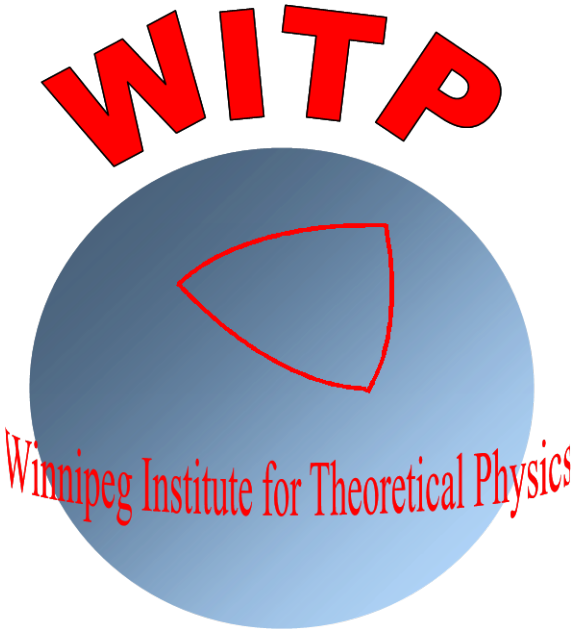
The Winnipeg Institute for Theoretical Physics Annual Report



September 2022 – August 2023

Web site: `http://www2.physics.umanitoba.ca/u/witp/`

Contents

1 General Background

The Winnipeg Institute for Theoretical Physics is a type III research Institute and a joint institute of the Universities of Manitoba and Winnipeg. It 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, colloquia, 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.

2 Governance, Personnel and Affiliations

2.1 Membership

The WITP executive for 2022 consisted of Director Evan McDonough, Winnipeg, Director-Elect Kyle Shiells, Manitoba, and Past-Director Andrew Frey, Winnipeg. The WITP membership is summarized in Table. 1, with a complete list given in Appendix A. The WITP has no advisory board or staff. All the administrative work is done on a volunteer basis by the members of the Institute.

Member Type	Members
Permanent Member	19
Senior Scholars and Emeriti	9
Associate Members	4
Total	32

Table 1: WITP Membership. For a complete list, see Appendix A.

Student Member Program	Members
PhD	15
MSc	7
Undergraduate	21
Total	43

Table 2: WITP student membership.

2.2 Major Affiliations

The WITP is a joint institute of the University of Manitoba and the University of Winnipeg. It is further affiliated with Brandon University, which supports WITP both financially (Sec.6) and via membership (see Appendix A).

2.3 Equity, Diversity, and Inclusion

The WITP is dedicated to principles of Equity, Diversity, and Inclusion, and to the development and implementation of EDI best practices in research.

In 2023 the WITP was a proud sponsor of the Women In Physics Canada conference, July 4-7 2023, University of Manitoba, organized by WITP member Prof. Samar Safi-Harb. The WITP provided funds in the amount of $2500 (allocated pre-COVID) to the conference, and organized a booth at the graduate studies fair, including a graduate student recruitment poster which can be found here: link.

The WITP is committed to amplifying diverse voices and increasing representation in STEM. To actualize this, The WITP organized a public lecture by prominent Black scientist and author Dr. Sylvester James Gates Jr. (poster here: link), detailed in Sec. 3, and a book club and meeting with author and physicist Dr. Katie Mack, on her book *The End of Everything (Astrophysically Speaking)*.

2.4 Truth and Reconciliation

The WITP is committed to Truth and Reconciliation. All WITP events begin with a land acknowledgement, and all WITP members are encouraged to reflect on their role in truth and reconciliation. Going forward, the WITP, through a newly launched outreach initiative, will provide opportunities for for Indigenous youth to engage with and learn about cutting-edge theoretical physics. This works towards the aims of call to action 7 of the Truth and Reconciliation Commission Calls to Action, which discusses "closing the education and employment gap". Activities in 2022-2023 included presentations at high schools in the North-End of Winnipeg. Future steps are discussed in Sec. 5.

3 Research

3.1 Research Transformation

The WITP strives to foster research transformation by creating venues for the exchange of ideas. This is accomplished by 'regular programming' comprised of formal scientific events such as seminars and colloquia and informal events such as lunches, along with annual or semi-annual special events such as a conference or public lecture, and sponsorship of external scientific programs such as conferences. This is summarized in Table. 3.

3.2 Impact on programs and policies

The WITP events summarized in Tab. 3 serve to generate dialogue both between WITP members and with outside experts. This generates new research collaborations and and brings in new students. For example, these events lead to new research collaborations, often in the form of student co-supervision by WITP members, such as a PhD candidate currently co-supervised by A. Frey and M. Carrington. This also generates new research by aiding in the recruitment of new students – one prototypical example is an undergraduate student from Ontario, who attended the WITP Summer School and Student Symposium in August 2023 (poster here: link) where he learned about quantum computation and the research being done by WITP members. In Fall 2024, they will (tentatively) pursue graduate studies in this topic at the University of Manitoba.

The WITP activites also impact programs and policies *outside* of UM, in particular through the program sponsorship activities of Tab. 3. The WITP provided financial support to the annual conference series Women in Physics Canada, allowing it to fund travel of students and speak-

Activity	Date	Title
Regular Programming	Nov. 3, 2022	WITP Colloquium at UW, Speaker: K. Shiells (UM)
	Jan 16, 2022	WITP Colloquium at BU, Speaker: E. McDonough (UW)
	Feb. 10, 2023	WITP "Theoretical Pizza" lunch event at UW
	Mar. 22, 2023	WITP Colloquium at UM, Speaker: M. Carrington (BU)
	Mar. 23, 2023	WITP "Theoretical Pizza" lunch event at UW
	May 29, 2023	WITP Colloquium at UM, Speaker: D. Lorenzoni
	Oct 6, 2023	WITP Colloquium at UM, Speaker: T. Fugleberg (BU)
	Oct 20, 2023	WITP Colloquium at UW, Speaker: N. Steinle (UM)
Special Events	March 23, 2023	Public Lecture by Dr. Sylvester James Gates Jr. (Maryland)
	Aug. 14-16, 2023	WITP Summer School and Student Symposium
	Aug 18, 2023	WITP Book Club with Author Dr. Katie Mack (Perimeter)
Program Sponsorship	June 15-17, 2023	Theory Canada 15, Mt. Allison University
	July 4-7, 2023	Women in Physics Canada Conference, UManitoba
	April 2, 2023	WITP & CAP DTP P.R. Wallace Thesis Prize

Table 3: WITP Research Activities

ers from across the country. The WITP also supports the annual Theory Canada conference, which is an important annual activity for the national community. Finally, in partnership with the Canadian Association of Physicists Division of Theoretical Phyiscs (CAP DTP), the WITP co-sponsors a National PhD thesis prize, to encourage and promote excellence in Canadian theoretical physics research. WITP Past Director is an ex officio member of the thesis competition judging panel.

3.3 Top transformative publication, presentation, or contribution

Amongst the varied activities in Tab. 3, of particular note is the public lecture by prominent Black public intellectual and physicist Dr. Sylvester James Gates Jr, on March 23, 2023, at the University of Winnipeg. Gates spoke about his journey from a segregated high school in the American South, to a physics PhD at MIT, and on to his illustrious career including serving on American President Obama's science advisory council and receiving the National Medal of Science. The talk was well attended, with 218 out of 220 seats reserved in advance. During Gates' visit he also met with WITP students and WITP faculty members, where he discussed both his professional and personal life as a trailblazing theoretical physicist.

3.4 Other Activities: Nothing to report.

4 Training

4.1 Training and Mentorship Activities

Training and mentorship of WITP student members is acheived via both the regular programming and special events of the WITP. Of particular note in 2022-2023 was a 3-day WITP Summer School and Student Symposium, featuring lectures on Machine Learning (Michael Toomey, MIT), Quantum Information and Holography (Alex May, Perimeter Institute), and

Quantum Walks (Hermie Monterde, UM), along with research talks by 16 WITP student members. The event had 55 registered participants.

4.2 Other Profession Development, Continuing Education, and Training Opportunities. Nothing to report.

5 Future Plans

The main initiatives of the coming year as follows:

1. WITP Outreach Initiative: The WITP, with a broad base of members spanning a wide array of topics in theoretical physics, which provides a wealth of possibilities for theoretical physics outreach material. WITP faculty and student members will work together to design and deliver lectures to elementary and high school students, with the aim of providing access and opportunity to under-served and underrepresented groups.

2. WITP Visitor Program: With WITP membership invigorated by an active 2022-2023, in the coming year the WITP will again play an active role in organizing and funding research visitors, such as faculty from across Canada and United States, for both short and extended stays.

6 Finances

The WITP receives $7,000 in funding each year, coming from UM ($3000), UW ($2000), and BU ($2,000). In addition a reserve of funds from COVID era still remains, which amounted to nearly $14,000 budget surplus on Jan 1, 2023, and has been reduced to $9,000 budget surplus on Jan 1, 2024. Details of budget 2022-2023 and the projected budget for 2023-2024 are given in Tab. B.1 and B.2 in Appendix B.

6.1 The past year: September 2022 – August 2023. See Tab. B.1.

6.2 The year ahead: September 2023 – August 2024. See Tab. B.2.

7 Challenges

Going forward, the WITP seeks to create an active visitor program, comprised of short (1-2 day) and long (1 week) stays by researchers from other institutions. Given the limited finances of the WITP, institute will act to *subsidize* visitor expenses, e.g. covering 50% of the expenses up a set maximum. However, this comes at a time when travel expenses (flights, hotel, food) have increased significantly, and graduate student stipends have increased, while both WITP funding and WITP faculty NSERC grants are largely stagnant. Thus creating an active visitor program will require some creative thinking and sharing of financial resources.

Appendix A

Membership

Permanent (Faculty) Members

- M.E. Alexander[2], *Ph.D. (Manchester University, UK)*
- P.G. Blunden[1], *Ph.D. (Queen's)* [Director, 93-94]
- L. Butler[1], *Ph.D. (Queen's)*
- M.E. Carrington[3], *Ph.D. (SUNY, Stony Brook)*
- J. D. Fiege[1], *Ph.D. (McMaster)*
- A.R. Frey[2] *Ph.D. (UCSB)* [Director, 13-14, 19-21]
- T.D. Fugleberg[3], *Ph.D. (UBC)*
- D. Krepski[1], *Ph.D. (Toronto)*
- E. McDonough[2], *Ph.D. (McGill)*
- 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]
- K. Shiells[1], *Ph.D. (University of Manitoba)*
- 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]
- T. Woods[1], *Ph.D. (Max Planck Institute for Astrophysics)*

Senior Scholars and Emeriti

- G. Kunstatter[2], *Ph.D. (Toronto)* [Director, 91-92, 09-12]
- P.D. Loly[1], *Ph.D. (London)* [Director, Fall 99, 00-01]
- C. O'Dea[1], *Ph.D. (Massachusetts)*
- M. Whitmore[1], *Ph.D. (McMaster)*
- 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]

Associate Members

WITP faculty members report a total of 6 postdoctoral fellows supervised. These numbers may not include those whose supervisors did not provide an update for this report.

The following individuals have registered as Associate Members and consented for their information to be published in this report. Supervisors are listed in parentheses.

Postdoctoral Fellows

- A. Chatterjee (Safi-Harb)
- S. Moein (Plosker with N. Johnson, Mt Allison)
- A. Mukherjee (Carrington and Kunstatter)
- R. Alves Pimenta (Sirker)

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

Student Members

The numbers of each class of Student Member are as follows:

- 15 Ph.D. Students
- 7 M.Sc. Students
- 21 Undergraduate Research Students

These numbers may not include those whose supervisors did not provide an update for this report.

The following individuals have registered as Student Members and consented for their information to be published in this report. Supervisors are listed in parentheses.

Graduate Students

- H. Monterde (Plosker)
- R. Begum Popy (Stamps)
- K. Au (Fiege)
- N. Agarwal (Frey)
- C. Duggal (O'Dea)
- B. Meggison (Carrington and Frey)
- V. Arendt (Shalchi)
- M. Singha (O'Dea with S. Baum, Manitoba)
- K. Monkman (Sirker)
- A. Urichuk (Sirker)
- Z. Arif (Shiells)

Undergraduate Students

- P. Singh (Frey)
- G. Payeur (McDonough)
- J. Yang (Frey)
- A. Rossi (McDonough)
- S. Heiland (Safi-Harb)
- B. Man (Safi-Harb)
- I. Sander (Safi-Harb)

- N. Doerksen (Safi-Harb)
- B. Friesen (Carrington)
- J. Elder (Fugleberg)
- T. Friesen (Carrington)

Appendix B

Budget Tables

WITP Expenses for Sept. 2022- Aug. 2023

Budget Item	**Annual Amount**
Summer School and Symposium	$7063
Regular Programming (visitors and colloquia)	$687
Public Lecture	$3213
Conference Support	$1000
DTP/WITP PhD Thesis Prize	$500
Outreach Program	$100
Total Expenses	$12,563

Figure B.1: WITP Expenditures for 2022-2023. The annual funding is $7000, contributed by UM ($3000), UW ($2000), and BU ($2000). A siginificant reserve of funds remains from two years of near-zero spending during covid.

WITP Projected Budget for Sept. 2023 - Aug. 2024

Budget Item	**Annual Amount**
Summer School and Symposium	$2500
Regular Programming (visitors and colloquia)	$2000
Public Lecture (held every three years)	$500
Conference Support	$1000
DTP/WITP PhD Thesis Prize	$500
Outreach Program	$500
Total Expenses	$7000

Figure B.2: WITP Projected Budget for 2023-2024.

Appendix C

Research Interests of Members

M.E. Alexander

My principal research interests are:

Orbital precession in exoplanet systems. (1) (Manuscript submitted to *Monthly Notices of Royal Astronomical Society*: 26 August, 2022; under revision) Collaborating with with Dr. E. Budding (Carter Observatory, Wellington, New Zealand), a theoretical model to explain anomalies in photometric and spectroscopic measurements of exoplanet transits in several systems, using data primarily from the Keplerand TESS missions. The model has been developed to include interaction of the normal mode oscillations of a rotating host star with an orbiting exoplanet, without assuming alignment of the rotation and orbital axes (as has been the case in the literature). Rotational-orbital motion interaction causing resonance effects give rise to significant orbital precession and nutation. The effects, which occur mainly in exoplanetary systems hosted by early-type stars, are at the limit of detectability in the Kepler mission data. In the past 3 years, the much-improved data from TESS has revealed intrinsic oscillations in Upper Main Sequence stars. Modern missions, such as James Webb Space Telescope, will open up these new areas. The spin-orbit interactions in these systems have been shown to be dynamically complex: an analytical model and numerical experiments indicate the resonance-induced orbital precession effects are comparable to "classical" (rotation-distortion induced) precession. The effects of precession on transit time variations have been estimated. Observational data of systems with unaligned rotation and orbital axes are becoming more plentiful and accurate, and the predictions of this paper will soon be within reach of modern exoplanet system measurements. This work is an extension of earlier work, published in 2 papers in *Monthly Notices of the Royal Astronomical Society* (1987, 1988).

(2) **Intrinsic and forced oscillations in Upper Main Sequence binary systems**. In collaboration with Dr. E. Budding (Carter Observatory, Wellington, New Zealand), Dr. J. Southworth (Keele Univ., England) and Dr. T. Banks (Victoria Univ., Wellington, New Zealand), we will analyze *TESS* data on the Upper Main Sequence binary VV Orionis, which shows variations in orbital inclination indicative of short-period precessional motion. There is the possibility of orbital-normal mode resonances which can be investigated using an extension of the model in (1).

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.

L. T. Butler

Research Interest: Hamiltonian mechanics and integrable systems.

Chaos theory traces its origins to Poincaré's groundbreaking discovery that the equations of motion of 3 massive bodies (e.g. the earth, moon and sun) are non-integrable. Most differential equations that a student may encounter are exactly solvable, or integrable, but these are the exception not the rule. Mathematicians study integrable systems because, like precious gems, their rarity bestows value.

The theory of integrability in dynamical systems is loosely analogous to the theory of solvability of polynomial equations by radicals. The purely algebraic aspect is studied using the tools of differential algebra. However, there are also analytical and even topological aspects to the theory. Today, many fundamental questions remain unresolved. For example, it is not known if being algebraically non-integrable implies analytic non-integrability or the existence of chaos. In many cases, the answer is known, but no general theory exists. It is also not known if chaos can co-exist with analytic integrability, although it is known that chaos and smooth integrability do co-exist.

In addition to their intrinsic worth, integrable systems are useful starting places to understand 'near-integrable' systems. With the tools of KAM theory, for example, it is possible to prove that certain models used in molecular dynamics exhibit paradoxical behaviour: when the temperature is increased, the model predicts the material freezes!

M.E. Carrington

My main area of interest is field theory. There are standard techniques for doing field theoretic calculations in systems that are weakly coupled and equilibrated, but these methods are not applicable to many physically interesting situations. I am particlularly interested in the study of quark-gluon plasmas, and strongly coupled condensed matter systems like graphene.

Non-perturbative field theoretic approaches are technically difficult to implement, and often involve issues with renormalizability and gauge invariance. One approach is the use of nPI effective actions which, in principle, can be used arbitrarily far from equilibrium. One of the main thrusts of my research is developing methods to renormalize nPI effective actions. I am also working to understand the gauge dependence of the method in lower dimensional theories.

Systems that are close to equilibrium can be studied using transport theory, which 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 via long wavelength collective modes. The dynamics of quark-gluon plasmas is strongly influenced by imaginary modes, or plasma instabilities, which are not included in traditional formulations of transport theory. Another direction of my research is the development of methods to incorporate the role of plasma instabilities in transport theory.

I am also interested in the glasma phase of the matter produced in heavy ion collisions. This phase is the most difficult to study, and the least well understood of the phases of matter produced in a heavy ion collision. A good understanding of the glasma phase is crucial however, because the glasma provides the initial conditions for the long-lasting hydrodynamically evolving phase that follows. I am working to develop methods to apply the Colour Glass Condensate approach to study the temporal evolution of the glasma phase.

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.

One focus of my research is developing a deeper understanding of models of extra dimensions in string theory that have been discovered in the last 20 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 for modern models of extra dimensions; 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). This is a particularly active area in the literature due to questions about whether de Sitter spacetimes — the basic model for the late-time behavior of our universe — exist in string theory (or any theory of quantum gravity).

A major thread of my research program concerns the AdS/CFT correspondence and its generalizations, which state that a gravitational system (such as string theory) on anti-de Sitter or similar spacetimes is equivalent to a quantum field theory without gravity on the boundary of that spacetime. I currently have an active program understanding how the gravity side of the correspondence represents information theoretic quantities from the quantum field theory. I am especially interested in complexity, which, roughly speaking, measures the difficulty of creating the quantum field theory state, and how it maps to the full higher-dimensional description of AdS/CFT in string theory. I am further interested in developing connections to de Sitter spacetime and string compactifications.

In the recent past, I have also investigated when small amounts of matter in AdS collapse and form a black hole, which relates to non-equilibrium dynamics of strongly coupled gauge theories, and I am still working on related questions. I am interested in strongly coupled theories more generally and am also collaborating with Margaret Carrington on other nonperturbative approaches to these theories.

Finally, I maintain a long-standing interest in uncovering the nature of dark matter, yet-to-be-discovered particles known only by their influence on gravity, particularly phenomenological models to explain anomalies in astroparticle physics.

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

My research interests since retirement in 2018 include:

- Simple models of black formation and evaporation in which the singularity has been eliminated, ostensibly by quantum gravitational effects.
- Einstein gravity with cosmological constant obtained from spontaneous symmetry breaking of conformal symmetry.
- Ring down waveforms and shadows of black holes in the presence of a dark matter spike.
- Isotropization in a scalar model for the gluon plasma (glasma) produced in heavy ion collisions.

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/`

E. McDonough

My research develops the interface of cosmology and high energy physics. Taking input from quantum field theory, supergravity, and string theory, I strive to understand the relation between cosmological observables, such as the cosmic microwave background and large scale structure of the universe, and the underlying fundamental theory.

I have worked extensively on a proposal for the earliest moments of the universe, namely cosmic inflation, wherein the universe underwent a phase of exponential expansion. I am particularly interested in the implications for high energy of an observation or non-observations of primordial gravitational waves, encoded in the polarization of the cosmic microwave background. With Guth and Kaiser (2021) I demonstrated that the observable predictions of one of simplest models of inflation, namely axion inflation, can be significantly modified if the radial counterpart to the axion (itself the phase of a complex scalar) is evolving during inflation. In work with Scalisi (2016) I developed new models of inflation in supergravity, and in work with Kolb and Long (2021) studied the spontaneous emission of gravitinos (the partner to the graviton in supergravity) that occurs in the transition from inflation to standard cosmology. In work with Alexander (2018) we demonstrated that the primordial gravitational wave signal from inflation in string theory can be substantially larger than the naive single-field expectation.

I am very active in the study of dark matter, and in particular "ultra-light" dark matter candidates. These models are characterized by wave-like behavior on astrophysical scales, and phenomena usually associated with condensed matter physics, such as Bose-Einstein condensation, superfluidity, and superconductivity. In papers with Spergel and Alexander (2018 and 2021) we developed ultra-light dark matter as a composite state in non-Abelian gauge theory, and superconductivity in astrophysical environments. This broad class of models can be distinguished from more conventional particle dark matter models (such as WIMP models) in a variety of experimental arenas, ranging from particle colliders to astrophysical observations. In recent work with Cappanelli, Ferreira, and Alexander, we proposed dark matter vortices as an explanation for the coherent rotation of cosmic filaments, some of the largest structures in the universe. I am active in studying new models and new astrophysical phenomena of ultralight dark matter.

Finally, I am active in understanding the apparent disagreement between cosmological data sets that probe differing epochs in the evolution of the universe. The cosmic microwave background allows an inference of the present expansion rate of the universe, namely the Hubble constant, that relies almost exclusively on early universe physics. However the CMB inferred value is in significant disagreement with the measurement using the cosmic distance ladder (winner of the 2011 Nobel prize in physics for the discovery of the accelerated expansion of the

universe) which relies solely on late universe physics. An open question is whether there exists an alternative cosmological model, wherein the CMB inferred value is changed, and brought into agreement with the cosmic distance ladder measurement. In several papers with collaborators I have performed statistical analyses of cosmological data sets to constrain field theory models, and have developed new models motivated by string theory. I am interested in developing new models that take input from fundamental theory, and can explain additional phenomena, such as particle physics anomalies.

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.

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 state transfer, applications of majorization, measures of coherence, and structured eigenvalues/eigenspaces in certain matrix families that arise naturally in quantum information theory.

A. Prymak

Research interests: discrete geometry, convexity, packing and covering in Euclidean spaces, probabilistic methods, approximation theory and geometric methods in analysis, shape-preserving approximation, measures of smoothness and approximation, computational and numerical methods, discretization and optimization, 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: one-variable and multi-variable calculus, power series and analytic functions, measure theory and integration, optimization, existence and uniqueness of solutions of differential equations, complex analysis, and functional analysis over non-Archimedean valued fields. 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 $\mathscr{R}$) is of particular interest; it is shown to be the smallest non-Archimedean ordered field extension of the real numbers that is complete in the topology induced by the order and real closed. In fact, $\mathscr{R}$ 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.

We have studied in my research group two topologies on $\mathscr{R}$: the valuation topology induced by the order on the field, and another weaker topology induced by a family of semi-norms, which we call weak topology. We showed that each of the two topologies results from a metric on $\mathscr{R}$, that the valuation topology is not a vector topology while the weak topology is, and that $\mathscr{R}$ 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.

We studied convergence of sequences and series in both topologies mentioned above, 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 dropped that restriction and showed that power series on the 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, the mean value theorem and the inverse function 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 ordered 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 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 at a point of its domain.

We developed a measure theory and integration on the Levi-Civita field $\mathscr{R}$. We introduced a measure that proved to be a natural generalization of the Lebesgue measure on the field of the real numbers and have similar properties. Then we introduced a family of simple functions from which we obtained a larger family of measurable functions and derived a simple characterization of such functions. We studied the properties of measurable functions, we showed how to integrate them over measurable sets, and we showed that the resulting integral satisfies similar properties to those of the Lebesgue integral of Real Analysis. We generalized the results to two and three dimensions. In particular, we defined a Lebesgue-like measure on $\mathscr{R}^2$ (resp. $\mathscr{R}^3$). Then we defined measurable functions on measurable sets using analytic functions in two (resp. three) variables and showed how to integrate those measurable functions using iterated integration. The resulting double (resp. triple) integral satisfies similar properties to those of the single integral as well as those properties satisfied by the double and triple integrals of real calculus.

Together with my collaborators Jose Aguayo and Miguel Nova from Concepcion (Chile), we developed an operator theory on the Banach space c_0 over $\mathscr{C} := \mathscr{R} + i\mathscr{R}$, where c_0 denotes the space of all null sequences of elements of $\mathscr{C}$. 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. 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, 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 $\mathscr{R}$ is interesting to study in detail for the reasons stated above, I have also expanded my research focus to include any non-Archimedean field extension of the real numbers that is real closed and complete in the topology induced by the order and whose Hahn group is Archimedean; such a field is denoted by F. For example, we studied the properties of weakly locally uniformly differentiable functions at a point or on an open subset of F or F^n and we proved local versions of the intermediate value theorem, the mean value theorem and Taylor's theorem for weakly locally uniformly differentiable functions on F. We also proved the inverse function theorem and implicit function theorem for weakly locally uniformly differentiable functions from F^n to F^n and from F^n to F^m ($m < n$), respectively. Moreover, the work on the topological structure as well as on the integration theory and its applications on the Levi-Civita field $\mathscr{R}$ has recently been extended to the field F.

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.

R. L. Stamps

My interests cover a range of topics in condensed matter physics including linear and nonlinear dynamics of magnetic and ferroelectric nanostructures, frustrated spin systems and glasses, inelastic light scattering and ferromagnetic resonance, spin electronics, and spin dynamics in constrained geometries. Current work falls under three topics: complex networks, artificial magnetic 'spin ice', and cavity magnonics.

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 .

J.G. Williams

My research focusses on a new approach to general relativity due to Ted Newman and his group: the null surface formulation (NSF). In this approach, it is not the metric that plays the primary role but families of null surfaces. These surfaces are specified by a function Z, which depends upon the spacetime variables and an additional parameter that labels the family. If desired, the

usual general relativistic metric can be derived to within a conformal factor. The field equations of the NSF are three in number and the dependent variable can be chosen to be Z itself or, more usually, a derivative of Z, thereby resulting in a reduction in the order of the main (partial) differential equation. This partial differential equation is called the main metricity condition and has proved extremely difficult to solve. It has never been solved in 3+1 dimensions. In recent years, my colleague, Tina Harriott, and I have been able to find the only three currently known solutions of the main metricity condition in 2+1 dimensions. The (2+1)-dimensional NSF is closely related to the early work on differential equations due to Elie Cartan (1938), and so our solutions also represent the first known nontrivial solutions of Cartan's metricity condition. Future work by Tina Harriott and myself will be concerned with the (3+1)-dimensional NSF and also with developing methods to move seamlessly between the NSF and the traditional approaches to general relativity.

T. E. Woods

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Appendix D

Publications of Permanent Members

M.E. Alexander

1. Murray E. Alexander. "Orbital precession in short-period hot Jupiter exoplanet systems" Monthly Notices of the Royal Astronomical Society *Submitted 26 August 2022; under revision*

P.G. Blunden

No update provided for this report

L. T. Butler

1. Butler, L. T. "Invariant tori for multi-dimensional integrable Hamiltonians coupled to a single thermostat" . 2022, Nonlinearity, 35, 4659.

2. Butler, L. T. "Horseshoes and invariant tori in cosmological models with a coupled field and non-zero curvature" . 2020, Classical and Quantum Gravity, 37, 195024.

3. Butler, L. T. "Horseshoes for singly thermostated hamiltonians" . SIAM Journal on Applied Dynamical Systems 19.4 (2020): 2268-2285.

4. Butler, L. T. "Invariant tori for a class of singly thermostated hamiltonians" . Journal of Mathematical Physics 61.8 (2020).

5. Butler, L. T. "Nosé-Thermostated Mechanical Systems on the n-Torus" . Archive for Rational Mechanics and Analysis 2.227 (2018): 855–867

M. E. Carrington

1. Glasma properties in small proper time expansion, Margaret .E. Carrington, Wade N. Cowie, Bryce T. Friesen, Stanisław Mrówczyński and Doug Pickering, Phys. Rev. C 108, 054903 (2023).

2. Results from a CGC and Proper Time Expanded Calculation of Glasma Properties, M.E. Carrington, A. Czajka, St. Mrówczyński, Acta Phys. Polon. Supp. 16, 118 (2023).

3. Phase transitions in 3-dimensional Dirac semi-metals using Schwinger-Dyson equations, Margaret E. Carrington, Wade N. Cowie, Brett A. Meggison, Eur. Phys. J. B96, 130 (2023).

4. The effect of different 3-D QED vertex ansaetze on critical coupling, M. E. Carrington, A. R. Frey, B. A. Meggison, Phys. Rev. D 107, 056012, (2023).

5. Isotropization of a rotating and longitudinally expanding ϕ^4 scalar system, Margaret E. Carrington, Gabor Kunstatter, Christopher Phillips and Marcelo E. Rubio, Entropy 2022, 24(11), 1612.

6. *Phase transitions in anisotropic graphene*, M.E. Carrington, A.R. Frey, B.A. Meggison, Int. Journal Mod. Phys. A 37, 2240018, (2022).

7. *Jet quenching in glasma,* Margaret E. Carrington, Alina Czajka, Stanislaw Mrówczyński Physics Letters B 834, 137464 (2022).

8. *Transport of hard probes through glasma*, Margaret E. Carrington, Alina Czajka, Stanislaw Mrówczyński, Phys. Rev. C 105, 064910 (2022).

9. Physical characteristics of glasma from the earliest stage of relativistic heavy ion collisions, Margaret E. Carrington, Alina Czajka, Stanislaw Mrówczyński, Phys. Rev C. 106, 034904 (2022).

10. "Collective modes in anisotropic plasmas," M. E. Carrington, B. M. Forster and S. Makar, Phys. Rev. C 104, 064908 (2021).

11. "The energy-momentum tensor at the earliest stage of relativistic heavy ion collisions," M. E. Carrington, A. Czajka and St. Mrówczyński, Eur. Phys. J. A58, 5 (2022).

12. "Effect of anisotropy on phase transitions in graphene," M. E. Carrington, A. R. Frey and B. A. Meggison, Phys. Rev. B 102, 125427 (2020).

13. "Heavy Quarks Embedded in Glasma," M. E. Carrington, A. Czajka and St. Mrówczyński, Nucl. Phys. A 1001, 121914 (2020).

14. "The HTL Lagrangian at NLO: the photon case," S. Carignano, M. E. Carrington and J. Soto, Phys. Lett. B 801, 135193 (2020).

15. "The effect of a Chern-Simons term on dynamical gap generation in graphene," M.E. Carrington, Phys Rev B99, 115432 (2019).

16. "A Non-Equilibrium approach To holographic superconductors using gradient flow," P. Mikula, M.E. Carrington, and G. Kunstatter, Phys. Rev. D100, 046004 (2019).

17. "Renormalization of the 4PI effective action using the functional renormalization group," M.E. Carrington, S.A. Friesen, C.D. Phillips and D. Pickering, Phys. Rev. D99, 074002 (2019).

18. "Effective Coupling Constant of Plasmons," M.E. Carrington and St. Mrówczyński, Phys. Rev. D100, 056020 (2019).

19. "Four loop scalar phi4 theory using the functional renormalization group," M.E. Carrington and C.D. Phillips, Universe 5, 9 (2019).

J. Fiege

No update provided for this report

A. R. Frey

Preprints

A. R. Frey, M. P. Grehan and P. Singh, "Holographic complexity of the Klebanov-Strassler background," [arXiv:2311.18804 [hep-th]].

A. R. Frey, R. Mahanta, A. Maharana, F. Muia, F. Quevedo and G. Villa, "String Thermodynamics In and Out of Equilibrium: Boltzmann Equations and Random Walks," [arXiv:2310.11494 [hep-th]].

Conference Proceedings

M. E. Carrington, A. R. Frey and B. A. Meggison, "Phase transitions in anisotropic graphene," Int. J. Mod. Phys. A, doi:10.1142/S0217751X22400188 [arXiv:2206.10111 [cond-mat.mes-hall]], *refereed*.

Refereed Publications

J. Yang and A. R. Frey, "Complexity, scaling, and a phase transition," JHEP **09**, 029 (2023) [arXiv:2307.08229 [hep-th]].

M. E. Carrington, A. R. Frey and B. A. Meggison, "The effect of different 3-D QED vertex ansaetze on critical coupling," Phys. Rev. D **107**, no.5, 056012 (2023) [arXiv:2210.08108 [cond-mat.mes-hall]].

A. R. Frey, R. Mahanta and A. Maharana, "Dark Radiation and the Hagedorn Phase," Phys. Rev. D **105**, no.6, 066007 (2022) doi:10.1103/PhysRevD.105.066007 [arXiv:2108.03317 [hep-th]].

A. R. Frey, M. P. Grehan and M. Srivastava, "Complexity of scalar collapse in anti-de Sitter spacetime," JHEP **12**, 135 (2021) doi:10.1007/JHEP12(2021)135 [arXiv:2110.09630 [hep-th]].

M. E. Carrington, A. R. Frey, and B. A. Meggison, "Effect of anisotropy on phase transitions in graphene," Phys. Rev. B **102**, no.12, 125427 (2020) doi:10.1103/PhysRevB.102.125427 [arXiv:2006.04790 [cond-mat.mes-hall]].

A. R. Frey, "Dirac branes for Dirichlet branes: Supergravity actions," Phys. Rev. D **102**, no.4, 046017 (2020) doi:10.1103/PhysRevD.102.046017 [arXiv:1907.12755 [hep-th]].

B. Cownden, N. Deppe and A. R. Frey, "Phase diagram of stability for massive scalars in anti–de Sitter spacetime," Phys. Rev. D **102**, no.2, 026015 (2020) [arXiv:1711.00454 [hep-th]].

Media Appearances

1. Interview for *PROFile* column, The Uniter (University of Winnipeg newspaper).
2. Comments on the Nobel Prize in Physics 2019, National Post article, Oct 8, 2019.
3. Comments on the Nobel Prize in Physics 2019, Canadian Press article (syndicated throughout Canada), Oct 8, 2019.

Talks

1. "String Thermo*dynamics*," Crete Center for Theoretical Physics, 2023.
2. "Dark Radiation vs Hagedorn Strings," McGill University, 2022.
3. "Holographic Complexity in Gravitational Collapse," Canadian Association of Physicists Congress online, invited speaker, 2021.
4. "Quantum Information for Quantum Gravity for Undergraduates," *Prairie University Physics Seminar Series*, University of Lethbridge & University of Saskatchewan, 2021.
5. "Dirac Branes for Dirichlet Branes," McGill University, 2020
6. "The Winnipeger's Guide to the 2019 Nobel Prize in Physics," public lecture at Fred Douglas Place, Winnipeg, and University of Winnipeg, 2019, Millenium Library, Winnipeg, 2020.
7. "Disentangling Brane & Flux Degrees of Freedom," Perimeter Institute, 2019.
8. "Black Holes: The Ultimate Quantum Computers?" Millenium Library, Winnipeg, 2019.

T. D. Fugleberg

No update provided for this report

D. Krepski

Publications

1. (with J. Watts and S. Wolbert) Sheaves, principal bundles, and Čech cohomology for diffeological spaces, 25 pages. arXiv:2111.01032 (submitted)
2. (with J. Vaughan) Multiplicative vector fields on bundle gerbes, Differential Geometry and its Applications, 84 (2022) 31 pages, DOI: https://doi.org/10.1016/j.difgeo.2022.101931
3. Basic equivariant gerbes on non-simply connected compact simple Lie groups. Journal of Geometry and Physics, 133 (2018), pp. 30-41.

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

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

G. Kunstatter

Refereed Journal Articles:

- Margaret E. Carrington, Gabor Kunstatter, Christopher D. Phillips,
  Marcelo E. Rubio,"Isotropization of a rotating and longitudinally expanding ϕ^4
  scalar system", Entropy 2022, 24, 1612. [arXiv: 2210.05504]

- Ramin G. Daghigh, Gabor Kunstatter, "Spacetime metrics and ringdown waveforms for galactic black holes surrounded by a dark matter spike", ApJ 940 33, 2022 [arXiv:2206.04195].

- Jonathan Ziprick and Gabor Kunstatter, "Quantum mechanics does not allow violation of the pigeon counting principle", Phys. Letts. **A415**, 127642 (2021) [arXiv:2002.01876]

- Ramin G. Daghigh, Michael D. Green, Gabor Kunstatter, "Scalar Perturbations and Stability of a Loop Quantum Corrected Kruskal Black Hole", Phys. Rev. D 103, 084031 (2021) [arXiv:2012.13359]

- Ramin G. Daghigh, Michael D. Green, Jodin C. Morey, Gabor Kunstatter, "Perturbations of a Single-Horizon Regular Black Hole", Phys. Rev. D 102, 104040 2020
  [arXiv:2009.02367]

- J. Ziprick and G. Kunstatter, "Escape from the Quantum Pigeon Conundrum", Physics Letters **A 384** Issue 27, 28 September 2020, 126686 [arXiv:2002.01876].

- P. Mikula, M.E. Carrington, G. Kunstatter,
  "Nonequilibrium approach to holographic superconductors using gradient flow", Phys. Rev. D 100, 046004 (2019) .

- P. Mikula, M.E. Carrington, G. Kunstatter, "Gradient Flow in the Ginzburg-Landau Model of Superconductivity", Phys. Rev. D 100, 046004 (2019) 1. [arXiv:1902.08669]

Books Published:

- S. Das and G. Kunstatter, *Symmetry, Special Relativity and Quantum Mechanics: The Foundations of Physics*,
  385 pages + 150 page solution manual, (Springer, 2020); ISBN 978-3-030-55420-0.

Invited talks at meetings:

- G. Kunstatter, "The Fast and the Furious: special relativity for high school", **Invited**, CAP Congress, Virtual, 2021.

- G. Kunstatter, " Lost Horizons: Regular Black Hole Formation and Evaporation", **Invited**, CAP Congress, SFU June, 2019.

INVITED LECTURES:

- "2020 Nobel Prize in physics: how black holes benefit humankind", University of Winnipeg, November 2020.

- "Lost horizons: formation and evaporation of regular black holes", Bishops University, November 2020.

- "Escape from the quantum pigeon conundrum", University of Mississippi, October, 2020.

- "What can quantum gravity tells us about beginning and end of time?", University of Winnipeg, September, 2019.

- "Lost Horizons: Regular Black Hole Formation and Evaporation", SFU January, 2019.

P.D. Loly

1. Peter Loly, "Integer Square Matrices - The Science," submission to *Notebook Archive*, Wolfram Foundation, `https://www.notebookarchive.org/imfinal30jan2021-nb--2021-02-0j6p1q1/`.

2. Peter D. Loly and Ian D. Cameron, "Frierson's 1907 Parameterization of Compound Magic Squares Extended to Orders 3^l, $l = 1, 2, 3, ...$, with Information Entropy," arXiv:2008.11020 (2020).

E. McDonough

Publications for period 2018-2023: 34 published papers, 37 papers including submitted manuscripts.

2023:

37. E. McDonough, J. C. Hill, M. M. Ivanov, A. La Posta and M. W. Toomey, *Observational constraints on early dark energy*, Invited Review for International Review of Modern Physics D, submitted. [arXiv:2310.19899]. Role: primary author.

36. C. Capanelli, L. Jenks, E. W. Kolb and E. McDonough, *Cosmological Implications of Kalb-Ramond-Like-Particles*, JHEP, submitted. [arXiv:2309.02485]. Role: primary author.

35. S. Alexander, H. Gilmer, T. Manton and E. McDonough, *The π-axion and π-axiverse of dark QCD*, Phys.Rev.D 108 (2023) [arXiv:2304.11176]. Role: primary author.

34. M. Cicoli, M. Licheri, R. Mahanta, E. McDonough, F. G. Pedro and M. Scalisi, *Early Dark Energy in Type IIB String Theory*, *Early Dark Energy in Type IIB String Theory*, JHEP 06 (2023) 052 [arXiv:2303.03414] Role: primary author.

33. W. Qin, S. R. Geller, S. Balaji, E. McDonough and D. I. Kaiser, *Planck Constraints and Gravitational Wave Forecasts for Primordial Black Hole Dark Matter Seeded by Multifield Inflation*, Phys.Rev.D 108 (2023) 4, 043508 [arXiv:2303.02168]. Submitted. Role: primary author.

2022:

32. M. X. Lin, E. McDonough, J. C. Hill and W. Hu, *A Dark Matter Trigger for Early Dark Energy Coincidence*, Phys.Rev.D 107 (2023) 10, 103523, [arXiv:2212.08098]. Submitted. Role: primary author.

31. L. Jenks, K. Koutrolikos, E. McDonough, S. Alexander and S. J. Gates, *Towards A Direct Detection of the Spin of Dark Matter*, Phys.Lett.B 842 (2023) 137956 , [arXiv:2212.07442] Submitted. Role: primary author.

30. E. W. Kolb, A. J. Long, E. McDonough and G. Payeur, *Completely Dark Matter from Rapid-Turn Multifield Inflation*, JHEP 02 (2023) 181 [arXiv:2211.14323].

29. E. McDonough and M. Scalisi, *Towards Early Dark Energy in String Theory*. JHEP 06 (2023) 052 [arXiv:2209.00011]. Role: primary author.

28. A. Maleknejad and E. McDonough, *Ultra-Light Pion (ULP) and Baryon WIMPzilla Dark Matter*. Phys.Rev.D 106 (2022) 9, 095011 [arXiv:2205.12983]. Role: primary author.

27. S. Geller, W. Qin. E. McDonough, and D. I. Kaiser, *Primordial Black Holes from Multifield Inflation with Nonminimal Couplings*. Phys.Rev.D 106 (2022) 6, 063535 [arXiv:2205.04471]. Role: primary author.

2021:

26. E. McDonough, M. X. Lin, J. C. Hill, W. Hu and S. Zhou, *The Early Dark Sector, the Hubble Tension, and the Swampland*. Phys.Rev.D 106 (2022) 4, 043525 [arXiv:2112.09128]. Role: primary author.

25. S. Alexander, C. Capanelli, E. G. M. Ferreira, and E. McDonough, *Cosmic Filament Spin from Dark Matter Vortices*. Phys.Lett.B 833 (2022) 137298 [arXiv:2111.03061]. Role: primary author.

24. K. Inomata, E. McDonough and W. Hu, *Amplification of Primordial Perturbations from the Rise or Fall of the Inflaton*. JCAP 02 (2022) 02, 031 [arXiv:2110.14641]. Role: primary author.

23. K. Inomata, E. McDonough, and W. Hu, *Primordial Black Holes Arise When The Inflaton Falls*. Phys.Rev.D 104 (2021) 12, 123553. [arXiv:2104.03972]. Role: primary author.

22. E. W. Kolb, A. J. Long and E. Mcdonough, *The Gravitino Swampland Conjecture*. Phys. Rev. Lett. 127 (2021) 13, 131603 [arXiv:2103.10437]. Role: primary author.

21. E. W. Kolb, A. J. Long, and E. McDonough, *Catastrophic Production of Slow Gravitinos*. Phys. Rev. D 104 (2021) 7 [arXiv:2102.10113]. Role: primary author.

2020:

20. S. Alexander, E. McDonough, and David N. Spergel, *Strongly-Interacting Ultralight Millicharged Particles*. Phys. Lett. B, 822, 2021, 136653. [arXiv:2011.06589]. Role: primary author.

19. S. Alexander, L. Jenks and E. McDonough, *Higher Spin Dark Matter*. Phys. Lett. B 819, 2021,136436. [arXiv:2010.15125]. Role: primary author.

18. E. McDonough, A. H. Guth, D. I. Kaiser, *Nonminimal Couplings and the Forgotten Field of Axion Inflation*. Preprint available at [arXiv:2010.04179]. Role: primary author.

17. M. M. Ivanov, E. McDonough, J. C. Hill, M. Simonović, M. W. Toomey, S. Alexander, and M. Zaldarriaga, *Constraining Early Dark Energy with Large-Scale Structure*. Phys. Rev. D 102 (2020) 103502 . [arXiv:2006.11235]. Role: primary author.

16. J. C. Hill, E. McDonough, M. W. Toomey and S. Alexander, *Early Dark Energy Does Not Restore Cosmological Concordance*. Editors suggestion, Phys. Rev. D 102 (2020) 4, 043507 . [arXiv:2003.07355]. Role: primary author.

15. S. Alexander, G. Herczeg, J. Liu and E. McDonough, *Chiral Symmetry and the Cosmological Constant*. Phys. Rev. D 102 (2020) 8, 083526. [arXiv:2003.08416]. Role: primary author.

14. E. McDonough, *The Cosmological Heavy Ion Collider: Fast Thermalization after Cosmic Inflation*. Phys. Lett. B 809 (2020) 135755. [arXiv:2001.03633]. Role: primary author.

2019:

13. S. Alexander, E. McDonough, A. Pullen and B. Shapiro, *Physics Beyond The Standard Model with Circular Polarization in the CMB and CMB-21cm Cross-Correlation*. JCAP **2001**, no. 01, 032 (2020) [arXiv:1911.01418]. Role: primary author.

12. S. Alexander, S. Gleyzer, E. McDonough, M. W. Toomey and E. Usai, *Deep Learning the Morphology of Dark Matter Substructure*. Ap. J. 15 **893** (2020) [arXiv:1909.07346].

11. S. Alexander, S. J. Gates Jr. , L. Jenks, K. Koutrolikos, and E. McDonough, *Higher Spin Supersymmetry at the Cosmological Collider: Sculpting SUSY Rilles in the CMB*. JHEP **1910**, 156 (2019) [arXiv:1907.05829]. Role: primary author.

10. S. Alexander and E. McDonough, *Axion-Dilaton Destabilization and the Hubble Tension*. Phys. Lett. B797 (2019) [arXiv:1904.08912]. Role: primary author.

9. R. Kallosh, A. Linde, E. McDonough, and M. Scalisi, *dS vacua and the Swampland*. JHEP 1903 (2019) 134 [arXiv:1901.02022]. Role: primary author.

8. S. Alexander, J. Bramburger, and E. McDonough, *Dark Disk Substructure and Superfluid Dark Matter*. Phys. Lett. B797 (2019) [arXiv:1901.03694]. Role: primary author.

2018:

7. S. Alexander and E. McDonough, *Primordial Circular Polarization in the Cosmic Microwave Background*. Phys. Lett. B 0370 (2018) 2693 [arXiv:1811.05953]. Role: primary author.

6. R. Kallosh, A. Linde, E. McDonough and M. Scalisi, *4d models of dS uplift in KKLT*. Phys.Rev. D99 (2019) no.4, 046006 [arXiv:1809.09018]. Role: primary author.

5. S. Alexander, E. McDonough, R. Sims and N. Yunes, *Hidden-Sector Modifications to Gravitational Waves From Binary Inspirals*, Class. Quant. Grav. 35, no. 23, 235012 (2018) [arXiv:1808.05286]. Role: primary author.

4. R. Kallosh, A. Linde, E. McDonough and M. Scalisi, *de Sitter Vacua with a Nilpotent Superfield*. Fortschr. Phys. 2018, 1800068 [arXiv:1808.09428]. Role: primary author.

3. K. Dasgupta, M. Emelin, E. McDonough, and R. Tatar, *Quantum Corrections and the de Sitter Swampland Conjecture*. JHEP **1901**, 145 (2019) [arXiv:1808.07498]. Role: primary author.

2. S. Alexander and E. McDonough, *Observable Chiral Gravitational Waves from Inflation in String Theory*. JCAP 1811, no. 11, 030 (2018) [arXiv:1806.05684]. Role: primary author.

1. S. Alexander, E. McDonough, and D. N. Spergel, *Chiral Gravitational Waves and Baryon Superfluid Dark Matter*, JCAP 1805, no. 05, 003 (2018) [arXiv:1801.07255]. Role: primary author.

Peer Reviewed Conferences and Workshops

Recordings of selected talks, at Stanford University, at the Institute for Advanced Study, and at the Perimeter Institute, can be found on my website here: www.evanmcdonoughphysics.com .

Peer Reviewed contributions from 2018-2023:

46. Invited colloquium speaker, Prairie University Physics Speaker Series (PUPSS), University of Regina, *Cosmological Condensed Matter Physics*, Feb 10, 2023.

45. Invited colloquium speaker, Prairie University Physics Speaker Series (PUPSS), University of Saskatoon, *Cosmological Condensed Matter Physics*, Feb 9, 2023.

44. WITP Colloquium, Brandon University, January 16, *Cosmological Condensed Matter Physics*, Feb 9, 2023.

43. Invited colloquium speaker at the University of Manitoba, *Ultralight Dark Matter and Cosmological Condensed Matter Physics*, November 25, 2022.

42. Invited colloquium speaker at the University of North Dakota, *Ultralight Dark Matter and Cosmological Condensed Matter Physics*, October 28, 2022.

41. Invited talk at McGill University, *Ultralight Dark Matter from A(LPs) to U(LPs)*, October 12, 2022.

40. Keynote talk at Canadian Association of Physicists (CAP) Congress 2022, McMaster University, Hamilton ON. *Ultralight Dark Matter and Cosmological Condensed Matter Physics*, June 9, 2022.

39. Invited talk at the Institute for Advanced Study, Princeton, NJ, *Ultralight Dark Matter and Cosmological Condensed Matter Physics*, April 21st, 2022.

38. Invited talk at the University of Calgary, *The Light and Fuzzy Side of Dark Matter*, February 17th, 2022.

37. Invited talk at the University of Lethbridge, *The Light and Fuzzy Side of Dark Matter*, February 1st, 2022.

36. Invited talk at CITA National Jamboree, *Strongly Interacting Millicharged Particles*, October 8th, 2021.

35. Invited talk at Peebles Symposium, Canadian Association of Physicists Congress 2021, *New Directions for Dark Matter*, June 8th, 2021.

34. Invited talk at Stanford, *Catastrophic Production of Slow Gravitinos*. May 14, 2021.

33. Invited talk at CERN, *Catastrophic Production of Slow Gravitinos*. May 12, 2021.

32. Invited talk at Ben Gurion University, *Catastrophic Production of Slow Gravitinos*. May 10, 2021.

31. Invited talk at McGill University, *The Gravitino Swampland Conjecture*. Apr. 26, 2021.

30. Invited talk at University of Illinois at Urbana-Champagne, *Catastrophic Production of Slow Gravitinos*. Apr. 23, 2021.

29. Invited talk at String Pheno Webinar, *The Gravitino Swampland Conjecture*. Apr. 13, 2021.

28. Invited talk at the University of Chicago, Kadanoff Center for Theoretical Physics, *The Gravitino Swampland Conjecture*. Apr. 7, 2021.

27. Invited talk at Queen's University, *Constraining Early Dark Energy with Large Scale Structure*. Mar. 16, 2021.

26. Invited talk at Higher Spin Gravity Webinar, *Higher Spin Dark Matter*. Mar. 2, 2021.

25. Invited talk at the Perimeter Institute for Theoretical Physics, *Constraining Early Dark Energy with Large Scale Structure*. Feb. 16, 2021.

24. Invited talk at the University of New Brunswick, *Higher Spin Dark Matter*. Feb. 9, 2021.

23. Invited talk at Newton 1665 seminar, *STUMP Dark Matter*. Jan. 26, 2021.

22. Invited talk at the Massachusetts Institute of Technology, Joint MIT/Tufts cosmology seminar, *Constraining Early Dark Energy with Large Scale Structure*. Oct. 20, 2020.

21. Invited talk at MPA Garching, *Constraining Early Dark Energy with Large Scale Structure*. Oct. 20, 2020.

20. Invited talk at PACMAN (Particle Astro/Cosmo Meeting Around NYC) seminar, *Ultralight Fermionic Dark Matter: Halo Cores as Dark Neutron Stars*. Oct. 13, 2020.

19. Invited talk at Copernicus Webinar Series, *Constraining Early Dark Energy with Large Scale Structure*. July 23, 2020.

18. Invited talk at the Theoretical Cosmology, Gravity and Fields Workshop, Dartmouth College. *Constraining Early Dark Energy with Large Scale Structure*. July 21, 2020.

17. Invited talk at University of Illinois Urbana-Champaign, *Gravitational Lamp Posts for Dark Matter Physics*. Dec. 6, 2019.

16. Invited talk at Northeastern University, *The Chirality of Primordial Gravitational Waves*. Sept. 30, 2019.

15. Invited talk at Theory Canada 14, *New (Old) Gravitational Probes of Dark Matter*. May 31, 2019.

14. Invited Lecture at Atlantic General Relativity 2019, *Primordial Cosmology and High Energy Physics*. May 27, 2019.

13. Seminar at the Flatiron Institute, Center for Computational Astrophysics, *Strong Gravity Probes of Dark Matter*. May 1, 2019

12. Seminar at the ETH Zurich, *The Chirality of Primordial Gravitational Waves*. March 22, 2019

11. Seminar at the Max Planck Institute for Astrophysics (MPA) Garching, *The Chirality of Primordial Gravitational Waves*. March 19, 2019

10. Seminar at the Syracuse University, *The Chirality of Primordial Gravitational Waves*, Dec 11, 2018.

9. Seminar at the Massachusetts Institute of Technology, *The Chirality of Primordial Gravitational Waves*, Dec 11, 2018.

8. Invited Speaker at Canadian Association of Physicists (CAP) Congress 2018, June 11-15, 2018. Dalhousie University, Halifax, Nova Scotia.

7. Session Chair and contributed talk at the Theory Canada 13, June 7-9, 2018. St. Francis Xiavier University, Antigonish, Nova Scotia.

6. Invited speaker at conference New England Cosmology Workshop, October 13-14, 2018. Massachusetts Institute of Technology.

5. Seminar at the Dartmouth College, *Chiral Gravitational Waves and Baryon Superfluid Dark Matter*, May 2, 2018.

4. Seminar at the University of Pennsylvania, *Chiral Gravitational Waves and Baryon Superfluid Dark Matter*, April 26, 2018.

3. Seminar at the New York University, *Chiral Gravitational Waves and Baryon Superfluid Dark Matter*, April 17, 2018.

2. Seminar at the Institute for Advance Study, Princeton, *Chiral Gravitational Waves and Baryon Superfluid Dark Matter*, March 12, 2018.

1. Seminar at Harvard University, Dvorkin-Finkbeiner-Kovacs journal club, *Chiral Gravitational Waves and Baryon Superfluid Dark Matter*, February 20, 2018.

C. O'Dea

Refereed Articles

1. G. Rocha, R. Keskitalo, B. Partridge, A. Marscher, **C. O'Dea**, T. J. Pearson, K. M. Górski, "Polarization and variability of compact sources measured in Planck time-ordered data," *Astronomy & Astrophysics*, 669, A92-A109 (2023)

2. N. Winkel, B. Husemann, M. Singha*, V. N. Bennert, F. Combes, T. A. Davis, M. Gaspari, K. Jahnke, R. McElroy, **C. P. O'Dea**, M. A. Pérez-Torres, "The Close AGN Reference Survey (CARS). A parsec scale multi-phase outflow in the super-Eddington NLS1 Mrk 1044," *Astronomy & Astrophysics*, 670, A3-A20 (2023)

3. A. Capetti, B. Balmaverde, R.D. Baldi, S. Baum, M. Chiaberge, P. Grandi, A. Marconi, **C. O'Dea**, G. Venturi, "The MURALES survey. VII. Optical spectral properties of the nuclei of 3C radio sources at $0.3 < z < 0.82$," *Astronomy & Astrophysics*, 671, A32-A48 (2023)

4. Y. A. Gordon, **C. P. O'Dea**, S. A. Baum, K. Bechtol, C. Duggal*, Peter S. Ferguson, "Compact Steep Spectrum Radio Sources with Enhanced Star Formation are Smaller than 10 kpc," *The Astrophysical Journal Letters*, 948, L9-16 (2023)

5. **C. P. O'Dea**, S. A. Baum, "Wide-Angle-Tail (WAT) Radio Sources," *Galaxies*, 11, 67 (2023)

6. J. C. S. Pierce, C. Tadhunter, C. Ramos Almeida, P. Bessiere, J. V. Heaton, S. L. Ellison, G. Speranza, Y. Gordon, **C. O'Dea**, L. Grimmett, L. Makrygianni, "Galaxy interactions are the dominant trigger for local type 2 quasars," *Monthly Notices of the Royal Astronomical Society*, 522, 1736-1751 (2023)

7. M. Singha*, **C. O'Dea**, S. A. Baum, "What Drives the Ionized Gas Outflows in Radio-Quiet AGN?" *Galaxies*, 11, 85 (2023)

8. M. M. Boyce, A. M. Hopkins, S. Riggi, L. Rudnick, M. Ramsay, C. L. Hale, J. Marvil, M. Whiting, P. Venkataraman, **C. P. O'Dea**, S. A. Baum, Y. A. Gordon, A. N. Vantyghem, M. Dionyssiou, H. Andernach, J. D. Collier, J. English, B. S. Koribalski, D. Leahy, M. J. Michałowski, S. Safi-Harb, M. Vaccari, E. Alexander, M. Cowley, A. D. Kapinska, A. S. G. Robotham, H. Tang, "Hydra II: Characterisation of Aegean, Caesar, ProFound, PyBDSF, and Selavy source finders," *Publications of the Astronomical Society of Australia*, 40, e027 (2023)

9. M. M. Boyce, A. M. Hopkins, S. Riggi, L. Rudnick, M. Ramsay, C. L. Hale, J. Marvil, M. Whiting, P. Venkataraman, **C. P. O'Dea**, S. A. Baum, Y. A. Gordon, A. N. Vantyghem, M. Dionyssiou, H. Andernach, J. D. Collier, J. English, B. S. Koribalski, D. Leahy, M. J. Michałowski, S. Safi-Harb, M. Vaccari, E. Alexander, M. Cowley, A. D. Kapinska, A. S. G. Robotham, H. Tang, "Hydra I: An extensible multi-source-finder comparison and cataloguing tool," *Publications of the Astronomical Society of Australia*, 40, e028 (2023)

10. Y. A. Gordon, L. Rudnick, H. Andernach, L. K. Morabito, **C. P. O'Dea**, K-M. Achong, S. A. Baum, C. Bayona-Figueroa, E. J. Hooper, B. Mingo, M. E. Morris, A. N. Vantyghem, "A Quick Look at the 3GHz Radio Sky. II. Hunting for DRAGNs in the VLA Sky Survey," *The Astrophysical Journal Supplements*, 267, 37- 61 (2023)

11. M. Singha**, N. Winkel, S. Vaddi, M. Pérez-Torres, M. Gaspari, I. Smirnova-Pinchukova, **C. P. O'Dea**, F. Combes, O. Omoruyi, T. Rose, R. McElroy, B. Husemann, T. A. Davis, S. A. Baum, C. Lawlor-Forsyth**, J. Neumann, G. R. Tremblay, "The Close AGN Reference Survey (CARS): An Interplay between Radio Jets and AGN Radiation in the Radio-quiet AGN HE0040-1105," *The Astrophysical Journal*, 959, 107-127 (2023)

12. A. Capetti, B. Balmaverde, C. Tadhunter, A. Marconi, G. Venturi, M. Chiaberge, R.D. Baldi, S. Baum, R. Gilli, P. Grandi, E. T. Meyer, G. Miley, **C. ODea**, W. Sparks, E. Torresi, and G. Tremblay, "The MURALES survey. V. Jet-induced star formation in 3C 277.3 (Coma A)," *Astronomy & Astrophysics*, 657, A114 (2022)

13. R. Timmerman, R. J. van Weeren, J. R. Callingham, W. D. Cotton, R. Perley, L. K. Morabito, N. A. B. Gizani, A. H. Bridle, **C. P. O'Dea**, S. A. Baum, G. R. Tremblay, P. Kharb, N. E. Kassim, H. J. A. Röttgering, A. Botteon, F. Sweijen, C. Tasse, M. Brüggen, J. Moldon, T. Shimwell, and G. Brunetti, "Origin of the ring structures in Hercules A. Sub-arcsecond 144 MHz to 7 GHz observations," *Astronomy & Astrophysics*, 685, A5 (2022)

14. S. O'Neill, S. Kiehlmann, A. C. S. Readhead, M. F. Aller, R. D. Blandford, I. Liodakis, M. L. Lister, P. Mróz, **C. P. O'Dea**, T. J. Pearson, V. Ravi, M. Vallisneri, K. A. Cleary, M.

J. Graham, K. J. B. Grainge, M. W. Hodges, T. Hovatta, A. Lähteenmäki, J. W. Lamb, T. J. W. Lazio, W. Max-Moerbeck, V. Pavlidou, T. A. Prince, R. A. Reeves, M. Tornikoski, P. Vergara de la Para, J. A. Zensus, "The Unanticipated Phenomenology of the Blazar PKS 2131-021: A Unique Supermassive Black Hole Binary Candidate," *Astrophysical Journal Letters*, 926, L35-56 (2022)

15. J. C. S. Pierce, C. N. Tadhunter, Y. Gordon, C. Ramos Almeida, S. L. Ellison, **C. O'Dea**, L. Grimmett, L. Makrygianni, P. S. Bessiere, P. Doña Girón, "Do AGN triggering mechanisms vary with radio power? - II. The importance of mergers as a function of radio power and optical luminosity," *Monthly Notices of the Royal Astronomical Society*, 510, 1163-1183 (2022)

16. M. Singha, B.Husemann, T. Urrutia, **C. P. O'Dea**, J. Scharwächter, M. Gaspari, F. Combes, R. Nevin, B. A. Terrazas, M. Pérez-Torres, T. Rose, T. A. Davis, G. R. Tremblay, J. Neumann, I. Smirnova-Pinchukova, S. A. Baum, "The Close AGN Reference Survey (CARS). Locating the [O III] wing component in luminous local Type 1 AGN," *Astronomy & Astrophysics*, 659, A123 (2022)

17. B. Husemann, M. Singha, J. Scharwächter, R. McElroy, J. Neumann, I. Smirnova-Pinchukova, T. Urrutia, S. A. Baum, V. N. Bennert, F. Combes, S. M. Croom, T. A Davis, Y. Fournier, A. Galkin, M. Gaspari, H. Enke, M. Krumpe, **C. P. O'Dea**, M. Pérez-Torres, T. Rose, G. R. Tremblay, C. J. Walcher, "The Close AGN Reference Survey (CARS). IFU survey data and the BH mass dependence of long-term AGN variability," *Astronomy & Astrophysics*, 659, A124 (2022)

18. I. Smirnova-Pinchukova, B. Husemann, T. A. Davis, C. M. A. Smith, M. Singha, G. R. Tremblay, R. S. Klessen, M. Powell, T. Connor, S. A. Baum, F. Combes, S. M. Croom, M. Gaspari, J. Neumann, **C. P. O'Dea**, M. Pérez-Torres, D. J. Rosario, T. Rose, J. Scharwächter, N. Winkel, "The Close AGN Reference Survey (CARS). No obvious signature of AGN feedback on star formation, but subtle trends," *Astronomy & Astrophysics*, 659, A125 (2022)

19. B. Balmaverde, A. Capetti, R.D. Baldi, S. Baum, M. Chiaberge, R. Gilli, A. Jimenez-Gallardo, A. Marconi, F. Massaro, E. Meyer, **C. O'Dea**, G. Speranza, E. Torresi, G, Venturi, "The MURALES survey. VI. Properties and origin of the extended line emission structures in radio galaxies," *Astronomy & Astrophysics*, 662, A23 (2022)

20. T. Morishita, M. Chiaberge, B. Hilbert, E. Lambrides, L. Blecha, S. Baum, S. Bianchi, A. Capetti, G. Castignani, F. D. Macchetto, G. K. Miley, **C. P. O'Dea**, C. A. Norman, "The Host Galaxy of the Recoiling Black Hole Candidate in 3C 186: An Old Major Merger Remnant at the Center of a $z = 1$ Cluster," *The Astrophysical Journal*, 931, 165-176 (2022)

21. N. Winkel, B. Husemann, T. A. Davis, I. Smirnova-Pinchukova, V. N. Bennert, F. Combes, M. Gaspari, K. Jahnke, J. Neumann, **C. P. O'Dea**, M. Pérez-Torres, M. Singha, G. R. Tremblay, H. W. Rix, "The Close AGN Reference Survey (CARS). Tracing the circumnuclear star formation in the super-Eddington NLS1 Mrk 1044," *Astronomy & Astrophysics*, 663, A104 (2022)

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A. ZuHone "A Galaxy-Scale Fountain of Cold Molecular Gas Pumped by a Black Hole," Astrophysical Journal, 865, 13 - 37 (2018)

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S. Plosker

Peer-Reviewed Journal Articles

1. S. Kirkland, H. Monterde*, and S. Plosker, *Quantum state transfer between twins in graphs*, Journal of Algebraic Combinatorics, **58**, pp. 623–649, 2023.

2. N. Johnston, S. Moein*, R. Pereira, and S. Plosker, *Absolutely k-Incoherent Quantum States and Spectral Inequalities for Factor Width of a Matrix*, Physical Review A, **106**, 052417, 2022.

3. N. Johnston, S. Moein*, R. Pereira, and S. Plosker, *Birkhoff–James Orthogonality in the Trace Norm, with Applications to Quantum Resource Theories*, Electronic Journal of Linear Algebra, **38**, pp. 760-776 2022.

4. L. Cao, D. McLaren*, S. Plosker, *The Complete Positivity of Symmetric Tridiagonal and Pentadiagonal Matrices*, Special Matrices, **11** (1), 2022.

5. S. Plosker and C. Ramsey*. *Bistochastic operators and quantum random variables*, New York Journal of Mathematics, **28**, pp. 580-609, 2022.

6. D. Farenick, O. Ojo*, and S. Plosker, *Universality of Weyl Unitaries*, Linear Algebra and its Applications, **634**, pp. 57–76, 2022.

7. D. Farenick, F. Huntinghawk*, A. Masanika*, and S. Plosker, *Complete order equivalence of spin unitaries*, Linear Algebra and its Applications, **610**, pp. 1-28, 2020.

8. A. Chan, S. Fallat, J.C.-H. Lin, S. Kirkland, S. Nasserasr, and S. Plosker. *Complex Hadamard diagonalisable graphs*, Linear Algebra and its Applications, **605**, pp. 158-179, 2020.

9. P. Ganesan, L. Gao, S. Pandey, and S. Plosker, *Quantum majorization on semifinite von Neumann algebras*, Journal of Functional Analysis, 108650, 2020.

10. L. Cao, D. McLaren*, and S. Plosker, *Centrosymmetric stochastic matrices*, Linear and Multilinear Algebra, pp. 1-16, 2020.

11. D. McLaren*, S. Plosker, and C. Ramsey*. *On operator valued measures*, Houston Journal of Mathematics, **46**(1), pp. 201-226, 2020.

12. M. Adm, S. Fallat, K. Meagher, S. Nasserasr, S. Plosker, and B. Yang. *Achievable multiplicity partitions in the inverse eigenvalue problem of a graph*, Special Matrices (special issue dedicated to Charlie Johnson), **7**, pp. 276-290, 2019. Received *Editor's Choice* recognition.

13. S. Kirkland, S. Plosker, and X. Zhang*. *Switching and partially switching the hypercube while maintaining perfect state transfer*, Quantum Information and Computation, **19**, no. 7& 8, pp. 0541-0554, 2019.

14. S. Moein*, R. Pereira, and S. Plosker. *A simplified and unified generalization of some majorization results*, Journal of Mathematical Analysis and Applications, **478**, pp. 1049-1058, 2019.

15. S. Plosker and C. Ramsey*. *An operator-valued Lyapunov theorem*, Journal of Mathematical Analysis and Applications, **469**, pp. 117–125, 2019.

Peer-Reviewed Conference Proceedings

16. K. Tanner, S. Plosker, and G. Srivastava. *A Reflection on Cybersecurity Indigenous Educational Experiences*, Institute of Electrical and Electronics Engineers (IEEE) International Conference on Big Data, 2023

17. S. Plosker, and G. Srivastava. *Cybersecurity Education in Rural Indigenous Canada*, IEEE Canadian Conference of Electrical and Computer Engineering (CCECE) 2021

18. F. Huntinghawk*, C. Richard*, S. Plosker, and G. Srivastava. *Expanding Cybersecurity Knowledge Through an Indigenous Lens: A First Look*, IEEE Canadian Conference of Electrical and Computer Engineering (CCECE) 2020.

Invited Lectures

19. *Operator Algebras and Quantum Information Theory*, Culminating Workshop presentation, Groundwork for Operator Algebras Lecture Series (GOALS); GOALS aims to increase participation and retention in the field by persons from traditionally underrepresented groups, July 25, 2021.

20. *Operator-valued functions that are integrable against a positive, operator-valued measure*, Operator Algebras and Applications Session, *Quantum theoretic aspects of spin unitary matrices*, Quantum Information Theory Session, CMS Summer Meeting (virtual), June 7-14, 2021

21. *Bistochastic operators and quantum random variables*, The 49th Canadian Operator Symposium (COSy) (virtual), May 31-June 4, 2021.

22. *Centrosymmetric Stochastic Matrices*, SIAM Conference on Applied Linear Algebra (virtual), May 17-21, 2021.

23. *Centrosymmetric Stochastic Matrices*, Waterloo Algebraic Graph Theory Seminar Series (virtual), Mar. 22, 2021.

24. *Centrosymmetric Stochastic Matrices*, Matrix Seminar Series, University of Nevada, Reno (virtual), Mar. 1, 2021.

25. *Indigenous beadwork in a mathematics classroom*, Geometry: Education, Art, and Research (GEAR), Banff International Research Station, (virtual), Feb. 19-21, 2021.

26. *Complete order equivalence of spin unitaries*, special session on Advances in Operator Algebras, Joint Mathematics Meetings (JMM), Washington, D.C. (virtual), Jan. 6-9, 2021.

27. Six invited talks at national and international conferences cancelled due to COVID-19, Summer 2020.

28. *Quantum information on complex Hadamard diagonalizable graphs*, Quantum Information on Graphs Session, *Beadwork as a method of teaching linear algebra*, The Art of Mathematics Session, CMS Summer Meeting, Toronto, ON, Dec. 6-9, 2019.

29. *How superpositioned is my quantum state?*, Science Seminar Series, Brandon University, Oct. 31, 2019.

30. *The robustness of* **k***-coherence and* **k***-entanglement*, Algebraic and Statistical ways into Quantum Resource Theories Workshop, Banff International Research Station for Mathematical Innovation and Discovery (BIRS), Banff, AB, July 21-26, 2019.

31. *Schur multipliers and mixed unitary maps*, Invited Minisymposium: Linear Algebra and Quantum Information Science, International Linear Algebra Society (ILAS) Meeting Rio, Brazil, July 8-12, 2019.

32. *The robustness of k-coherence*, The Mathematics behind Quantum Information Science Session, CMS Summer Meeting, Regina, SK, June 7-10, 2019.

33. *Quantum majorization via operator space duality*, 47th Canadian Operator Symposium, University of Regina, Regina, SK, June 3-7, 2019.

34. *Finding the "closest" diagonal state to an arbitrary quantum state*, Special Session on Combinatorial Matrix Theory, American Mathematical Society Sectional Meeting, Auburn University, Auburn, AL, Mar. 15-17, 2019.

35. *On operator-valued measures*, Math dept. research seminar, Texas A&M University, Feb. 2, 2019.

Contributed Talks

1. *Universality of Weyl Unitaries*, Great Plains Operator Theory Symposium (GPOTS) (virtual), May 10-14, 2021

A. Prymak

1. A. Prymak, J. Singh, *Whitney-type estimates for convex functions*, pre-print.
`http://arxiv.org/abs/2311.00912`

2. A. Arman, A. Bondarenko, A. Prymak, *Convex bodies of constant width with exponential illumination number*, pre-print.
`http://arxiv.org/abs/2304.10418`

3. F. Dai, A. Kroó, A. Prymak, *On Bernstein- and Marcinkiewicz-type inequalities on multivariate C^α-domains*, pre-print.
`http://arxiv.org/abs/2204.02349`

4. A. Arman, A. Bondarenko, A. Prymak, D. Radchenko, *Upper bounds on chromatic number of $\mathbb{E}^n$ in low dimensions*, pre-print.
`http://arxiv.org/abs/2112.13438`

5. F. Dai, A. Prymak, *Polynomial approximation on C^2-domains*, Constructive Approximation, published online Oct. 21, 2023.
`http://arxiv.org/abs/2206.01544`

6. F. Dai, A. Prymak, A. Shadrin, V. Temlyakov, S. Tikhonov, *On cardinality of the lower sets and universal discretization*, J. of Complexity, J. of Complexity, **76** (2023), 101726.
`http://arxiv.org/abs/2208.02113`

7. F. Dai, A. Prymak, *Optimal polynomial meshes exist on any multivariate convex domain*, Found. Comp. Math., published online Jan. 23 2023.
`http://arxiv.org/abs/2205.14111`

8. A. Prymak, *A new bound for Hadwiger's covering problem in $\mathbb{E}^3$*, SIAM J. Discrete Math., **37** no. 1 (2023), 17–24.
`http://arxiv.org/abs/2112.10698`

9. F. Dai, A. Prymak, *On directional Whitney inequality*, Canadian Journal of Mathematics, **74** (3) 2022, 833–857, doi:10.4153/S0008414X21000110.
http://arxiv.org/abs/2010.08374

10. A. Bondarenko, A. Prymak, D. Radchenko, *Spherical coverings and X-raying convex bodies of constant width*, Canad. Math. Bull., **65** (4) 2022, 860–866, doi:10.4153/S0008439521001016.
http://arxiv.org/abs/2011.06398

11. F. Dai, A. Prymak, *L^p-Bernstein inequalities on C^2-domains*, Trans. Amer. Math. Soc., accepted on Aug. 23 2021.
http://arxiv.org/abs/2010.06728

12. A. Prymak, *Geometric computation of Christoffel functions on planar convex domains*, Journal of Approximation Theory, **268** (2021), 105603.
http://arxiv.org/abs/2003.12833

13. F. Dai, A. Prymak, A. Shadrin, V. Temlyakov, S. Tikhonov, *Entropy numbers and Marcinkiewicz-type discretization theorem*, Journal of Functional Analysis, **281** (2021), 109090, doi:10.1016/j.jfa.2021.109
http://arxiv.org/abs/2001.10636

14. F. Dai, A. Prymak, A. Shadrin, V. Temlyakov, S. Tikhonov, *Sampling discretization of integral norms*, Constructive Approximation, **54** (2021), 455–471.
http://arxiv.org/abs/2001.09320

15. A. Prymak, V. Shepelska, *On the Hadwiger covering problem in low dimensions*, J. Geom. **111**:42 (2020), 1-11.
http://arxiv.org/abs/1811.08962

16. F. Dai, A. Prymak, V.N. Temlyakov, S. Tikhonov, *Integral norm discretization and related problems*, *Russ. Math. Surv.*, **74** (2019), 579–630. Translation from *Uspek hi Mat. Nauk*, **74**, Is. 4 (448) (2019), 3–58 [Russian].
http://arxiv.org/abs/1807.01353

17. A. Prymak, O. Usoltseva, *Pointwise behavior of Christoffel function on planar convex domains*, in: Topics in Classical and Modern Analysis, In Memory of Yingkang Hu, Birkhäuser, 2019, 293–302.
http://arxiv.org/abs/1709.10509

18. A. Prymak, O. Usoltseva, *Christoffel function on planar domains with piecewise smooth boundary*, Acta Math. Hungar., **158** (2019), no. 1, 216–234.
http://arxiv.org/abs/1809.09205

S. Safi-Harb

Refereed Journal Papers

1. Safi-Harb, S. 2022, Nature, Vol 612, P. 641-642. doi: 10.1038/d41586-022-04445-2 (Invited News and Views article)

2. West, J. L., Campbell, J. L., Bhaura, P., Kothes, R., Safi-Harb, S. et al. 2022, ApJ, 941, 6. doi:10.3847/1538-4357/ac9b58

3. Safi-Harb, S., Mac Intyre, B., Zhang, S., et al. 2022, ApJ, 935, 163. doi:10.3847/1538-4357/ac7c05

4. Jana, A., Chang, H-K, Chatterjee, A., Naik, S., Safi-Harb, S. 2022, The Astrophysical Journal, Volume 936, Issue 1, id.3, 7 pp., doi:10.3847/1538-4357/ac84dd

5. Jana, A., Ricci, C., Naik, S., Tanimoto, A., Kumari, N., Chang, H-K, Nandi, P., Chatterjee, A. & Safi-Harb, S. 2022, MNRAS, 512, 5942. doi:10.1093/mnras/stac799

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Proceedings Papers and Circulars

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White Papers

- *Equity, Diversity and Inclusion and the Canadian Astronomical Society in the next decade* by Spekkens, K. et al., Canadian Long Range Plan for Astronomy & Astronomy (LRP2020), submitted (2019.10.18)

- *Colibrì Instrument* by Hoffman, K. et al., LRP2020, submitted (2019.09.30)

- *Colibrì Science* by Caiazzo, I. et al., LRP2020, submitted (2019.09.30)

- *The cosmic origin and evolution of the elements* by Fernandez, R., LRP2020, submitted (2019.09.30)

- *Canada's Role in Multi-Messenger Gravitational-Wave Discoveries* in the 2020's by Ruan, J. et al., LRP2020, submitted (2019.09.30)

- *Canadian Investigations of the ISM* by Hill, A. et al., LRP2020, submitted (2019.09.30)

- *Cosmic Magnetism* by West, J. L., LRP2020, submitted (2019.09.30)

- *DRAO ST* by Landecker, T. , LRP2020, submitted (2019.09.30)

- *NGVLA White Paper for LRP2020* By J. diFrancesco et al., LRP2020, submitted (2019.09.30)

- *The Square Kilometer Array: Final report to the LRP panel* for LRP2020 by Spekkens, K. et al., submitted (2019.09.30)

- *Magnetic field studies in the next decade* by Furuya, R. et al., EAO Submillimetre futures paper series, 2019, submitted (2019.09.30)

- *Exploring the physics of neutron stars with high-resolution, high-throughput X-ray spectroscopy* by Heyl, J., Caiazzo, I., Safi-Harb, S. et al. (plus 21 co-authors), Colibrì Astro2020 (US Decadal Survey for Astronomy & Astrophysics) white paper, 2019BAAS...51c.491H

- *Testing general relativity with accretion onto compact objects* by Caiazzo, I. et al. (23 co-authors), Colibrì Astro2020 white paper, 2019BAAS...51c.516C

- *High-Resolution X-ray Imaging Studies of Neutron Stars, Pulsar Wind Nebulae and Supernova Remnants*; by Safi-Harb, S., Amato, E., Gotthelf, E.V., Katsuda, S., Sasaki, M., Uchiyama, Y., Tsuji, N. & Guest, B. A white paper for the NAS Astro2020 Decadal Survey, submitted 11 March (2019); 2019arXiv190406600S

- *Future X-ray Studies of Supernova Remnants*; by Williams, B. et al. A white paper for the NAS Astro2020 Decadal Survey, submitted 11 March (2019); 2019arXiv190405857W

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- *Multi-Messenger Astrophysics SAG: Thermonuclear Supernovae*; by Zingale, M. et al. A white paper for the NAS Astro2020 Decadal Survey, submitted 11 March (2019)

- *MeV Emission from Pulsar Wind Nebulae: Understanding Extreme Particle Acceleration in Highly Relativistic Outflows*; by Gelfand, J. et al. A white paper for the NAS Astro2020 Decadal Survey, submitted 11 March (2019)

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- *The Advanced Imaging X-ray Satellite: AXIS* by R. Mushotzky et al.. A Probe-class mission study commissioned by NASA for the National Academy of Science (NAS) Astro2020 Decadal Survey, submitted 11 March (2019) 2019arXiv190306760C

- Report for the CSA CASTOR science study, entitled *Prospects for CASTOR Studies of Supernova Remnants, Pulsar Wind Nebulae and Neutron Stars* by S. Safi-Harb, submitted 21 Feb (2019)

Conference Presentations/Abstracts

- *Supernova Remnants in the context of Cosmic PeVatrons* by Safi-Harb. S., invited talk, HONEST Workshops: Hot Topics in High Energy Astrophysics (PeVatrons), 29 Nov - 1 Dec. (2022)

- *Estimation of Spin of the Galactic Black Hole Candidate GRS 1758–258 though X-ray Spectroscopy* by Chatterjee, A. (PDF), WITP Symposium, 17 Aug. (2022)

- *Long-term NICER Monitoring of Black Hole Low-mass X-ray Binary 4U 1755–338* by Heiland, S. (NSERC USRA), WITP Symposium, 17 Aug. (2022)

- *The Neutron Star Merger: GW170817* by Doerksen, N. (FoS USRA), WITP Symposium, 17 Aug. (2022)

- *Pulsar Wind Nebulae: Powerful Cosmic Ray Accelerators* by Sander, I. (URA USRA), WITP Symposium, 17 Aug. (2022)

- *Zooming in on the Environment of the Vela Jr.?s Central Compact Object* by Suherli, J. (PhD candidate) et al., Chandra Supernova Remnants and Their Progenitor Workshop, Aug 16-18 (2022)

- *Progenitors and Explosion Properties of Supernova Remnants Hosting Central Compact Objects* by Braun. C. (PhD candidate) et al., Chandra Supernova Remnants and Their Progenitor Workshop, Aug 16-18 (2022)

- *Broadband X-ray Study of the Galactic Microquasar W50/SS433, a Galactic PeVatron Candidate* by Mac Intyre, B. (PhD candidate) et al., TeVPA 2022, Kingston, Ontario, 8-12 Aug. (2022)

- *Optical Imprints of the Vela Jr. Central Compact Object as Seen with MUSE* by Suherli, J. et al., International Astronomical Union's General Assembly, online, 2-11 Aug (2022)

- *A hard X-ray look at the Manatee nebula (W50) powered by the Galactic microquasar SS 433* by Safi-Harb, S. et al., 7th Heidelberg International Symposium on High-Energy Gamma-Ray Astronomy (γ2022), Barcelona, Spain, 4-8 July (2022)

- Chatterjee, A., Safi-Harb, S., Jana, A., et al., 44th COSPAR Scientific Assembly. Held 16-24 July, 44, 2348 (2022)

- Chatterjee, A., Safi-Harb, S., Heyl, J., et al., 44th COSPAR Scientific Assembly. Held 16-24 July, 44, 2054 (2022)

- Gallagher, S., Heyl, J., Caiazzo, I., Safi-Harb, S. et al., 44th COSPAR Scientific Assembly. Held 16-24 July, 44, 2024 (2022)

- *A hard X-ray look at the Manatee nebula (W50) powered by the Galactic microquasar SS 433* by Safi-Harb, S. et al., Ten years of High-Energy Universe in Focus: NuSTAR 2022 meeting will be held in Cagliari, Italy (hybrid), 20-22 June (2022)

- *Barriers and Pathways to Indigenous Achievement in STEM: Highlights of Indigenous Initiatives at the University of Manitoba* by Safi-Harb, S., Turtle Island Indigenous Science Conference, University of Manitoba. 14–16 June (2022)

- *Zooming in on the Environment of Central Compact Objects with Integral Field Spectroscopy* by Suherli, J. et al., invited talk for the Institut Teknologi Bandung (ITB), Astronomy Department Colloquia Series, 17 June (2022)

- *Barriers and Pathways to Indigenous Achievement in STEM: Highlights of initiatives at the University of Manitoba* by Safi-Harb, S., CASCA AGM at Waterloo, online, 16-20 May (2022)

- *Zooming in on the Environment of the Vela Jr.'s Central Compact Object* by Suherli, J., Safi-Harb, S. et al., CASCA AGM, online, 16-20 May (2022)

- *The extreme environment around Galactic black holes: A Case study with MAXI J1728–36* by Chatterjee, A. (PDF) et al., CASCA AGM, online, 16-20 May (2022)

- *Multi-wavelength Study of PeVatron Candidate Pulsar Wind Nebulae* Woo, J., An, H., Burgees, D., et al. (including Safi-Harb), AAS/High Energy Astrophysics Division, April (2022)

- *Zooming in on highly magnetized neutron stars - lessons learnt from PSR J1119–6127 and its environment* by Safi-Harb, S., oral presentation at IAU SYMPOSIUM 363, 29 Nov (2021)

- Five presentations by students (Janette Suherli, Chelsea Braun, Brydyn Mac Intyre, Cole Treyturik, and collaborator Ismael Moumen) at CASCA 2021, online, June (2021)

- *Pulsar Wind Nebulae at High Energies* by Safi-Harb, S., COSPAR ASSEMBLY Sydney, Australia (online due to COVID-19), Jan-Feb (2021)

- *Colibri's eyes on neutron stars* by Safi-Harb, S., Heyl, J. Gallagher, S. and the Colibri collaboration, COSPAR ASSEMBLY, Sydney, Australia (online due to COVID-19), Jan-Feb (2021)

- *Accretion Physics with Colibri* by Gallagher, S., Heyl, J. Safi-Harb, S. and the Colibri collaboration; COSPAR ASSEMBLY to take place in Sydney, Australia (online due to COVID-19), Jan-Feb (2021)

- *The Colibri X-ray Telescope* by Heyl, J., Gallagher, S., Safi-Harb S. and the Colibri collaboration; COSPAR ASSEMBLY to take place in Sydney, Australia (online due to COVID-19), Jan-Feb (2021)

- *Radio/X-ray Synergy to study PWNe* by Kothes, R., Reich, W. & Safi-Harb, S., COSPAR ASSEMBLY to take place in Sydney, Australia (online due to COVID-19), Jan-Feb (2021)

- *Colibri: Taking the pulse of black holes and neutron stars* by Heyl, J. and the Colibri collaboration, SPIE ASTRONOMICALTELESCOPES+INSTRUMENTATION SYMPOSIUM, Yokohama (Japan), online due to COVID-19, Dec. (2020)

- *A New Version of SNRcat: the High Energy Catalogue of Supernova Remnants* by Safi-Harb, S., Ramsay, M., Ferrand, G. and West, J., CASCA 2020 (online, York Univ.), May (2020)

- *A New View of the Supernova Remnant Puppis A with VLT?s MUSE* CASCA2020 by Suherli, J., (PhD candidate), Vogt, F. & Safi-Harb, S., CASCA 2020 (online, York Univ.), May (2020)

- *Discovery of Variability from Pulsar Wind Nebulae Using Spectral Index Maps* by Guest, B. (PhD candidate), and Safi-Harb, S. CASCA 2020 (online, York Univ.), May (2020)

- *A Global Progenitor Study of Supernova Remnants Hosting Central Compact Objects: RCW 103 Associated with the Peculiar Source 1E 16134–5055* by Braun, C. (PhD candidate), Safi-Harb, S. & Fryer, C., CASCA 2020 (online, York Univ.), May (2020)

- Five undergraduate students presentations for the Canadian Undergraduate Physics Conference (CUPC, Nov. 2019), the UofM's posters competition (Oct. 2019) and the Faculty of Science poster competition (Aug. 2019). ' HQP: Austin MacMaster (NSERC USRA on GW170817), Neil Doerksen (FoS USRA on GW170817), Michael Ramsay (FoS USRA on the new version of SNRcat).

- Two WITP presentations by undergraduate students: Michael Ramsay (on SNRcat) and Austin MacMaster+Neil Doerksen (on GW170817), WITP symposium, U. of Winnipeg. Aug. 28 (2019)

- *Spectral Index Maps of Pulsar Wind Nebulae* by Ben Guest (PhD candidate), A. MacMaster (undergraduate student) & S. Safi-Harb, SUPERNOVA REMNANTS II: AN ODYSSEY IN SPACE AFTER STELLAR DEATH, Chania, Crete, Greece, June 2–8 (2019)

- *An X-ray Imaging and Spectroscopic Study of the Supernova Remnant RCW 103 Using Chandra and XMM-Newton*, by Chelsea Braun (PhD candidate), S. Safi-Harb and C. Fryer, SUPERNOVA REMNANTS II: AN ODYSSEY IN SPACE AFTER STELLAR DEATH, Chania, Crete, Greece, June 2–8 (2019)

- *A New Version of SNRcat: the High Energy Catalogue of Supernova Remnants* by S. Safi-Harb, Michael Ramsay (undergraduate), G. Ferrand and Jennifer West, SUPERNOVA REMNANTS II: AN ODYSSEY IN SPACE AFTER STELLAR DEATH, Chania, Crete, Greece, June 2–8 (2019)

- *The X-ray Evolution of the PWN in the SNR Kes 75*, by S. Safi-Harb, Eric V. Gotthelf, Yosi Gelfand and Samayra Straal, SUPERNOVA REMNANTS II: AN ODYSSEY IN SPACE AFTER STELLAR DEATH, Chania, Crete, Greece, June 2–8 (2019)

- *G182.5-4.0: A new supernova remnant near the Crab Nebula*, by Jennifer West, Roland Kothes and S.. Safi-Harb, SUPERNOVA REMNANTS II: AN ODYSSEY IN SPACE AFTER STELLAR DEATH, Chania, Crete, Greece, June 2–8 (2019)

- *Radioactive Isotopes in Core-Collapse Remnants*, Chris Fryer, Aimee Hungerford, Oleg Korobkin, Sam Jones, S. Safi-Harb, SUPERNOVA REMNANTS: AN ODYSSEY IN SPACE AFTER STELLAR DEATH, Chania, Crete, Greece, June 2–8 (2019)

- *O CEASAR: The Optical Catalogue of ExtrAgalactic Supernova Remnants* by I. Moumen, C. Robert, D. Devost, R. P. Martin, L. Rousseau-Nepton, D. Patnaude, S. Safi-Harb, L. Drissen, T. Martin, SUPERNOVA REMNANTS: AN ODYSSEY IN SPACE AFTER STELLAR DEATH, Chania, Crete, Greece, June 2–8 (2019)

- *Piercing the Veil: Using X-rays to Study the Supernova Remnant 3C397* by Cole Treyturik (undergraduate) & Safi-Harb, S., UofM Undergraduate Poster Competition, 25 Oct. (2018)

- *Particle acceleration in SNRs: from 3D simulations to X-ray observations* by Brock Kleppenstein (undergraduate), S. Safi-Harb & G. Ferrand, UofM Undergraduate Poster Competition, 25 Oct. (2018)

- *The University of Manitoba's High-Energy Catalogue of Supernova Remnants: What's New?* by Michael Ramsay (computer science co-op), S. Safi-Harb, G. Ferrand & J. West; the UofM Undergraduate Poster Competition, 25 Oct. (2018)

- *Mapping the Unreachable: Pulsar Wind Nebula 3C58* by Austin MacMaster (undergraduate, NSERC USRA), S. Safi-Harb & B. Guest, UofM Undergraduate Poster Competition, 25 Oct. (2018)

- *From Darkness, Light: GW170817* by Neil Doerksen (undergraduate), S. Safi-Harb & Rogers, A., UofM Undergraduate Poster Competition, 25 Oct. (2018)

- Thirteen presentations in 2018: CASCA (Victoria, 2 graduate students presentations), UofM Undergraduate Posters competition (5 undergrad presentations), Ireland (2 invited talks at the 2018 summer school in High Energy Astrophysics), Washington, D.C. (2 Invited talks on Supernova Remnants in the 2020's and a colloquium at George Washington University), Waterloo (invited talk on Supernova Surveys), Italy (Invited talk on Pulsar Wind Nebulae)

Invited Talks

- *Supernova Remnants in the context of Cosmic PeVatrons* by Safi-Harb. S., HONEST2 Workshop on PeVatrons, 29 Nov - 1 Dec. (2022)

- *What's up with the Winnipeg-sized stars?* Physics Colloquium, Univ. of Winnipeg, 18 Nov. (2022)

- *Extreme Astrophysics* Wawatay summer orientation, Faculty of Science, University of Manitoba, 22 July (2022)

- *The Beauty And Their Beast: Supernovae Remnants Unveiling The Engines Of The Compact Objects Zoo* Astrophysics colloquium, MIT, 10 May (2022)

- *Neutron Stars Diversity*, keynote speaker, Global Summit on Gravitation, Astrophysics and Cosmology (GSGAC2022), Tokyo, Japan (online), 21 Apr. (2022)

- *Zooming in and out of the Neutron Stars Zoo*, Astrophysics colloquium, University of Minnesota and Minnesota Institute for Astrophysics (online), 01 Oct. (2021)

- *The zoo of neutron stars, associated nebulae and supernova remnants* Astronomy colloquium, Anton Pannekoek Institute for Astronomy, University of Amsterdam (online), 15 Sep. (2021)

- *Transitioning to University Life in Pursuit of Science: Barriers and Pathways to Indigenous Achievement*, Canadian Mathematical Society, June (2021)

- *Overview of Pulsar Wind Nebulae at High Energies*, Invited talk for COSPAR (Committee on Space Research) event E1.2, Sydney, Australia (online), 28 Jan.–04 Feb (2021)–virtual due to covid19

- *Neutron Stars as Drivers for Interdisciplinary Research, new X-ray missions and Multi-Messenger Astrophysics*, Frontier of High-Energy Astrophysics Workshop, Kavli IPMU, Japan, 16–18 Oct. (2019)

- *Where do the heavy elements really come from?*, Royal Astronomical Society, Spruce Woods Party, in Glenboro, MB, 01 Sep. (2019)
- *Neutron Star Mergers as Cosmic Mines of Heavy Elements*, American University of Beirut, 17 July (2019)
- *My Journey into Astrophysics*, American University of Beirut, 18 July (2019)
- *Probing the Physics of the Extreme with Supernovae and their Remnants*, Physics Colloquium at the New York University Abu Dhabi, 19 Dec. (2018)
- *Pulsar Wind Nebulae*, in Particle acceleration and Transport: From the Sun to Extragalactic Sources, Universite.lla Calabria in Rende (Italy), 12-16 Nov. (2018)
- *High-Energy and Supernova Surveys*, Canadian Wide Field Astronomy, Perimetre Institute, Waterloo, Canada, 10-12 Oct. (2018)
- *SuperNova Remnants at the end of 2020's* at the AXIS summer workshop entitled 'X-Ray Skies with High-Res Eyes: Imaging the Cosmos with AXIS', Carnegie Institute for Science, Washington D.C., Aug. (2018)
- *Supernova Remnants*, High-Energy Astrophysics Summer School, Dublin, Ireland, June (2018)
- *Neutron Stars and Supernovae: The Most Exotic Astrophysical Objects That Keep Surprising Us*, George Washington Frances E. Walker Colloquium, Washington, D.C., April (2018)

Media, Outreach and Press Releases

- Guest for first year astronomy class at Univ. of South Carolina, 9 Nov (2022)
- 'Cosmic manatee accelerates particles from head', European Space Agency press release, 4 July (2022)
- 'Researchers pinpoint location of extremely energetic particles in a Space Manatee', UM Today, 4 July (2022)
- 'Hyperfast white dwarfs moving like billiard balls may change understanding of supernovae', UofM, Japan and Saclay (France) releases, 6 May (2022)
- 'It's a very exciting time to be in astrophysics at UM', UM Today FoS feature article, 28 Jan (2022)
- 'Three new Canada Research Chairs', UM today following NSERC CRC announcement, 12 Jan (2022)
- Participant to the Faculty of Science's Science Promotion Youtube Video, Fall 2021
- Participant to Alliance Francaise du Manitoba, Science Exposed, Contributed images, Fall (2021)

- Interviewed for the Astronomy Magazine, Oct 2021 issue, article entitled: 'Neutron stars: A cosmic gold mine– These exotic stars may hold the key to solving some of physics' greatest mysteries.' (2021)
- 'ASTRONOMERS CATCH A PULSAR WIND POWERED BY MAGNETAR OUTBURSTS', University of Manitoba and Western Virginia press releases, 04 Oct (2021)
- Speaker for the Wawatay summer session, July (2021)
- WISDOM EDI Panel entitled: 'Diversity in Science: Unscripted', Panelist, 30 June (2021)
- 'UM astronomer and former graduate student take close look at powerful new 'baby magnetar' in Sagittarius', New Magnetar press release, appeared in several media releases including space.com and cosmoquest, 23 Nov (2020)
- Innovation News Network, Health Europa: Article following an interview highlighting my astrophysics research in the UK-based Research Media magazine, featured as an Innovation News Story, 04 Sep. (2020)
- Equity, Diversity and Inclusion (EDI): Interview for an article about 'Women in Physics', by Ashley Okuwosa (Columbia U., New York) for The Delacorte Review, 20 Apr. (2020)
- Media and press coverage for Dr. James Peebles (Winnipeg-born and UofM Alumnus) having won the 2019 Nobel Prize in Physics; interviews for CBC, Winnipeg Free Press and City News (TV), 08 Oct. (2019)
- Café Scientifique presentation on 'Nature's elements 150 years later: From a list of parts, we are seeing the future!'; MacNally Robinson Cafe, 28 Nov. (2019)
- Royal Astronomical Society Meeting Spruce Woods Star Party, Public Talk on 'Where did all the heavy elements really come from?', 01 Sep (2019)
- Mentorship talk entitled 'My Journey into Astrophysics: The Fun and the Challenges', American University of Beirut, 18 July (2019)
- Pint of Science (POS) talk on gravitational waves astrophysics and the formation of the elements, Winnipeg, 20 May (2019)
- Girls in Science, roundtable discussion, UofM, 01 May (2019)
- School Visit; Reading about Space and a Space Activity for KG and Grade 2 kids; Whyte Ridge Elementary School, Winnipeg, 22 Feb (2019)
- *A kilonova in our neighbourhood: Not 'super', but still pretty good*: UofM news article about the gravitational wave event GW170817, Feb (2019)
- Interview with Science News, *Astronomers may have spotted the birth of a pulsar*, Sep. (2018)

- Diversity Panel at the Canadian Conference for Undergraduate Women in Physics, CCUWiP, Ottawa, 19–20 Jan. (2019)
- Several media interviews (CBC radio, CJOB, CJNU (Winnipeg), National Post Media (Toronto), Women of Influence, etc.) following the 2017 WXN Canada's Most Powerful Women Top 100 award (2017–2018)
- Discover your Future in Science Presentations, UofM, 08 Feb (2018).

Conference Organization

- Chair, Women in Physics Canada Conference (WIPC), postponed due to COVID-19, to be held at UofM, 5-8 July (2023)
- Scientific Organizing Committee Member, High Energy Phenomena in Relativistic Outflows (HEPRO VIII) to take place in Paris, Oct. 23–26 (2023)
- Organizing committee member and Sloan conference proposal Co-I, Turtle Island Indigenous Science Conference hosted at the U. of Manitoba, 14-16 June (2022)
- Scientific Organizing Committee, Gamma2020 postponed to 2022, International Symposium on gamma-ray astronomy, held in Barcelona, Spain, July 4-8 (2022)
- Scientific Organizing Committee, IAU Symposium: Neutron Star Astrophysics at the Crossroads: Magnetars and the Multi-messenger revolution, virtual, Nov 29–Dec 3 (2021)
- Scientific Organizing Committee, The Future of Canadian Radio Astronomy, NRC's Herzberg, Penticton, B.C. (2019)
- Scientific Organizing Committee, High Energy Phenomena in Relativistic Outflows, Barcelona (Spain) 9–12 July (2019)
- Scientific Organizing Committee, Astrophysics of hot plasma in extended X-ray sources, Madrid (Spain) 12–14 June (2019)
- Scientific Organizing Committee member and session chair. Supernova Remnants: An Odyssey in Space after Stellar Death II, Crete, (Greece), June (2019)

Astrophysics Missions science working groups

- Lead for the Compact Objects-Supernova Remnants Science Working Group of NASA's AXIS Probe X-ray mission (2022/05–present)
- Science working group member for the CASTOR optical/UV mission, Canada's top priority space mission (2019–present)
- Lead for the Neutron Stars Science working group of the Colibrì mission concept study, CSA, Canada's Flagship X-ray mission (2018–present)

- Science working group member for the proposed ESA's Athena X-ray mission (2015–present)
- Member of the Cherenkov Telescope Array (CTA) future gamma-ray mission (2014–present)
- Associate member of the H.E.S.S. gamma-ray collaboration (2011–present)
- Member of the Thirty Meter Telescope (TMT) International Science Development Team (2017–present)
- Member of the ASTRO-H/Hitomi X-ray mission; lead of SNR and Magnetars science (2011–2018)

Selected professional service activities

- NASA's Postdoctoral fellowship Program external reviewer (2022)
- External reviewer for PhD thesis from India, Aug-Sep (2022)
- External Reviewer for promotion and tenure of US faculty (2 candidates, Fall 2022)
- NRC's Covington Fellowship Search Committee (2022; 2018–2019)
- NSERC Discovery Grants Physics Evaluation Group (2019–2022; 2021-2022: Group Chair)
- Canadian Astronomical Society's Vice-President (2020–2021)
- In 2021 and 2022, refereed for the NSERC CRC, NASA ADAP program, NSERC DG, Astrophysical Journal, MNRAS, and Nature
- European Space Agency's Time Allocation Committee for the XMM-Newton Satellite (2020)
- Equity, Diversity and Community Lead for the Faculty of Science (2019–2021)
- NASA Senior Review for the Chandra X-ray Observatory (2018)
- CASCA Board of Directors (2018–2019)
- NRC's Gemini Assessment Point Committee (2018)
- Chair (2018) and member (multiple times), NASA/Chandra Peer Review Panel
- Chair (2018) and member (2015–2018), NRC Canadian Time Allocation Committee Galactic Panel

Recent recognition

Perimeter Institute Affiliate, by invitation, Dec. (2022)

E. Schippers

No update for this report
Publications

1. Schippers, E; and Staubach, W. *Scattering theory of harmonic one-forms on Riemann surfaces.* Submitted. arXiv:2112.00835

2. Schippers, E; and Staubach, W. *Analysis on quasidisks: a unified approach through transmission and jump problems*. To appear in European Mathematical Society Surveys in Mathematical Sciences. https://arxiv.org/abs/2009.01954

3. Schippers, E; Shirazi, M; and Staubach, W. *Schiffer operators and approximations on Riemann surfaces bordered by quasicircles*. J. Geom. Anal. **31** (2021), no. 6, 5877—5908.

4. Radnell, D; Schippers, E; Shirazi, M.; and Staubach, W. *Schiffer operators and computation of a determinant line in conformal field theory*. New York J. Math. **27** (2021), 253—271.

5. Schippers, E.; and Staubach, W. "Transmission of harmonic functions through quasicircles on compact Riemann surfaces". Annales Academiae Scientiarum Fennicae **45** (2020), 1111–1134

6. Schippers, E.; and Staubach, W.. "Plemelj-Sokhotski isomorphism for quasicircles in Riemann surfaces and the Schiffer operators". Mathematische Annalen **378** (2020), 1613–1653.

7. Radnell, D; Schippers, E; and Staubach, W. *Dirichlet spaces of domains bounded by quasicrcles*. Communications in Contemporary Mathematics **22** (2020), no. 3.

8. Radnell, D.; Schippers, E.; and Staubach, W. "A Model of the Teichmüller space of genus-zero bordered surfaces by period maps". Conformal Geometry and Dynamics **23** (2019), 32-51 arXiv:1710.06960

9. Schippers, E. "Conformal invariants associated with quadratic differentials". Israel J. of Math. **223** (2018), no. 1, 449–491.

10. 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.

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

12. Schippers, E.; Staubach, W. "Riemann boundary value problem on quasidisks, Faber isomorphism and Grunsky operator.", Complex Anal. Oper. Theory **12** (2018), no. 2, 325–354.

Book Chapter

13. Schippers, E.; and Staubach, W. "Comparison moduli spaces of Riemann surfaces" New Trends and Open Problems in Complex Analysis and Dynamical Systems, 231–271, Trends Math., Birkhäuser/Springer, Cham, 2018.

Research Presentations

14. Reading seminar on geometric quantization, Liouville, and related topics (online), Hausdorff Center for Mathematics Bonn University, July 2021.

15. Canadian Mathematical Society Summer Meeting (online), Session on Recent Advances in Complex Analysis and Applications, Ottawa, June 2021.

16. Analysis Seminar, Uppsala University, Uppsala, Sweden, May 2019.

17. American Mathematical Society Session on Complex Analysis and its Applications, Portland, Oregon, April 2018.

18. Uppsala University Mathematics Colloquium, May 2018.

19. Lie Groups/Quantum Mathematics Seminar, Rutgers University, February 2018.

A. Shalchi

1. Shalchi, A. & Arendt V., Simulations of Field Line Random Walk in Noisy Slab Turbulence, Advances in Space Research, in press (2023)

2. Shalchi, A., Heuristic Construction of Field Line Random Walk Diffusion Coefficients, Advances in Space Research, in press (2023)

3. Shalchi, A., A Detailed Numerical Study of Field Line Random Walk in Magnetic Turbulence, Monthly Notices of the Royal Astronomical Society **526**, 5141-5154 (2023)

4. Shalchi, A., Constants of Motion in the Theory of Energetic Particles Propagating Through Magnetic Turbulence, Astrophysics and Space Science **367**, 93 (2022)

5. Shalchi, A., The Ratio of Perpendicular and Parallel Diffusion Coefficients of Low-energy Particles in Turbulent Space Plasmas, The Astrophysical Journal **936**, 1 (2022)

6. Shalchi, A., Perpendicular Diffusion of Energetic Particles: A Complete Analytical Theory, The Astrophysical Journal **923**, 209 (2021)

7. Shalchi, A., Field Line Random Walk in Magnetic Turbulence, Physics of Plasmas **28**, 120501 (2021)

8. Shalchi, A., Landau Damping of LangmuirWaves: An Alternative Derivation, Physics **3**, 940-954 (2021)

9. Shalchi, A., Subspace Approximation to the Cosmic Ray Fokker-Planck Equation with Perpendicular Diffusion, Astrophysics and Space Science **366**, 69 (2021)

10. Abdalla, H., ..., Shalchi, A., et al., Sensitivity of the Cherenkov Telescope Array for probing cosmology and fundamental physics with gamma-ray propagation, Journal of Cosmology and Astroparticle Physics **2**, 48 (2021)

11. Acharyya, A., ..., Shalchi, A., et al., Sensitivity of the Cherenkov Telescope Array to a dark matter signal from the Galactic centre, Journal of Cosmology and Astroparticle Physics **1**, 57 (2021)

12. Arendt, V. & Shalchi, A., Detailed Test-Particle Simulations of Energetic Particles Interacting with Magnetized Plasmas, I. Two-Component Turbulence, Advances of Space Research **66**, 2001-2023 (2020)

13. Shalchi, A., Heuristic Description of Perpendicular Particle Transport in Turbulence with Super-Diffusive Magnetic Field Lines, The Astrophysical Journal **898**, 2 (2020)

14. Shalchi, A. & Arendt, V., Distribution Functions of Energetic Particles Experiencing Compound Sub-Diffusion, The Astrophysical Journal **890**, 147 (2020)

15. Shalchi, A., Perpendicular Transport of Energetic Particles in Magnetic Turbulence, Space Science Reviews **216**, 23 (2020)

16. Shalchi, A., Heuristic Description of Perpendicular Transport, From the Sun's Atmosphere to the Edge of the Galaxy: A Story of Connections. 19th IGPP International Astrophysics Conference. American Institute of Physics Conference Proceedings **1620**, 012018 (2020)

17. Shalchi, A., Field Line Random Walk, Field Line Separation, and Particle Transport in Turbulence with Weak Transverse Complexity, Advances of Space Research **64**, 2426 (2019)

18. Shalchi, A., Heuristic Description of Perpendicular Diffusion of Energetic Particles in Astrophysical Plasmas, The Astrophysical Journal Letters **881**, L27 (2019)

19. Lasuik, J. & Shalchi, A., Subspace Approximations to the Cosmic Ray Fokker-Planck equation, Monthly Notices of the Royal Astronomical Society **485**, 1635 (2019)

20. Gammon, M., Heusen, M., & Shalchi, A., Comparison between test-particle simulations and test-particle theories for cosmic ray transport: III. Dynamical turbulence, Journal of Physics: Communications **3**, 015016 (2019)

21. Acharyya, A., ..., Shalchi, A., et al., Monte Carlo studies for the optimisation of the Cherenkov Telescope Array layout, Astroparticle Physics **111**, 35 (2019)

22. Shalchi, A. & Gammon, M., Perturbation Theory Based Solution of the Pitch-Angle Dependent Cosmic Ray Diffusion Equation, Advances in Space Research **63**, 653 (2019)

Khodr M. Shamseddine

Refereed Journal Publications

- On a Lebesgue-like measure on the Levi-Civita space $\mathscr{R}^j$, *Mateo Restrepo Borrero and Khodr Shamseddine*, submitted.
- On the Complex Levi-Civita field: Algebraic and Topological Structures, and Foundations for Analysis, *Khodr Shamseddine*, **Khayyam Journal of Mathematics**, in print.
- On a new measure on the Levi-Civita field $\mathscr{R}$, *Mateo Restrepo Borrero, Vatsal Srivastava, and Khodr Shamseddine*, textbf*p*-Adic Numbers, Ultrametric Analysis, and Applications, Volume 15 # 1, 2023, pp. 1-22.
- A weaker smoothness criterion for the inverse function theorem, intermediate value theorem, and mean value theorem in a non-Archimedean setting, *Khodr Shamseddine and Aaron Shalev*, ***p*-Adic Numbers, Ultrametric Analysis, and Applications**, Volume 14, Suppl. # 1, 2022, pp. S45-S58.
- On the analyticity of WLUD$^\infty$ functions of one variable and WLUD$^\infty$ functions of several variables in a complete non-Archimedean valued field, *Khodr Shamseddine*, **Proceedings of the Edinburgh Mathematical Society**, Volume 65, 2022, pp. 691-704.
- On non-Archimedean valued fields: a survey of algebraic, topological and metric structures, analysis and applications, *Khodr Shamseddine and Angel Barria Comicheo*, Advances in Non-Archimedean Analysis and Applications - The *p*-adic Methodology, a special volume in **STEAM-H: Science, Technology, Engineering, Agriculture, Mathematics & Health**, 2021, pp. 207–252.
- Taylor's theorem, the inverse function theorem and the implicit function theorem for weakly locally uniformly differentiable functions on non-Archimedean spaces, *Khodr Shamseddine*, ***p*-Adic Numbers, Ultrametric Analysis, and Applications**, Volume 13 # 2, 2021, pp. 148–165.
- On computational applications of the Levi-Civita field, *Darren Flynn and Khodr Shamseddine*, **Journal of Computational and Applied Mathematics**, Volume 382, 2021.
- On the topological structure of the Hahn field and convergence of power series, *Darren Flynn and Khodr Shamseddine*, **Indagationes Mathematicae**, Volume 30 # 5, 2019, pp. 773-795.
- 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.

Edited Proceedings

- 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.

Refereed Conference Proceedings

- On an operator theory on a Banach space of countable type over a Hahn field, *Khodr Shamseddine and Changying Ding*, Proceedings of the 11th ISAAC Congress (Växjö, Sweden, August 2017), **Analysis, Probability, Applications, and Computation**, 2019, pp. 267–282.

- 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.

- 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.

Invited Talks at Conferences

- On the complex Levi-Civita field: algebraic and topological structures, and foundations for analysis, 15th International Conference on p-adic Analysis and Dynamical Systems, an online meeting, July 11 and 14, 2023.

- On non-Archimedean Valued Fields and Ultrametric Spaces: the Hahn Fields and Levi-Civita Fields, CIMPA-CIMAT Research School, p-Adic Numbers, Ultrametric Analysis, and Applications, Guanajuato, Mexico, May 23-31, 2022.

- On non-Archimedean valued fields: a survey of algebraic, topological and metric structures, analysis and applications, Eighth International Conference on p-adic Mathematical Physics and its Applications, an online conference, May 17-28, 2021.

- Calculus theorems for locally uniformly differentiable functions on a non-Archimedean ordered field extension of the real numbers, Seventh International Conference on p-adic Mathematical Physics and its Applications, Covilha, Portugal, September 30-October 4, 2019.

Mini-Courses at Conferences

- Introduction to Non-Archimedean Analysis (mini-course: 3 hours), the Canadian Mathematical Society Summer Meeting, St. John's, Newfoundland, June 3-6, 2022.

Contributed Talks at Conferences

- 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

- Department of Mathematics and Statistics, Universidad de la Frontera, Temuco, Chile, May 20, 2022.

- Department of Physics and Engineering Physics, University of Saskatchewan, March 9, 2021.
- Department of Physics and Astronomy and Winnipeg Institute for Theoretical Physics (joint colloquium), University of Manitoba, March 8, 2019.
- Department of Mathematics, Universidad de Concepcion, Concepcion, Chile, March 23, 2018.

Conference and Workshop Organization

- Member of the International Scientific Committee, NUMTA2023: Numerical Computations: Theory and Algorithms, Italy (June 2023)
- Member of the International Scientific Committee, 15th International Conference on p-Adic Functional Analysis, Poland (July 2023).
- Member of the International Organizing Committee, Eighth International Conference on p-adic Mathematical Physics and its Applications, Online Conference (May 17-28, 2021)
- Member of the International Scientific Committee, 15th International Conference on p-Adic Functional Analysis, Poland (July 2020). This conference was postponed due to COVID-19.
- Member of the International Advisory 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)

J. Sirker

No update provided for this report

1. J. Sirker,
   "Physics at the nanoscale (Preface of special issue in Physica E",
   Editor: J. Sirker,
   Physica E **110** (2019).
2. J. Sirker,
   "Transport in one-dimensional integrable quantum systems",
   arXiv:1910.12155 (2019) [SciPost].
3. Y. Zhao, J. Sirker,
   "Logarithmic entanglement growth in two-dimensional disordered fermionic systems",
   Phys. Rev. B **100**, 014203 (2019).
4. F. Göhmann, K. K. Kozlowski, J. Sirker, J. Suzuki,
   "The equilibrium dynamics of the XX chain revisited", Phys. Rev. B **100**, 155428 (2019).

5. A. Naseri, S. Peng, W. Luo, J. Sirker,
"Spin Vortices and Skyrmions of a Single Electron in Inhomogeneous Magnetic Fields",
arXiv:1901.07149 (2019).

6. A. Urichuk, Y. Oez, A. Klümper, J. Sirker,
"The spin Drude weight of the XXZ chain and generalized hydrodynamics",
SciPost Phys. **6**, 005 (2019).

7. J. Sirker,
"Does a distinct quasi many-body localized phase exist? A numerical study of a translationally invariant system in the thermodynamic limit",
Phys. Rev. B **99**, 075162 (2019).

8. W. Luo, A. Naseri, J. Sirker, T. Chakraborty,
"Unique Spin Vortices in Quantum Dots with Spin-orbit Couplings",
Sci. Rep. **9**, 672 (2019).

9. 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).

10. 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).

Talks

11. 'Entanglement spreading in disordered low-dimensional quantum systems',
Theory Colloquium, University Kaiserslautern, November 2019

12. 'The Drude weight of the XXZ spin chain',
International Conference: 'Correlation days',
Max-Planck Institute Dresden, Germany, September 2019

13. 'The Drude weight of the XXZ spin chain',
XIth International Symposium: 'Quantum Theory and Symmetries (QTS)',
Centre de Recherches Mathematiques (CRM), Montreal, July 2019

14. 'Does a well-defined quasi many-body localized phase exist?',
American Physical Society: 'Annual meeting of the division of atomic, molecular and optical physics (DAMOP)',
Milwaukee, May 2019

15. 'Ergodicity and Thermalization in closed quantum systems',
Colloquium Dep. Of Physics & Astronomy,
UM, Winnipeg, December 2018

16. "Many-body localization in infinite chains",
SSPCM, Rzeszow, Poland, September 2018

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

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

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

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

R.L. Stamps

No update provided for this report

Refereed Publications

1. R. Stamps. Probing a Mesoscopic Elephant. NATURE MATERIALS, 20(2):127–128, February 2021.

2. I. Proskurin and R. L. Stamps. Symmetry Approach to Chiral Optomagnonics in Antiferromagnetic Insulators. In Kamenetskii, E, editor, CHIRALITY, MAGNETISM AND MAGNETOELECTRICITY: SEPARATE PHENOMENA AND JOINT EFFECTS IN METAMATERIAL STRUCTURES, volume 138 of Topics in Applied Physics, pages 207–240. 2021.

3. I. Proskurin and R. L. Stamps. Level attraction and exceptional points in a resonant spin-orbit torque system. PHYSICAL REVIEW B, 103(19), MAY 7 2021.

4. V. M. Parakkat, G. M. Macauley, R. L. Stamps, and K. M. Krishnan. Configurable Artificial Spin Ice with Site-Specific Local Magnetic Fields. PHYSICAL REVIEW LETTERS, 126(1), JAN 7 2021.

5. R. Macedo, R. C. Holland, P. G. Baity, L. J. McLellan, K. L. Livesey, R. L. Stamps, M. P. Weides, and D. A. Bozhko. Electromagnetic Approach to Cavity Spintronics. PHYSICAL REVIEW APPLIED, 15(2), FEB 25 2021.

6. J. O. Iyaro, I. Proskurin, and R. L. Stamps. Collective dynamics of domain walls: An antiferromagnetic spin texture in an optical cavity. PHYSICAL REVIEW B, 104(18), NOV 15 2021.

7. S. H. Skjaervo, C. H. Marrows, R. L. Stamps, and L. J. Heyderman. Advances in artificial spin ice (vol 2, pg 13, 2020). NATURE REVIEWS PHYSICS, 2(2):117, FEB 2020.

8. R. Macedo and R. L. Stamps. Electromagnetic waves in canted magnets. Compendium On Electromag- netic Analysis-From Electrostatics To Photonics: Fundamentals And Applications For Physicists And Engineers (In 5 Volumes), page 231, 2020.

9. G. M. Macauley, G. W. Paterson, Y. Li, R. Macedo, S. McVitie, and R. L. Stamps. Tuning magnetic order with geometry: Thermalization and defects in two-dimensional artificial spin ices. PHYSICAL REVIEW B, 101(14), APR 2 2020.

10. G. Gubbiotti, M. Madami, F. Montoncello, Y. Li, and R. L. Stamps. Magnetic normal modes of nanopatterned magnets investigated by both wavevector-and space-resolved brillouin light scattering spectroscopy. Compendium On Electromagnetic Analysis-From Electrostatics To Photonics: Funda- mentals And Applications For Physicists And Engineers (In 5 Volumes), page 263, 2020.

11. L. Desplat, C. Vogler, J.-V. Kim, R. L. Stamps, and D. Suess. Path sampling for lifetimes of metastable magnetic skyrmions and direct comparison with kramers' method. Phys. Rev. B, 101:060403, Feb 2020.

12. B. W. Zingsem, M. Farle, R. L. Stamps, and R. E. Camley. Unusual nature of confined modes in a chiral system: Directional transport in standing waves. PHYSICAL REVIEW B, 99(21), JUN 20 2019.

13. M. Wyss, S. Gliga, D. Vasyukov, L. Ceccarelli, G. Romagnoli, J. Cui, A. Kleibert, R. L. Stamps, and M. Poggio. Stray-field imaging of a chiral artificial spin ice during magnetization reversal. ACS nano, 2019.

14. S. H. Skjærvø, C. H. Marrows, R. L. Stamps, and L. J. Heyderman. Advances in artificial spin ice. Nature Reviews Physics, pages 1–16, 2019.

15. I. Proskurin, R. Macedo, and R. L. Stamps. Microscopic origin of level attraction for a coupled magnon- photon system in a microwave cavity. NEW JOURNAL OF PHYSICS, 21, SEP 10 2019.

16. J. M. Porro, S. A. Morley, D. A. Venero, R. Macêdo, M. C. Rosamond, E. H. Linfield, R. L. Stamps, C. H. Marrows, and S. Langridge. Magnetization dynamics of weakly interacting sub-100 nm square artificial spin ices. Scientific reports, 9(1):1–11, 2019.

17. G. W. Paterson, G. M. Macauley, Y. Li, R. Macêdo, C. Ferguson, S. A. Morley, M. C. Rosamond, E. H. Linfield, C. H. Marrows, R. L. Stamps, et al. Heisenberg pseudo-exchange and emergent anisotropies in field-driven pinwheel artificial spin ice. Physical Review B, 100(17):174410, 2019.

18. Y. Li, G. W. Paterson, G. M. Macauley, F. S. Nascimento, C. Ferguson, S. A. Morley, M. C. Rosamond, E. H. Linfield, D. A. MacLaren, R. Macedo, C. H. Marrows, S. McVitie, and R. L. Stamps. Superferro- magnetism and Domain-Wall Topologies in Artificial "Pinwheel" Spin Ice. ACS NANO, 13(2):2213–2222, FEB 2019.

19. L. Desplat, J. Kim, V, and R. L. Stamps. Paths to annihilation of first- and second-order (anti)skyrmions via (anti)meron nucleation on the frustrated square lattice. PHYSICAL REVIEW B, 99(17), MAY 13 2019.

20. I. Proskurin, A. S. Ovchinnikov, J.-i. Kishine, and R. L. Stamps. Excitation of magnon spin photocurrents in antiferromagnetic insulators. PHYSICAL REVIEW B, 98, 2018.

21. I. Proskurin, A. S. Ovchinnikov, J.-i. Kishine, and R. L. Stamps. Cavity optomechanics of topological spin textures in magnetic insulators. PHYSICAL REVIEW B, 98, 2018.

22. R. Macedo, G. M. Macauley, F. S. Nascimento, and R. L. Stamps. Apparent ferromagnetism in the pinwheel artificial spin ice. PHYSICAL REVIEW B, 98, 2018.

23. R. Macedo, T. Dumelow, R. E. Camley, and R. L. Stamps. Oriented Asymmetric Wave Propagation and Refraction Bending in Hyperbolic Media. ACS PHOTONICS, 5:5086–5094, 2018.

24. M. Harder, Y. Yang, B. M. Yao, C. H. Yu, J. W. Rao, Y. S. Gui, R. L. Stamps, and C. M. Hu. Level Attraction Due to Dissipative Magnon-Photon Coupling. PHYSICAL REVIEW LETTERS, 121, 2018.

25. L. Desplat, D. Suess, J.-V. Kim, and R. L. Stamps. Thermal stability of metastable magnetic skyrmions: Entropic narrowing and significance of internal eigenmodes. PHYSICAL REVIEW B, 98, 2018.

26. J. P. Azpizau, S. Morley, D. A. Venero, R. Macedo, M. Rosamond, R. L. Stamps, C. H. Marrows, and S. Langridge. Magnetization dynamics of weakly interacting sub-100 nm square artificial spin ices. In 2018 IEEE INTERNATIONAL MAGNETIC CONFERENCE (INTERMAG), 2018.

Refereed Publications

1. A. Zelenskiy , M. L. Plumer, B. W. Southern , M. E. Zhitomirsky, and T. L. Monchesky "Chiral nematic and fluctuation-induced first-order phase transitions in AB-stacked kagome bilayers" Physical Review B 108: L060402 (2023)

2. J. S. R. McCoombs, A. Zelenskiy , M. L. Plumer, B. W. Southern , and T. L. Monchesky "Impact of Dzyaloshinskii-Moriya and anisotropic exchange interactions on the cubic kagome antiferromagnets Mn3X and Mn3AB" . Physical Review B. 107: 064407 (2023)

3. A. Zelenskiy , T. L. Monchesky , M. L. Plumer, and B. W. Southern "Magnetic interactions in AB-stacked kagome lattices: Magnetic structure, symmetry, and duality" . Physical Review B. 106: 144433 (2022)

4. S. Belkatir, S. Bekhechi, and B. W. Southern "Monte Carlo study of site disordered 3d Heisenberg models in the presence of a magnetic field and a weak random anisotropy" Physica A 596 127191 (2022)

5. A. Zelenskiy, T. L. Monchesky, M. L. Plumer, and B. W. Southern. "Anisotropic magnetic interactions in hexagonal AB-stacked kagome lattice structures: Application to Mn3X (X=Ge,Sn,Ga) compounds". Physical Review B. 103: 144401 (2021).

6. M. D. LeBlanc, A. A. Aczel, G. E. Granroth, B. W. Southern, J.-Q. Yan, S. E. Nagler, J. P. Whitehead, and M. L. Plumer, "'Impact of further-range exchange and cubic anisotropy on magnetic excitations in the fcc kagome antiferromagnet IrMn3"', Physical Review B. 104: 014427 (2021).

7. B. Alkadour, B.W. Southern, J.P. Whitehead and J. van Lierop. "Triangular array of gamma-Fe2O3 nanoparticles: A simulation study of intraparticle and interparticle magnetism", Physical Review B **100**, 094416 (2019)

8. 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).

Conference Contributions

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J.P. Svenne

No update provided for this report

No Current Refereed Publications

G.C. Tabisz

No update provided for this report

No Current Refereed Publications

J.M. Vail

No update provided for this report

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M. Whitmore

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J.G. Williams

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