Hekatelyne, R. A. Riffel, D. Sales, A. Robinson, J. Gallimore, T. Storchi-Bergmann, P. Kharb, C. O’Dea, S. Baum, “Gemini IFU, VLA and HST observations of the OH Megamaser galaxy IRASF23199+0123: the hidden monster and its outflow,” Monthly Notices of the Royal Astronomical Society, 474, 5319-5329 (2018)

3. K. Cooke, K. Fogarty, J. S. Kartaltepe, J. Moustakas, C. P. O’Dea, M. Postman “Stellar Mass and 3.4 m M/L Ratio Evolution of Brightest Cluster Galaxies in COSMOS since z$\sim$ 1.0,” Astrophysical Journal, 857, 122 - 136 (2018)

4. C. Stuardi, V. Missaglia, F. Massaro, F. Ricci, E. Liuzzo, A. Paggi, R. P. Kraft, G. R. Tremblay, S. A. Baum, C. P. O’Dea, B. J. Wilkes, J. Kuraszkiewicz, W. R. Forman, D. E. Harris, “The 3CR Chandra extragalactic survey at $1.0 < z < 1.5$,” Astrophysical Journal Supplements, 235, 32 - 52 (2018)

5. G. R. Tremblay, F. Combes, J. B. Raymond Oonk, H. R. Russell, M. A. McDonald, M. Gaspari, B. Husemann, P. E. J. Nulsen, B. R. McNamara, S. L. Hamer, C. P. O'Dea, S. A. Baum, T. A. Davis, M. Donahue, G. M. Voit, A. C. Edge, E. L. Blanton, M. N. Bremer, E. Bulbul, T. E. Clarke, L. P. David, L. O. V. Edwards, D. A. Eggerman, A. C. Fabian, W. R. Forman, C. Jones, N. Kerman, R. P. Kraft, Y. Li, M. C. Powell, S. W. Randall, P. Salomé, A. Simionescu, Y. Su, M. Sun, C. M. Urry, A. N. Vantyghem, B. J. Wilkes, J. A. ZuHone "A Galaxy-Scale Fountain of Cold Molecular Gas Pumped by a Black Hole," Astrophysical Journal, 865, 13 - 37 (2018)

6. C. Hekatelyne, R. A. Riffel, D. Sales, A. Robinson, T. Storchi-Bergmann, P. Kharb, J. Gallimore, S. Baum, C. O'Dea, "Star formation and gas inflows in the OH Megamaser galaxy IRAS03056+2034," Monthly Notices of the Royal Astronomical Society, 479, 3966 - 3977 (2018)

7. M. C. Powell, B. Husemann, G. R. Tremblay, M. Krumpe, T. Urrutia, S. A. Baum, G. Busch, F. Combes, S. M. Croom, T. A. Davis, A. Eckart, C. P. O'Dea, M. Prez-Torres, J. Scharwchter, I. Smirnova-Pinchukova, C. M. Urry, "The Close AGN Reference Survey (CARS): No evidence of galaxy-scale hot outflows in two nearby AGN," Astronomy & Astrophysics, 618, A27-37 (2018)

8. G. Busch, B. Husemann, I. Smirnova-Pinchukova, A. Eckart, S.A. Baum, F. Combes, S.M. Croom, T.A. Davis, N. Fazeli, C. Fischer, M. Gaspari, R. Klein, M. Krumpe, R. McElroy, C.P. O'Dea, M.A. Perez-Torres, M.C. Powell, . Snchez-Monge, J. Scharwchter, G.R. Tremblay, T. Urrutia, "The Close AGN Reference Survey (CARS): SOFIA detects spatially-resolved [CII] emission in the luminous AGN HE0433-1028," Astrophysical Journal Letters, 866, L9-15 (2018)

9. B. Balmaverde, A. Capetti, A. Marconi, G. Venturi, M. Chiaberge, R.D. Baldi, S. Baum, R. Gilli, P. Grandi, E. Meyer, G. Miley, C. O'Dea, W. Sparks, E. Torresi, G. Tremblay, "The MURALES survey. I. A dual AGN in the radio galaxy 3C459?" Astronomy & Astrophysics, 619, A83-89 (2018)

10. F. Ricci, L. Lovisari, R. P. Kraft, F. Massaro, A. Paggi, E. Liuzzo, G. Tremblay, W. R. Forman, S. Baum, **C. O'Dea**, B. Wilkes, "Stormy weather in 3C 196.1: nuclear outbursts and merger events shape the environment of the hybrid radio galaxy 3C 196.1," Astrophysical Journal, 867, 35 - 47 (2018)

11. C. P. O'Dea, D. M. Worrall, G. R. Tremblay, T. E. Clarke, B. Rothberg, S. A. Baum, K. P. Christiansen, C. A. Mullarkey, J. Noel-Storr, R. Mittal, "Testing for Shock-Heated X-ray Gas Around Compact Steep Spectrum Radio Galaxies," Astrophysical Journal, 851, 87-99 (2017)

12. J. E. Coleman, L. J. King, M. Oguri, H. R. Russell, R. E. A. Canning, A. Leonard, R. Santana, J. A. White, S. A. Baum, D. I. Clowe, A. Edge, A. C. Fabian, B. R. McNamara and C. P. O'Dea, The mass distribution of the unusual merging cluster Abell 2146 from strong lensing, Monthly Notices of the Royal Astronomical Society, 464, 2469-2480 (2017)

13. C. Reynolds, B. Punsly, G. Miniutti, C. P. O'Dea, N. Hurley-Walker, The Relativistic Jet-Accretion Flow-Wind Connection in Mrk 231," Astrophysical Journal, 836, 155-176 (2017)

14. M. Chiaberge, J. C. Ely, E. T. Meyer, M. Georganopoulos, A. Marinucci, S. Bianchi, G. R. Tremblay, B. Hilbert, J. P. Kotyla, A. Capetti, S. A. Baum, F. D. Macchetto, G. Miley, C. P. O'Dea, E. S. Perlman, W. B. Sparks, C. Norman, The puzzling radio-loud QSO 3C 186: a gravitational wave recoiling black hole in a young radio source?" Astronomy & Astrophysics, 600, 57-72 (2017)

15. L. Gu, J. Mao, C. P. O'Dea, S. A. Baum, M. Mehdipour, J. Kaastra, Charge exchange in the ultraviolet: implication for interacting clouds in the core of NGC 1275, Astronomy & Astrophysics, 601, 45-53 (2017)

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

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

18. 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)

19. 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)

20. 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)

21. 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)

22. 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)

23. 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)

24. 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)

25. 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)

26. 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)

    A. N. Vantyghem, B. R. McNamara, H. R. Russell, M. T. Hogan, A. C. Edge, P. E. J. Nulsen, A. C. Fabian, F. Combes, P. Salome, S. A. Baum, M. Donahue, R. A. Main, N. W. Murray, R. W. O'Connell, C. P. O'Dea, J. B. R. Oonk, I. J Parrish, J. S. Sanders, G. Tremblay, G. M. Voit, Molecular Gas Along a Bright H-alpha Filament in 2A 0335+096 Revealed by ALMA, Monthly Notices of the Royal Astronomical Society, 832, 148-160 (2016)

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T.A. Osborn

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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.
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S. Plosker

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2. S.J. Harris, R.H. Levene, V.I. Paulsen, S. Plosker, M. Rahaman. *Schur multipliers and mixed unitary maps*, Journal of Mathematical Physics, **59**, 112201 (2018).
3. S. Kirkland, D. Mclaren*, R. Pereira, S. Plosker, and X. Zhang*. *Perfect quantum state transfer in weighted paths with potentials (loops) using orthogonal polynomials*, Linear and Multilinear Algebra, pp. 1-19, 2018.
4. N. Johnston, C.-K. Li, S. Plosker, Y.T. Poon., and B. Regula. *Evaluating the robustness of k-coherence and k-entanglement*, Physical Review A, **98**, 022328, 2018
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11. J. Li, R. Pereira and S. Plosker. *Some geometric interpretations of quantum fidelity.* Linear Algebra and its Applications, **487**, pp. 158-171, 2015.

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

13. 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.

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

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

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19. B. Kacsmar*, S. Plosker, and R. Henry *Computing Low-Weight Discrete Logarithms*, the 24th Annual Conference on Selected Areas in Cryptography (SAC) Ottawa, ON, 2017

Invited Lectures

20. *Switching the hypercube while maintaining perfect state transfer*, Optimization Techniques in Quantum Information Theory Session, CMS Summer Meeting, Fredericton, NB, Jun. 1-4, 2018.

21. *Hadamard diagonalizable graphs, cubelike graphs, and perfect state transfer*, Algebraic Graph Theory and Quantum Walks Workshop, Waterloo, ON, Apr. 23–27, 2018.

22. *Perfect quantum state transfer on weighted paths*, Mathematical Aspects of Quantum Information Session, CMS Winter Meeting, Waterloo, ON, Dec. 8–11, 2017.

23. *Achieving perfect state transfer using Hadamard diagonalizable graphs*, Matrix Analysis and its Applications Special Session, 3rd Pacific Rim Mathematical Association (PRIMA2017) Congress, Oaxaca, Mexico, Aug. 14–18, 2017.

24. *Clean quantum measurements via operator systems*, Workshop on Operator Systems in Quantum Information, Guelph, ON, Aug. 14–17, 2017

25. *Quantum state transfer via Hadamard diagonalizable graphs*, Invited Minisymposium: Linear Algebra and Quantum Information Science, 21st Meeting of the International Linear Algebra Society (ILAS) Ames, IA, USA, July 24–28, 2017

26. *Hadamard diagonalizability and cubelike graphs*, Special Western Canada Linear Algebra Meeting, Banff International Research Station for Mathematical Innovation and Discovery (BIRS), Banff, AB, July 7–9, 2017

27. *Hadamard diagonalizable graphs with perfect state transfer*, Prairie Discrete Math Workshop, Lumsden, SK, June 2–5, 2017.

28. *Optimal bounds on fidelity of quantum state transfer with respect to errors*, Optimization Techniques in Quantum Information Theory Session, CMS Winter Meeting, Niagara Falls, ON, Dec. 2–5, 2016.

29. *Applications of matrix theory to quantum coherence*, 2016 Workshop on Matrices and Operators (MAO), Jeju Island, South Korea, July 3–6, 2016.

30. *The probability of quantum state transfer: a matrix analysis approach*, The Thirteenth Workshop on Numerical Ranges and Numerical Radii, Taipei, Taiwan, June 28–30, 2016.

31. *Some matrix theory questions arising from quantum coherence*, Special Session on Matrix and Operator Theory, AMS Sectional Meeting, Fargo, ND, USA, April 16–17, 2016.

32. *Some matrix theory questions arising from quantum coherence*, Math Colloquium, University of Manitoba, Mar. 11, 2016.

33. *The probability of quantum state transfer: a matrix analysis approach*, 5th International Conference on Matrix Analysis and Applications (ICMAA), Fort Lauderdale, FL, USA, Dec 17–20, 2015.

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

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

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

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

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

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

40. *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

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

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

43. *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

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

A. Prymak

1. S. Brodiuk, N. Palko, A. Prymak, *On Banach-Mazur distance between planar convex bodies*, *Aequationes Math.*, **92** (2018), 993–1000.
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3. A. Prymak, *Upper estimates of Christoffel function on convex domains*, *J. Math. Anal. Appl.*, **455** (2017), 1984–2000.
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5. 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.
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6. Z. Ditzian, A. Prymak, *On Nikol'skii inequalities for domains in* R^d, Constructive Approximation, **44** (2016), 23–51.
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S. Safi-Harb

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3. Hitomi Collaboration (including Safi-Harb) 2018, Publications of the Astronomical Society of Japan, in press (2018PASJ..tmp..128H; arXiv:1810.00704)

4. Hitomi Collaboration (including Safi-Harb, S., Guest, B.) 2018, Publications of the Astronomical Society of Japan, 70, 38

5. MAGIC and HESS Collaboration (including Safi-Harb, S.) 2018, Astronomy & Astrophysics, 612, 14

6. H.E.S.S. Collaboration (including Safi-Harb, S.) 2018, Astronomy & Astrophysics, 612, 3

7. H. E. S. S. Collaboration (including Safi-Harb, S.) 2018, Astronomy & Astrophysics, 612, 1

8. Hitomi Collaboration (including Safi-Harb, S.) 2018, Publications of the Astronomical Society of Japan, 70, 17

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23. West, J. L., Safi-Harb, S. & Ferrand, G. 2017, Astronomy & Astrophysics, 597, 121

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25. Hitomi Collaboration, including Safi-Harb, S. 2017, the Astrophysical Journal Letters, ApJ, 837, L15

26. Rogers, A. 2017, Monthly Notices of the Royal Astronomical Society, vol. 465, issue 2, pp. 2151-2159

27. Miceli, M., Bamba, A., Orlando, S., Zhou, P., Safi-Harb, S., Chen, Y. & Bocchino, F. 2017, Astronomy & Astrophysics, 599, 45

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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

- **Several** presentations in 2018: CASCA (Victoria, 2 with graduate students), UofM Undergraduate Posters competition (5 total undergrad presentations), Ireland (2 invited talks at summer school), Washington, D.C. (2 Invited talks), Waterloo (invited talk), Italy (Invited talk)

- 'Neutron Stars–Supernova Remnants associations' by S. Safi-Harb, Riken, Japan, Nov. 7 (2017)

- UofM Undergraduate Poster Competition by Austin MacMaster (NSERC USRA), winner of the 3rd prize in the Natural Sciences Category, Oct. 13 (2017)

- 'High-Energy' (synergy with radio) by S. Safi-Harb, Future of Canadian Radio Astronomy, McGill, Montreal, Sep. 13–14 (2017)

- 'Neutron Stars: Observational Diversity and Evolution', PNS2017 conference, St Petersburg, Russia, July 10–14 (2017)

- 'Hitomi's Glimpse at Supernova Remnants' by Safi-Harb, S., CASCA, Edmonton, May 29–June 1 (2017)

- '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).

- 'Pulsar Wind Nebulae' review by S. Safi-Harb, Modelling Nebulae workshop, Sant Cugat Forum on Astrophysics, Barcelona, Spain, June 14–17 (2016)

- Pulsar Wind Nebula G21.5–0.9 by B. Guest & S. Safi-Harb, Modelling Nebulae workshop, Sant Cugat Forum on Astrophysics, Barcelona, Spain, June 14–17 (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).

Invited Talks

- Delivered 9 invited talks in 2018 in Canada, USA and overseas (2018)
- Neutron Stars–Supernova Remnants associations; Workshop on 'The Theories of Astrophysical Big Bangs', Riken, Japan, Nov. 6–10 (2017)
- Neutron stars: Observational diversity and evolution; Physics of Neutron Stars conference celebrating 50 years since the discovery of neutron stars, ST Petersburg, Russia, July 10–14 (2017)
- Supernova Remnants and Neutron Stars: an Astrophysical Laboratory for Probing the Physics of the Extreme, B.C Tour (U. Victoria and TRIUMF colloquia, UBC astro lunch) March 15–16 (2017)
- Discover your Future in Science Presentation, UofM, 08 Feb (2017)
- 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)

Media and Press Releases

- Delivered several media interviews in 2018: Science News, CBC, Winnipeg Free Press,..(2018)

- How do Sun-like stars explode? Hitomi Mission Glimpses Cosmic Recipe for Nearby Universe, UofM/NASA/JAXA press releases, Nov (2017)

- Une recette cosmique pour un univers pres du notre, RCI Radio Canada, Nov. 18 (2017)

- CBC radio, CJOB, CJNU (Winnipeg), National Post Media (Toronto) interviews for the Top 100 award, Nov (2017)

- CFI event attended by Minister of Science Kristy Duncan, UofM downtown campus, Oct 12 (2017)

- Opening new windows into our universe, UofM and other press releases on the Hitomi first Nature paper on Perseus Cluster, July 2016

- 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.

Recent Conference Organization

- Scientific Organizing Committee member for the 'Future of Canadian Radio Astronomy', McGill, Sep. (2017)
- Scientific Organizing Committee member for the International Astronomical Union (IAU) Symposium 331 on 'SN1987A, 30 years later', 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).

Missions membership and other activities

- Neutron Stars Science working group lead for the Colibri X-ray mission concept (2018–)
- 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/Hitomi X-ray mission (2011–2018)
- Member of Thirty Meter Telescope International Science Development Team
- Chair and member, NASA/Chandra Peer Review Panel
- Chair and member, NRC Canadian Time Allocation Committee Galactic Panel
- Chair of the CSA high-energy astrophysics Diffuse Emission Subcommittee
- Member of NASA's Chandra Users Committee
- Member of the Canadian Time Allocation Committee
- CASCA local representative
- Member of the ACURA Advisory Committee for the Square Kilometre Array (AACS)
- Referee for astronomy and astrophysics journals, NASA, NSERC, and graduate students' theses

E. Schippers

No update provided for this report

Publications

1. Schippers, E. "Conformal invariants associated with quadratic differentials". Israel J. of Math. (2017). https://doi.org/10.1007/s11856-017-1625-5.

2. Schippers, E.; Staubach, W. "Harmonic reflection in quasicircles and well-posedness of a Riemann-Hilbert problem on quasidisks.", Journal of Mathematical Analysis and Applications **448** (2) (2017), 864–884.

3. Schippers, E.; Staubach, W. "Well-posedness of a Riemann-Hilbert problem on d-regular quasidisks.", Annales Academiae Scientiarum Fennicae **42** (2017), 141–147.

4. Schippers, E.; Staubach, W. "Riemann boundary value problem on quasidisks, Faber isomorphism and Grunsky operator.", Complex Analysis and Operator Theory (2016) https://doi.org/10.1007/s11785-016-0598-4

5. 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.

6. 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).

7. Radnell, D.; Schippers, E.; and Staubach, W. "Quasiconformal maps of bordered Riemann surfaces with L^2 Beltrami differentials." Jounal d'Analyse Mathematique **132** (1) (June 2017) 229–245.

8. Radnell, D.; Schippers, E.; and Staubach, W. "Weil-Petersson class non-overlapping mappings into a Riemann surface." Commun. Contemp. Math. 18, 1550060 (2016) DOI: http://dx.doi.org/10.1142/S0219199715500601.

9. 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.

10. 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) DOI: http://dx.doi.org/10.1142/S0219199715500169.

11. Reimer, K.; and Schippers, E. "Faber-Tietz functions and Grunsky coefficients for maps into a torus" Complex Analysis and Operator Theory **9**, Issue 8 (2015), 1663 –1679.

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

Book Chapter

Schippers, E.; and Staubach, W. "Comparison moduli spaces of Riemann surfaces" New Trends and Open Problems in Complex Analysis and Dynamics, Birkhauser, to appear. arXiv:1706.09168

Refereed Conference Proceedings

13. Schippers, E. "Quadratic differentials and conformal invariants". Journal of Analysis. **2** (2016) 209–228. DOI 10.1007/s41478-016-0014-5.

14. Radnell, D.; Schippers, E; Staubach, W. "Quasiconformal Teichmuller theory as an analytic foundation for two-dimensional conformal field theory." In 'Lie algebras, Vertex Operator Algebras and Related Topics'. eds Katrina Barron, Elizabeth Jurisich, Antun Milas, Kailash Misra. Contemporary Mathematics **695**, Amer. Math. Soc. (2017).

Research Presentations

15. University of Western Ontario analysis seminar, April 2017.

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

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

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

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

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

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

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

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

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

25. McGill University analysis seminar, February 2013.

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

A. Shalchi

1. Shalchi, A. & Gammon, M., Perturbation theory based solution of the pitch-angle dependent cosmic ray diffusion equation, Advances in Space Research, in press (2018)
2. Shalchi, A., Analytical forms of the cosmic ray perpendicular diffusion coefficient with implicit contribution of slab modes, Advances in Space Research **62**, 2817 (2018)
3. Shalchi, A., Analytical Description of the Time-dependent Perpendicular Transport of Energetic Particles, The Astrophysical Journal **864**, 155 (2018)
4. Arendt, V. & Shalchi, A., Time-dependent transport of energetic particles in magnetic turbulence: computer simulations versus analytical theory, Advances in Space Research **363**, 116 (2018)
5. Lasuik, J. & Shalchi, A., The influence of non-Gaussian distribution functions on the time-dependent perpendicular transport of energetic particles, Advances in Space Research **61**, 2827 (2018)
6. Shalchi, A., Analytical Forms of the First 14 Moments of the Cosmic Ray Fokker-Planck Equation, Journal of Plasma Physics **83**, 905830603 (2017)
7. Negrea, M., Petrisor, I., & Shalchi, A., Stochastic field-line wandering in magnetic turbulence with shear. II. Decorrelation trajectory method, Physics of Plasmas **24**, 112303 (2017)
8. Gammon, M. & Shalchi, A., Simple Analytical Forms of the Perpendicular Diffusion Coefficient for Two-Component Turbulence, III. Damping Model of Dynamical Turbulence, The Astrophysical Journal **847**, 118 (2017)
9. Lasuik, J. & Shalchi, A., Time-Dependent Perpendicular Transport of Energetic Particles for Different Turbulence Configurations and Parallel Transport Models, The Astrophysical Journal **847**, 9 (2017)
10. Lasuik, J. & Shalchi, A., Solutions of the Cosmic Ray Velocity Diffusion Equation, Advances in Space Research **60**, 1532 (2017)
11. Shalchi, A., Time-dependent perpendicular transport of energetic particles in magnetic turbulence with transverse complexity, Physics of Plasmas Letters **24**, 050702 (2017)
12. Heusen, M. & Shalchi, A., Numerical Test of Analytical Theories for Perpendicular Diffusion in Small Kubo Number Turbulence, The Astrophysical Journal **839**, 2 (2017)
13. Acero, F., . . . , Shalchi, A., et al., Prospects for Cherenkov Telescope Array Observations of the young supernova remnant RX J1713.7-3946, The Astrophysical Journal **840**, 74 (2017)

14. Lasuik, J., Fiege, J. D., & Shalchi, A., Numerical Analysis of the Fokker-Planck Equation with Adiabatic Focusing: Realistic Pitch-Angle Scattering, Advances in Space Research **59**, 722 (2017)

15. 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)

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

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

18. 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)

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

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

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

22. 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)

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

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

25. 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).

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

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

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

29. 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).

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

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

32. 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).

33. 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).

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

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

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

37. 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).

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

39. 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).

Khodr M. Shamseddine

Refereed Journal Publications

1. On an operator theory on a Banach space of countable type over a Hahn field, *Khodr Shamseddine and Changying Ding*, in press.

2. On Integrable Delta Functions on the Levi-Civita Field, *Darren Flynn and Khodr Shamseddine*, ***p*-Adic Numbers, Ultrametric Analysis, and Applications**, Volume 10 # 1, 2018, pp. 32-56.

3. Positive operators on a free Banach space over the Levi-Civita field, *Jose Aguayo, Miguel Nova and Khodr Shamseddine*, ***p*-Adic Numbers, Ultrametric Analysis, and Applications**, Volume 9 # 2, 2017, pp. 122-137.

4. 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.

5. 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.

6. 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.)

Edited Proceedings

7. 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**, Volume 704, 2018, ISBN: 978-1-4704-3491-5.

8. 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.

9. 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

10. Summary on non-Archimedean valued fields, *Angel Barria Comicheo and Khodr Shamseddine*, **Contemporary Mathematics, American Mathematical Society**, Volume 704 (Advances in Ultrametric Analysis), 2018, pp. 1-36.

11. 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**, Volume 704 (Advances in Ultrametric Analysis), 2018, pp. 49-67.

12. 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.

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

Invited Talks at Conferences

14. One-variable and Multi-variable Integral Calculus over the Levi-Civita Field and Applications, Sixth International Conference on p-adic Mathematical Physics and its Applications, Mexico City, Mexico, October 23-27, 2017.

15. On the Levi-Civita Fields: Introduction and Summary of Selected Recent Research, 11th Congress of the International Society for Analysis, its Applications and Computations (ISAAC), Vxj, Sweden, August 14-18, 2017.

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.

Contributed Talks at Conferences

23. Elements of an operator theory on the space c_0 over a non-Archimedean valued field, 46th Canadian Operator Symposium, University of Manitoba, June 4-8, 2018.

Seminars and Colloquia at Universities

24. Department of Mathematics, Universidad de Concepcion, Concepcion, Chile, March 23, 2018.

25. Department of Mathematics, American University of Beirut, Beirut, Lebanon, August 31, 2017.

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

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

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

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

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

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

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

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

Conference Organization

- Member of the International Scientific Committee, Seventh International Conference on p-adic Mathematical Physics and its Applications, Portugal (September 2019)

- Member of the International Scientific Committee, NUMTA2019: Numerical Computations: Theory and Algorithms, Italy (June 2019)

- Member of the International Scientific Committee, 15th International Conference on p- Adic Functional Analysis, Poland (July 2018)

- Co-Organizer, Winnipeg Institute of Theoretical Physics Summer Symposium, U of Manitoba (July 31-August 1, 2017)

- 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)

J. Sirker

1. A. Urichuk, Y. Oez, A. Klmper, J. Sirker,
   "The spin Drude weight of the XXZ chain and generalized hydrodynamics",
   arXiv:1808.09033 (2018) [SciPost in print].
2. J. Sirker,
   "Does a distinct quasi many-body localized phase exist? A numerical study of a translationally invariant system in the thermodynamic limit",
   arXiv: 1805.08258 (2018).
3. W. Luo, A. Naseri, J. Sirker, T. Chakraborty,
   "Unique Spin Vortices in Quantum Dots with Spin-orbit Couplings",
   arXiv:1802.00788 (2018) [Scientific Reports in print].
4. N. Sedlmayr, P. Jaeger, M. Maiti, J. Sirker,
   "A bulk-boundary correspondence for dynamical phase transitions in one-dimensional topological insulators and superconductors",
   Phys. Rev. B **97**, 064304 (2018).
5. N. Sedlmayr, M. Fleischhauer, J. Sirker,
   "The fate of dynamical phase transitions at finite temperatures and in open systems",
   Phys. Rev. B **97**, 045147 (2018).
6. M. Kiefer-Emmanouilidis, J. Sirker,
   "Current reversals and metastable states in the infinite Bose-Hubbard chain with local particle loss",
   Phys. Rev. A **96**, 063625 (2017).
7. Y. Zhao, S. Ahmed, J. Sirker, "Localization of fermions in coupled chains with identical disorder", Phys. Rev. B **95**, 235152 (2017).
8. T. Enss, F. Andraschko, J. Sirker, "Many-body localization in infinite chains", Phys. Rev. B **95**, 045121 (2017).
9. 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).

10. Y. Zhao, F. Andraschko, J. Sirker, “Entanglement entropy of disordered quantum chains following a global quench”, Phys. Rev. B **93**, 205146 (2016).

11. 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).

12. C. Karrasch, R. G. Pereira, J. Sirker, “Low temperature dynamics of nonlinear Luttinger liquids”, New J. Phys. **17**, 103003 (2015).

13. F. Andraschko, J. Sirker, “Propagation of a single hole defect in the one-dimensional Bose-Hubbard model”, Phys. Rev. B **91**, 235132 (2015).

14. F. Andraschko, T. Enss, J. Sirker, “Purification and many-body localization in cold atomic gases”, Phys. Rev. Lett. **113**, 217201 (2014).

15. 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).

16. R. G. Pereira, V. Pasquier, J. Sirker, I. Affleck, “Exactly conserved quasilocal operators for the XXZ spin chain”, J. Stat. Mech. P09037 (2014).

17. J. Sirker, N.P. Konstantinidis, F. Andraschko, N. Sedlmayr, “Locality and Thermalization in Closed Quantum Systems”, Phys. Rev. A **89**, 042104 (2014).

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

19. 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).

Talks

20. ”Many-body localization in infinite chains”,
SSPCM, Rzeszow, Poland, September 2018

21. ”Transport from Integrability”,
Les Houches Summer School, Lectures, September 2018

22. ”The fate of dynamical phase transitions at finite temperatures and in open systems”,
International Conference, Natal, Brazil, July 2018

23. ”Many-body localization in infinite chains”,
Theory seminar, NPU, Xi’an, June 2018

24. ”Transport in integrable lattice models”,
International workshop in honor of Ian Affleck, UBC, April 2018

25. "Low temperature dynamics of nonlinear Luttinger liquids", Theory seminar, UBC, Vancouver, August 2017

26. "Many-body localization in infinite chains", Conference: Correlation days 2017, Dresden, Germany, September 2017.

27. "Low temperature dynamics of nonlinear Luttinger liquids", Theory seminar, UBC, July 2017.

28. "Low temperature dynamics of nonlinear Luttinger liquids", Theory seminar, Wuppertal University, May 2017.

29. "Low temperature dynamics of nonlinear Luttinger liquids", Theory seminar, FU Berlin, June 2017.

30. "Low temperature dynamics of nonlinear Luttinger liquids", Theory seminar, Marburg University, June 2017.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

B.W. Southern

Refereed Publications

1. A.R. Way, K.P.W. Hall, I. Saika-Voivod, M.L. Plumer and B.W. Southern, "Continuous degeneracy of the fcc lattice with magnetic dipolar interactions", Physical Review B **98**, 214417 (2018).

2. Bassel Alkadour, J.L. Mercer, J.P. Whitehead, B.W. Southern, and J. van Lierop, "Dipolar ferromagnetism in three-dimensional superlattices of nanoparticles", Physical Review B **95**, 214407 (2017).

3. Emrul Hasan and B.W. Southern, "Monte Carlo Study of a Geometrically Frustrated Rare Earth Compound: $SrGd_2O_4$", Physical Review B. **96**, 094407 (2017).

4. 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).

5. 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).

6. 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).

7. 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).

Conference Contributions

8. Bassel Alkadour, Jason Mercer, Byron Southern, John Whitehead, Johan van Lierop, "Dipolar ferromagnetism in three dimensional superlattices of nanaoparticles: a micromagnetic simulation study of $\gamma - Fe_2O_3$ nanoparticles", Manitoba Institute of Materials, Winnipeg MB, Canada (2017).

9. Kyle Hall, Martin Plumer, Ivan Saika-Voivod, Byron Southern, "The 3D diploar Kagome lattice", Atlantic Universities Physics and Astronomy Conference, St. John's Nfld, Canada (2017).

10. Daniel Maciel and Byron Southern, "H-T Phase Diagram of the 3D Kagome Lattice", Manitoba Institute of Materials Conference, Winnipeg MB, Canada (2017).

11. Emrul Hasan and Byron Southern, "Monte Carlo Study of SrGd2O4", Manitoba Institute of Materials Conference, Winnipeg MB, Canada (2017).

12. Andrew Way, Byron Southern, Martin Plumer, Ivan Saika-Voivod, "Monte Carlo Simulations of Kagome Lattices with dipolar interactions", Atlantic Universities Physics and Astronomy Conference, Canada (2016).

13. 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)

14. 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)

15. 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)

16. 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)

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)

G.C. Tabisz

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

Last Refereed Publications

1. Vail, J. M., Hernandez, O.J., Si, M. and Wang, Z., "Graphene electronic structure in charge density waves", Journal of Materials Research, vol. 32, pp. 3294 - 3506 (2017).

2. 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

No update provided for this report

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)

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

1. T.A. Harriott and J.G. Williams, "Three-variable solution in the (2+1)-dimensional null-surface formulation," General Relativity and Gravitation, **50**, 39 (2018).

2. 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), pp. 2525–2528 (2017).

3. 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).

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

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**
Theory Canada 13, June 2018 (Sponsorship)	$ 500
Visit Toka Diagana	$ 560
Nanoscale Workshop	$ 500
Meals/Hospitality	$ 83
DTP/WITP PhD Thesis Prize: $250 **Total Expenditures**	$1893

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.

This year, we did not host a summer school which lead to lower than usual expenses. The next WITP summer school is planned for 2019.

The WITP does not incur or depend on any fixed annual cost. Further, the purpose and the activities of the Institute are designed to ensure that virtually all funds go directly towards research, in the form of visitors, seminars, summer schools, etc. Since the WITP is a collection of theorists, we have no expensive equipment to maintain or technicians to employ, and there are virtually no no direct infrastructure costs. This allows the WITP to tailor its operations to match the level of funding it receives. However, in order for the WITP to create visibility for the theoretical physics community in Manitoba and in order to provide adequate training for our HPC, a certain minimum funding level is required as outlined below.

The following represents a minimal budget for WITP activities in the five-year period from 2018 to 2022. It is important to note that the most costly WITP activity, the visitor program, is primarily funded by Member research grants (over $700,000 total for 2016-2017), and those funds are not included in the proposed budget. The following expenditures are for activities that fall outside the usual purview of a research grant and which are more properly and efficiently organized as a collective. In addition, a small fraction of WITP funding will be used to supplement the visitor program by providing partial funding to extend the stay of some visitors or to make it possible for Members to extend an invitation.

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

- Conference support: $1500

  Advertises theoretical physics in Manitoba throughout Canada, promotes research collaborations and dissemination of results, provides opportunity to recruit graduate students

  - Theory Canada conferences: $500
    Main annual conference for Canadian theoretical physics
  - National & international conferences held in Manitoba and surrounding region: $1000
    Average annual amount

- Summer School and Summer Symposium for graduate and undergraduate student researchers: $3000

  One of the most important tasks of the WITP is to provide support in the adequate training of HQP. Contrary to other areas in physics such as nuclear physics, there are no large national labs or large research collaborations where students would be exposed to broader cutting-edge research outside of what is done in the group of their supervisor. Furthermore, the percentage of faculty members working in theoretical physics is—at last at UM—much smaller than at most other U15 universities and also much smaller than the international average. This leads to a relative lack of advanced courses in theoretical physics. The WITP plays an important role in filling this gap by bringing together students from all three Manitoban universities. The annual summer school/summer symposium, in particular, provides lectures by world-leading scientists and the opportunity for our students to present their research to a larger community.

- Visitor Support: $3000

  - Prominent visiting scientist for public lecture: $2000 every other year
    Outreach to the public, as well as scientific discussion
  - Support for other WITP visitors: $2000
    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.

- DTP/WITP PhD Thesis Prize: $500

  The WITP is sponsoring a thesis prize in theoretical physics together with the Division of Theoretical Physics (DTP) of the Canadian Association of Physicists (CAP). This sponsorship increases the visibility of the WITP and is also a recruiting tool to attract students and Postdocs to Manitoba.

- Miscellaneous: $500

  Printing, advertising of study opportunities at Canadian Undergraduate Physics Conference and other venues

Total: $8500 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: Physics at the Nanoscale

Invited Speakers and Talk Titles

Marco Ameduri (Cornell):
Transplanting curricula and rejuvenating premedical courses at Weill Cornell Medicine-Qatar
Abstract

Rene Coté (Sherbrooke) :
NMR spectra of charge-density-wave states in GaAs/AlGaAs quantum wells and 13C-enriched graphene
Abstract

Joseph Falson (MPI Stuttgart):
A cascade of phase transitions in an orbitally mixed half-filled Landau level
Abstract

Herbert Fertig (Bloomington):
Surface Magnetism as a Probe of Topology and Symmetry in Topological Crystalline Insulators

Topological crystalline insulators (TCI's) are a class of materials which support non-trivial topology in their electronic structure, "protected" by an underlying crystal symmetry. We will discuss how certain aspects of this topology can be uncovered at surfaces of such crystals when they are magnetically doped, and how the degeneracy of groundstates is dependent on both the symmetry of the surface as well as the density of electrons there. Moreover, the same surface may support a very "stiff" ferromagnet or a rather "floppy" one. The nature of the ferromagnet realized is in principle externally controllable, and for different cases it disorders at finite temperature through phase transitions of different universality classes. The type of system realized for a specific set of circumstances can be probed via the unique properties of domain walls which appear when the system is thermally excited.

Rolf Haug (Hannover):
Graphene: Folding and Rings
Abstract

Peter Maksym (Leicester):
Electron optics in bilayer graphene
Abstract

Jochen Mannhart (MPI Stuttgart):
Nanoscale Devices for Dissipationless, Non-superconducting Wires?
Abstract

Frank Marsiglio (Alberta):
Superconductivity: the role of local Coulomb correlations

Daniella Pfannkuche (Hamburg):
Title: TBA

Aron Pinczuk (Columbia):
Title: TBA

Rudolf Roemer (Warwick):
Resolution of the "exponent puzzle" for the Anderson transition in doped semiconductors

The Anderson metal-insulator transition (MIT) has long been studied, but there is still no agreement on its critical exponent ν when comparing experiments and theory. In this work we employ ab initio methods to study the MIT in sulfur-doped silicon (Si:S) when the dopant concentration is increased. We use linear-scaling DFT to study model Si:S systems at realistic concentrations (e.g., a few impurities, in a large simulation cell). From the resulting ab initio Hamiltonian, we build an effective tight-binding Hamiltonian for larger systems close to the critical concentration of the MIT. We characterize the MIT in Si:S via multifractal finite-size scaling and obtain estimates of the phase diagram and ν. Our results suggest a possible resolution of the long-standing "exponent puzzle" due to the interplay between conduction and impurity states.

Giovanni Vignale (Missouri-Columbia):
Negative electronic compressibility and electrically induced charge-density waves in the two-dimensional electron gas

We show that the negative electronic compressibility of two-dimensional electronic systems at sufficiently low density enables the generation of charge-density waves through the application of a uniform force field, provided no current is allowed to flow. The wavelength of the density oscillations is controlled by the magnitude of the (negative) screening length, and their amplitude is proportional to the applied force. Both are electrically tunable.

2 Appendix: WITP student workshop at Brandon University

The Winnipeg Institute for Theoretical Physics Summer Symposium

Conference Program

Brandon University

August 27, 2018

Schedule

9:50	Coffee
10:20	Words from Dean
10:30	Darian
11:00	Xiaohong
11:30	Brad
12:00-1:00	Lunch
1:00	Paul
1:30	Shawna
2:00	Coffee
2:30	LJ
3:00	Chris
3:30	Depart

Coffee and lunch breaks to be held in Brodie Building (BB) 1-54; talks to be held in BB 1-53.

Abstracts

Title Variations on the Dirac String [arXiv:1807.07401]

Speaker Brad Cownden (cowndenb@myumanitoba.ca)
Department of Physics & Astronomy, University of Manitoba
Department of Physics, University of Winnipeg

Co-authors Andrew R. Frey (a.frey@uwinnipeg.ca)
Department of Physics, University of Winnipeg

Abstract Following results derived from considering the motion of D3-branes in extra dimensions, we examine a variant of the Dirac string description for magnetic monopoles. We construct this formulation by expanding the monopole's position about an arbitrary, unphysical reference monopole. We then show equivalence between this description and Dirac's string description, as well as with conventional dual potential formulations. Finally, the advantages and potential applications of this description of monopoles is discussed.

Title Inducing Quantum State Transfer

Speaker Darian Mclaren (mclareda17@brandonu.ca)
Department of Mathematics & Computer Science, Brandon University

Co-authors Sarah Plosker (Brandon University), Chi-Kwong Li (College of William and Mary)

Abstract If we consider the particles of a spin network (with XX couplings) to be nodes and the couplings between particles to be edges we can model the spin network through the use of graph theory. By restricting to the single-excitation subspace the Hamiltonian of the spin network is simply the adjacency matrix of the graph. We then say that the graph admits *perfect state transfer* (PST) if after the spin network is initialized with an input node in the excited state, there exists a time t in which the probability of the excitation being at some other target node is 1. Alternatively, we get *pretty good state transfer* (PGST) if the probability of this occurring can be made arbitrarily close to 1. In this talk we explore graphs which do not exhibit PGST, but can be made to do so by adding potentials to the nodes (i.e. loops on the graph).

Title Gradient Flow in Holographic Superconductors

Speaker Paul Mikula (mikulap@myumanitoba.ca)
University of Manitoba / University of Winnipeg

Co-authors

Abstract

The AdS/CFT correspondence provides an equivalence between a gravity theory in some bulk anti-deSitter spacetime and a conformal field theory (CFT) in one fewer dimensions on the boundary. A superconductor that can be described by a gravity theory through this correspondence is referred to as a 'holographic superconductor'. Gradient flow equations will evolve any given initial field configuration towards one that is a solution to the equations of motion, this allows us to study stability of solutions as well as the behavior of a system far from equilibrium. Through the AdS/CFT correspondence, the gradient flow in the gravity theory should have a corresponding flow in the CFT and vice-versa. We focus on the flow of the matter fields in a gravity theory containing a black hole and a charged scalar field. In this system the flow equations move the system from a configuration with no scalar hair to a hairy black hole solution. We study the corresponding flow on the boundary superconducting theory, where a normal metal state transitions to a superconducting state.

Title Computational Renormalization of the 4PI Effective Theory

Speaker Christopher Phillips (christopherdphillips7@gmail.com)
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Co-authors M.E. Carrington: Department of Physics, Brandon University; D. Pickering: Department of Mathematics, Brandon University; S.A. Friesen: Department of Physics, Brandon University

Abstract
All quantum field theories contain infinite contributions in the form of divergent integrals. In order to obtain physical results, these divergences must be somehow extracted. For weakly interacting systems, a solution to this problem (perturbative renormalization) was discovered in the 1970's. However, many physically interesting systems are not weakly interacting - one example is the study of stellar evolution. Field theories that describe strongly interacting systems are much more complicated. One technique is called n-particle irreducible (nPI) effective theories. Preliminary calculations using these theories have produced some promising results. However, the problem of divergent integrals has never been resolved, except in the simplest (2PI) case. We are studying the 4PI effective theory at 4-loop order. We introduce a method to renormalize using a regulator function at the classical level, and calculating flow equations that translate the n-point functions of the theory between the classical and quantum realms. A tuning procedure is used to enforce the physical properties of the quantum system that is obtained. A complex logical structure is needed to numerically evaluate the resulting system of integro-differential equations. In this talk i will discuss the different components of this structure.

Title Lost Horizons: Formation and Evaporation of Regular CGHS Black Holes

Speaker Shawna Skelton(skelton-s84@webmail.uwinnipeg.ca)

Co-authors Gabor Kunstatter, Department of Physics, University of Winnipeg and Winnipeg Institute for Theoretical Physics, Winnipeg, Manitoba, Canada.

Jonathan Ziprick, Applied Computer Education Department, Red River College, Winnipeg, Manitoba, Canada.

Abstract
We model the evolution of 2 dimensional, spherically symmetric, non-singular black holes. We consider both generalized Callan-Giddings-Harvey-Strominger and Einstein-Lanczos-Lovelock actions, both of which produce coordinate invariant equations of motion. Hawking radiation is accounted for with the Polyakov action. Scalar

fields are solved numerically in a python code. Using the solutions to these fields at each point, the black holes evolution is modelled in light ray coordinates.

Title Switched and Partially Switched Hypercubes and their PST Property

Speaker Xiaohong Zhang(zhangx42@myumanitoba.ca)
Department of Mathematics, University of Manitoba

Co-authors Steve Kirkland (University of Manitoba), Sarah Plosker (Brandon University)

Abstract A graph is said to admit perfect state transfer (PST) if there are two distinct vertices a and b, and a time $t_0 > 0$, such that the information input at vertex a at time $t = 0$ can be transferred to vertex b at time $t = t_0$ perfectly. It is known that all the vertices of hypercubes pair up to exhibit PST at time $t = \pi/2$. In this talk, we introduce a new class of graphs - switched hypercubes, which are cospectral to the hypercubes and can be obtained from hypercubes with Godsil-McKay switching. We will show that exactly half of the vertices of a switched hypercube pair up to exhibit PST. We will also talk about partially switched hypercubes, which still admit PST, but between fewer pair of vertices, as well as about switching systems.

Title Models for Firewall Creation in Massless Scalar Field Theory

Speaker LJ Zhou (zhoul346@myumanitoba.ca)
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Co-authors M. Carrington, Brandon University; G. Kunstatter, University of Winnipeg; J. Louko, University of Nottingham

Abstract

Recently, Brown and Louko (JHEP 1508 (2015) 061) proposed a 1+1 dimensional mechanism for evolving boundary condition that mimic the creation of firewalls, which are thought by some to be needed to resolve the black hole information loss conundrum. We extend this calculation to the more physical case of 3+1 dimensions. In particular, we consider a spherically symmetric scalar field with specifically designed time dependent boundary conditions at the origin. These boundary conditions correspond to the creation at the origin of a point-like source that produces a null energy pulse.

In contrast to what happens in 1+1, the 3+1 dimensional pulse of energy is singular enough to break correlations that happen near the horizon of an evaporating black hole and may provide a viable model for firewalls. The detector response is

finite except in the instantaneous creation limit where the energy density blows up everywhere in the future of the creation event.

Participants

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Gabor Kunstatter
Darian Mclaren
Brett Meggison
Paul Mikula
Chris Phillips
Sarah Plosker
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