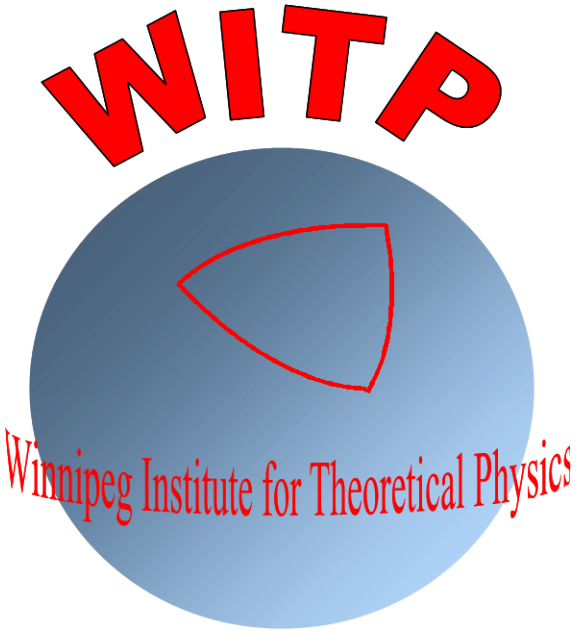
The Winnipeg Institute for Theoretical Physics Annual Report



September 2019 – August 2020

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

Contents

1 Director's Narrative Report

The Winnipeg Institute for Theoretical Physics is a type III research Institute and 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, visiting colloquium speakers, and short and long term visits by research collaborators of international standing. The permanent members of this Institute are drawn from Brandon University, the University of Manitoba, and the University of Winnipeg. Associated with the Permanent Members are research associates, postdoctoral fellows, graduate students and summer undergraduate research assistants.

The past year was the 30th year of the Institute's existence. As usual, the Institute sponsored several research colloquia. The Institute has provided support for Canadian theoretical physics and astronomy meetings in the last several years, for example by being a sponsor of the Theory Canada conference, the main national conference for theoretical physics. While many of our activities were altered by the pandemic (like every organization), they did continue. The WITP organized its annual summer student symposium online over Zoom on August 21, 2020, which included talks by 9 of our students. In order to emphasize the strong base of theoretical physics in Manitoba throughout the rest of Canada, the WITP also continues to co-sponsor a PhD thesis prize in conjunction with the Canadian Association of Physicists Division of Theoretical Physics.

For the previous five academic years, the list of visitors is found in section 3.1 and invited speakers in section 3.2. For 2019-20, please find a description of the WITP workshop in **??**, the cumulative list of graduate degrees awarded in section 3.5, and the published research work of members in section 3.6. Section 4.1 contains a summary of income and expenditures for one year (since the filing of last year's report.) The plans for the coming year depend somewhat on the progression of the pandemic but include a program of invited speakers (via Zoom when appropriate), possibly visiting research collaborations, and the yearly WITP symposium with invited external speakers if possible.

All of the funds available to the Institute are spent for scientific research expenses, including conference support, seminar activities, and travel expenses of visiting scientists. The Institute has no technical support staff or administrative staff. All the administrative work is done on a volunteer basis by the members of the Institute. The Institute's funding is substantially supplemented by contributions from the NSERC grants of individual members in pursuing the Institute's mandate.

The WITP Executive Committee at January 1, 2020 consisted of the Director, A. R. Frey (UWinnipeg), the Director-Elect, S. Safi-Harb (UManitoba), and the Past-Director, J. Sirker (UManitoba). Due to administrative overcommitment, J. Sirker resigned in Feb 2020, and S. Safi-Harb resigned in Dec 2020. Starting January 1, 2020, the Director will be A. R. Frey (UWinnipeg), and P. Blunden (UManitoba) will serve in the capacity of Past Director.

Andrew Frey (Director, WITP)

2 Current List of Members (2019-20)

The WITP executive for 2020 consisted of

- Director: Andrew Frey, Winnipeg, 8th year on executive (2nd consecutive term)
- Director-Elect: Samar Safi-Harb, Manitoba, 2nd year (resigned Dec 2020)
- Past Director: Jesko Sirker, Manitoba, 6th year (resigned Feb 2020)

The WITP has no staff.

2.1 Permanent (Faculty) Members

- M.E. Alexander[2], *Ph.D. (Manchester University, UK)*
- P.G. Blunden[1], *Ph.D (Queen's)* [Director, 93-94]
- 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, 19-20]
- T.D. Fugleberg[3], *Ph.D. (UBC)*
- D. Krepski[1], *Ph.D. (Toronto)*
- C. O'Dea[1], *Ph.D. (Massachusetts)*
- S. Plosker[3], *Ph.D. (Guelph)*
- A. Prymak[1], *Ph.D. (Kyiv National Taras Schevchenko)*
- S. Safi-Harb[1], *Ph.D. (Wisconsin-Madison)*
- E. Schippers[1], *Ph.D. (Toronto)*
- A. Shalchi[1], *Ph.D. (Ruhr-Universität Bochum)*
- K.M. Shamseddine[1], *Ph.D. (Michigan State)* [Director, 15-16]
- J. Sirker[1], *Ph.D. (Universität Dortmund)* [Director, 17-18]
- R. Stamps[1], *Ph.D. (Colorado State University)*
- D.W. Vincent[2], *Ph.D. (Toronto)* [Director, 94-95]
- J.G. Williams[3], *Ph.D. (Birmingham)* [Director, 96-97]
- J. Ziprick[24], *Ph.D. (Waterloo)*

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]
- 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]

2.2 Associate Members

Research Scholars

- Rebecca Danos (Frey/Kunstatter)

Research Associates

- Michelle Boyce (O'Dea)

Postdoctoral Fellows

- Angel Barria Comicheo (Shamseddine)
- Yjan Gordon (O'Dea)
- Peter Kristel (Krepski/Schippers)
- Fei Qi (Schippers)
- Adrian Vantyghem (O'Dea)

2.3 Graduate Students

Due to privacy regulations, this list relies on voluntary disclosure and may be incomplete.

- Naman Agarwal (M.Sc., visiting from SVNIT, India) (Frey)
- V. Arendt (Ph.D.) (Shalchi)
- Mykhailo Akhtariiev (M.Sc.) (Schippers, co-supervised with Chipalkatti, Manitoba)

[1]University of Manitoba
[2]University of Winnipeg
[3]Brandon University
[4]Home Institution: Red River College

- Bassel Alkadour (Ph.D.) (Southern, co-supervised with van Lierop, Manitoba)
- Yashashvi Bharani (M.Sc.) (O'Dea)
- Chelsea Braun (Ph.D.) (Safi-Harb)
- Bradley Cownden (Ph.D.) (Frey)
- Mingyang Diao (M.Sc.) (Prymak)
- Dinamo Djounvona (Ph.D.) (Krepski)
- Chetna Duggal (Ph.D.) (O'Dea)
- Darren Flynn (Ph.D.) (Shamseddine)
- Benson Guest (Ph.D.) (Safi-Harb)
- Cameron Lawlor-Forsyth (M.Sc.) (O'Dea)
- Brydyn Mac Intyre (M.Sc.) (Safi-Harb)
- Austin MacMaster (M.Sc.) (Safi-Harb)
- Julius Adili Masanika (M.Sc.) (Plosker, co-supervised with Farenick, Regina)
- Brett Meggison (M.Sc.) (Carrington/Frey)
- Hermie Monterde (M.Sc.) (Plosker, co-supervised with Kirkland, Manitoba)
- Oluwatobi Ruth Ojo (M.Sc.) (Plosker, co-supervised with Farenick, Regina)
- David Saroff (Ph.D.) (O'Dea)
- Mohammad Shirazi (Ph.D.) (Schippers)
- Mainak Singha (Ph.D.) (O'Dea)
- Janette Suherli (M.Sc.) (Safi-Harb)
- Cole Treyturik (Ph.D.) (Safi-Harb)
- Olena Usoltseva (Ph.D.) (Prymak)

2.4 Undergraduate Research Students 2019-20

These students carried out research in their supervisors' areas of interest as described in the appendix. This may be an incomplete list.

- Nathaniel Betts (Frey) (high school)
- Timothy Coates (Frey)
- Wade Cowie (Carrington)
- Jeremy Croitor (Shamseddine)
- Kent Dela Cruz (Ziprick, RRC)
- Omar Ducut (Ziprick, RRC)
- Bailey Forster (Carrington)
- Michael Grehan (Frey)
- Denys Horbenko (Ziprick, RRC)
- Michael Huff (Ziprick, RRC)
- Farrah Huntinghawk (Plosker)
- Bruno Illipronti (Ziprick, RRC)
- Waweru Kariuki (Schippers)
- J. Kim (Prymak)
- Brydn Mac Intyre (Safi-Harb)
- Ausin MacMaster (Safi-Harb)
- Sofiya Makar (Carrington)
- Darian McLaren (Plosker)
- Victoria McNabb (Ziprick, RRC)
- Ali Moghaddam (Ziprick, RRC)
- Kyle Moore (Ziprick, RRC)
- Alan Nguyen (O'Dea)
- Kaylee Nguyen (Ziprick, RRC)
- Melanie Par (Ziprick, RRC)
- Nirav Patel (Ziprick, RRC)

- Christopher Phillips (Carrington)
- Kangming Pu (Safi-Harb)
- Pukar Rai (Alexander)
- Michael Ramsay (Safi-Harb)
- Alexander Rennie (Ziprick, RRC)
- Candace Richard (Plosker, co-supervised with G. Srivastava)
- Dana Schultz (Ziprick, RRC)
- A. S. Sehgal (Prymak)
- Shawna Skelton (Kunstatter/Ziprick, Frey)
- Connor Speidel (Ziprick, RRC)
- Jovin Toews (Ziprick, RRC)
- Xinxin Wei (Ziprick, RRC)

3 Research Activities

3.1 Visitors: 2015-2020

Date	**Visitor**	**Institution**	**Host**
Feb.-Aug. 2020	Naman Agarwal	SVNIT, India	A.R. Frey
Oct. 2018	Toka Diagana	University of Alabama in Huntsville	K. Shamseddine
Oct. 30-Nov. 3, 2017	Shirin Moein	Isfahan University of Technology	S. Plosker
July 17-21, 2017	Gilles Ferrand	RIKEN, Japan	S. Safi-Harb
May 23-26, 2017	Takaaki Tanaka	Kyoto, Japan	S. Safi-Harb
May 15-19, 2017	Rajesh Pereira	Universty of Guelph	S. Plosker
Apr 20-24, 2017	Shigehiro Nagataki	Riken, Japan	Safi-Harb
Feb. 13-17, 2017	Don Page	University of Alberta	G. Kunstatter
Nov. 21-25, 2016	Nicholas Sedlmayr	Michigan State University (USA)	J. Sirker
Oct. 18-27, 2016	Hideki Maeda	Hokkai-Gakuen University (Japan)	G. Kunstatter
June 27-July 1, 2016	Jorma Louko	University of Nottingham (UK)	G. Kunstatter
May 16-20, 2016	Nathaniel Johnston	Mount Allison University	S. Plosker
Nov. 5-7, 2015	George Sawatzky	UBC	J. Sirker
Oct. 21-24, 2015	Christopher Fryer	Los Alamos National Laboratory	S. Safi-Harb
Sep. 30-Oct. 2, 2015	Saurya Das	University of Lethbridge	G. Kunstatter

3.2 Seminars: 2015-2020

Date	Speaker	Title
Nov. 10, 2020	Robert Brandenberger	"Stephen Hawking - A Personal Perspective"
Aug. 12, 2020	Ada Chan	"Spectra properties of graphs and their quantum walks"
July 22, 2020	Omer Blaes	"Magnetohydrodynamics and Convection in Accretion Disks: From Dwarf Novae to Luminous Quasars"
July 7, 2020	Crisitina Bena	"Majorana and other boundary modes from impurity states via T-matrix"
June 4, 2020	Aaron Vincent	"Very small black holes at very large experiments"
May 8, 2020	Naman Agarwal	"Holographic Complexity: What, Why and How"
Oct. 9, 2019	Igor Proskurin	"From chiral optics to optospintronics"
Sept. 23, 2019	Gabor Kunstatter	"What can quantum gravity tell us about the beginning and end of time?"
March 8, 2019	Khodr Shamseddine	"On non-Archimedean Valued Fields and Applications in Physics"
Oct. 26, 2018	Toka Diagana	"Existence Results for some classes of Integro-Differential Equations of Gurtin-Pipkin Type"
July 20, 2017	G. Ferrand	"From the supernova to the supernova remnant"
May 25, 2017	T. Tanaka	"Shaping our Understanding of Supernova Remnants with the Fermi Large Area Telescope"
Feb. 16, 2017	D. Page	"Anthropic Estimates for ManyParameters of Physics and Astronomy"
Jan. 17, 2017	A. Nielson	"Binary Black Hole Mergers in the First Advanced LIGO Observing Run"
Jan. 13, 2107	J. Ziprick	"Quantum gravitational collapse of a thin shell"
Dec. 2, 2016	A. Rogers	"Gravitational Lensing by Compact Objects in Plasma Environments"
Nov. 25, 2016	N. Sedlmayr	"The Superconductivity of Topologically Protected Surface States"
Oct. 21, 2016	H. Maeda	"Exact Solutions with a Scalar Field in General Relativity"
June 29, 2016	J. Louko	"Low Energy Lorentz Violation from High Energy Modified Dispersion"
April 1, 2016	A. Frey	"Black Hole Formation in Anti-de Sitter Spacetime (and What it Means)"
March 10, 2016	A. Prymak	"Compressed Sensing and Quantum State Tomography"
Jan. 28, 2016	S. Wykes	"HD simulations of internal jet-stellar wind interactions: the case of Centaurus A"
Nov. 26, 2015	E. Schippers	"Quasiconformal Teichmuller Theory and Conformal Field Theory"
Nov. 12, 2015	G. Ferrand	"Simulating particle acceleration in supernova remnants"
Nov. 6, 2015	G. Sawatzky	"Electronic structure of the doped Cuprates, Nickelates and superconducting Bismuthates"
Oct. 23, 2015	C. Fryer	"Chasing the Supernova Engine"
Oct. 1, 2015	S. Das	"Quantum Raychaudhuri equation and its applications to gravity and cosmology"

3.3 WITP Summer Student Symposium

On August 21, 2020, WITP held its annual Summer Student Symposium online using Zoom software. The 20 participants viewed talks on topics including condensed matter physics and high energy theory. Nine WITP graduate and undergraduate students gave talks. Detailed information is available on the WITP website at `http://www2.physics.umanitoba.ca/u/witp/summer/symposium20.html` . There was no cost due to the online format.

3.4 Conferences and National Event Support

- The WITP has provided support in recent years for several national and international conferences in theoretical physics, mathematics, and astrophysics:
  - Women in Physics Canada 2021, to be held at the University of Manitoba. WITP will fund two theory speakers for a total amount of $2500. WITP made this funding commitment in early 2020 because the conference was originally planned for summer 2020 and postponed due to the pandemic.
  - Canadian Association of Physicists Congress 2019, held at Simon Fraser University (BC) in June 2019 ($300). WITP funds supported the plenary lecture by Professor Cora Dvorkin of Harvard University.
  - Theory Canada 14 held in May-June 2019 at the University of British Columbia and TRIUMF ($500) in support of student attendance. Theory Canada is the leading national conference for theoretical physics.
  - Theory Canada 13 held in June 2018 at St. Francis Xavier University ($500).
  - The 16th Canadian Conference on General Relativity and Relativistic Astrophysics, SFU, July 6-8, 2016, G. Kunstatter and A. Frey members of the organizing committee ($500).
  - CASCA2016: the annual meeting of the Canadian Astronomical Society which was held in Winnipeg (May 30- June 2, 2016) and organized by WITP members from U of M and UW ($2,000). WITP support went toawrd theory speakers.
- In 2014, the WITP agreed to co-sponsor a prize with the Canadian Association of Physicists Division of Theoretical Physics for the best Ph.D. thesis in theoretical physics each year ($250/yr). The prize is now known as the DTP/WITP P. R. Wallace Thesis Prize, and the WITP Past Director sits on the award committee. The recent prize winners are
  - 2020 — Job Feldbrugge (PhD University of Waterloo) "Path Integrals in the Sky - Classical and Quantum Problems with Minimal Assumptions."
  - 2019 — jointly awarded to Evan McDonough (PhD McGill University, 2017) "High energy physics and the early universe" and Robie Hennigar (PhD University of Waterloo) "Explorations in black hole chemistry and higher curvature gravity." WITP made an additional $300 commitment to support the joint prize this year.

  - 2018 — Philippe Landry (PhD University of Guelph, 2016), "Tidal Response of a Rotating Neutron Star in General Relativity."
  - 2017 — no prize awarded
  - 2016 — Vincent Genest (PhD Université de Montréal, 2015), "Algebraic Structures, Super-Integrable systems and Orthogonal Polynomials."
  - 2015 — Solomon Akaraka Owerre (PhD Université de Montréal, 2014), "Etudes de l'effet tunnel des spins quantiques macroscopiques (Studies of the tunnel effect of macroscopic quantum spins)."

- In 2020, the WITP agreed to contribute $500 per year for three years for Canadian national dues paid to the Asia-Pacific Centre for Theoretical Physics. APCTP is a centre based in South Korea that organizes and sponsors large international workshops and conferences in theoretical physics. Canada is the only national member from the Americas (out of close to 20 member nations), and APCTP has provided significant sponsorship for events in Canada and held jointly with Canadian organizations in the last several years.

3.5 Graduate Degrees Supervised

Dates listed are defense dates.

1. Naman Agarwal (2020), "Holographics Complexity of Non-Trivial Spacetimes that Appear in String Theory," M.Sc. thesis (SVNIT, India) (Frey).

2. Bradley Cownden (2020), "Gravitational Collapse in Anti-de Sitter Spacetime," Ph.D. thesis (Frey).

3. Darren Flynn (2020), "On the Hahn and the Levi-Civita Fields: Topology, Analysis, and Applications," Ph.D. thesis (Shamseddine).

4. Benson Guest (2020), "X-ray observations of pulsar wind nebulae: The nature of pulsar winds and their environment," Ph.D. thesis (Safi-Harb)

5. Brett Meggison (2019), "Anisotropic Graphene," M.Sc. thesis (Carrington/Frey).

6. Mohammad Shirazi (2020), Ph.D. thesis (Schippers).

7. Olena Usoltseva (2019), "Estimates of Christoffel function on multivariate domains," Ph.D. thesis (Prymak).

3.6 Publications of Permanent Members

M.E. Alexander

1. Hagit Peretz-Soroka, Reuven Tirosh, Jolly Hipolito, Erwin Huebner, Murray Alexander, Jason Fiege, and Francis Lin. "A bioenergetic mechanism for amoeboid-like cell motility profiles tested in a microfluidic electrotaxis assay" Integrative Biology **9**(11): 839-896, 2017.

2. Ke Yang, Jiandong Wu, Guoqing Xu, Hagit Peretz-Soroka, Susy Santos, Murray Alexander, Ling Zhu, Michael Zhang, Yong Liu, Francis Lin. "A dual-docking microfluidic cell migration assay (D2-Chip) for testing neutrophil chemotaxis and the memory effect". Integrative Biology, **9**, 303-312, 2017.

3. S. Rathee, Nilam, M.E. Alexander. "Dynamics and control of glucose-insulin regulatory system in diabetics using vitamin D." Mathematics in Computer Science, (in press) Jul. 2017.

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

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

P.G. Blunden

No update provided for this report

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

Presentations

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

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

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

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

M. E. Carrington

- *Journal Articles*

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

2. "*Heavy Quarks Embedded in Glasma,*" M. E. Carrington, A. Czajka and S. Mrowczynski, Nucl. Phys. A **1001**, 121914 (2020).

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

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

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

6. "*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).

7. "*Effective Coupling Constant of Plasmons,*" M.E. Carrington and S. Mrowczynski, Phys. Rev. **D100**, 056020 (2019).

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

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

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

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

12. "*Smooth and sharp creation of a pointlike source for a* $(3+1)$*-dimensional quantum field,*" L.J. Zhou, Margaret E. Carrington, Gabor Kunstatter, Jorma Louko, Phys. Rev. **D95**, 085007 (2017).

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

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

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

- *Papers in Refereed Proceedings*

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

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

J. Fiege

No update provided for this report

A. R. Frey

Refereed Publications

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]].

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

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

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

Media Appearances

1. Comments on the Nobel Prize in Physics 2019, National Post article, Oct 8, 2019.

2. Comments on the Nobel Prize in Physics 2019, Canadian Press article (syndicated throughout Canada), Oct 8, 2019.

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

Talks

1. "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.

2. "Disentangling Brane & Flux Degrees of Freedom," Perimeter Institute, 2019.

3. "Black Holes: The Ultimate Quantum Computers?" Millenium Library, Winnipeg, 2019.

4. "To BH or Not To BH: Gravitational Stability of AdS and What That Means," University of Winnipeg, 2018.

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

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

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

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

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

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

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

T. D. Fugleberg

No update provided for this report

D. Krepski

Publications

1. (with J. Vaughan) Multiplicative vector fields on bundle gerbes, 35 pages. arXiv:2003.12874 (Submitted)

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

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

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

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

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

G. Kunstatter

Refereed Journal Articles:

- 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) .

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- L.J. Zhou, Margaret E. Carrington, G. Kunstatter, J. Louko, "Smooth and sharp creation of a pointlike source for a (3+1)-dimensional quantum field", Phys. Rev. **D95**, 085007 (2017) [arXiv:1610.08455].

- P. Mikula, M.E. Carrington, G. Kunstatter, "Gradient Flow in the Ginzburg-Landau Model of Superconductivity". Phys. Rev. B 94, 184501 (2017) [arXiv:1511.03714]

- J. Ziprick, J. Gegenberg and G. Kunstatter, "Polymer Quantization of a Self-Gravitating Thin Shell", Phys. Rev. **D94**, 1040176 (2016) [arXiv:1609.06665].

- Nils Deppe, Allison Kolly, Andrew R. Frey, Gabor Kunstatter, "Black Hole Formation in AdS Einstein-Gauss-Bonnet Gravity", JHEP10, 087 (2016) [arXiv:1608.05402].

- G. Kunstatter, H. Maeda and T. Taves, "New 2D dilaton gravity for nonsingular black holes" Classical and Quantum Gravity, **33**, 105005 (2016)102342.R1 2016 [arXiv:1509.06746].

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, " Lost Horizons: Regular Black Hole Formation and Evaporation", **Invited**, CAP Congress, SFU June, 2019.
- G. Kunstatter, "Lost Horizons: the formation and evaporation of regular black holes" **Invited, plenary**, JCAP-CGRRA, University of Alberta, June, 2018.

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.
- "Gradient flow in holographic superconductors",
  - University of Victoria, January 26, 2018.
  - Simon Fraser University, January 31, 2018.

P.D. Loly

1. Peter Loly, "Integer Square Matrices - The Science," submission to *Notebook Archive*, Wolfram Foundation.
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).

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

4. Adam Rogers, Ian Cameron and Peter Loly, "Compounding Doubly Affine Matrices", arXiv:1711.11084 (2017).

Talks

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

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

C. O'Dea

Refereed Articles

1. C. Reynolds, B. Punsly, G. Miniutti, C. P. O'Dea, N. Hurley-Walker, "Estimating the Jet Power of Mrk 231 during the 2017-2018 Flare," The Astrophysical Journal, 891, 59-83 (2020)

2. M. Lacy et al. "The Karl G. Jansky Very Large Array Sky Survey (VLASS): science case and survey design," Publications of the Astronomical Society of the Pacific, 132, 035001-035035 (2020)

3. T. Rose, A. C. Edge, F. Combes, S. Hamer, B. R. McNamara, H. Russell, M. Gaspari, P. Salomé, C. Sarazin, G. R. Tremblay, S. A. Baum, M. N. Bremer, M. Donahue, A. C. Fabian, G. Ferland, N. Nesvadba, C. O'Dea, J. B. R. Oonk, A. B. Peck, "A molecular absorption line survey towards the AGN of Hydra-A," Monthly Notices of the Royal Astronomical Society, 496, 364-380 (2020).

4. B. Sebastian, P. Kharb, C. O'Dea, J. F. Gallimore, S. A. Baum, "A radio polarimetric study to disentangle AGN activity and star formation in Seyfert galaxies," Monthly Notices of the Royal Astronomical Society, 499, 334-354 (2020).

5. A. Jimenez-Gallardo, F. Massaro, M. A. Prieto, V. Missaglia, C. Stuardi, A. Paggi, F. Ricci, R. P. Kraft, E. Liuzzo, G. R. Tremblay, S. A. Baum, C. P. O'Dea, B. J. Wilkes, J. Kuraszkiewicz, W. R. Forman, D. E. Harris, "The Chandra 3CR extragalactic survey at high redshift," The Astrophysical Jounral Supplements, 250, 1-7 (2020)

6. D. A. Sales, A. Robinson, R. A. Riffel, T. Storchi-Bergmann, J. F. Gallimore, P. Kharb, S. Baum, C. O'Dea, C. Hekatelyne, F. Ferrari, "Gemini IFU, VLA, and HST observations of the OH Megamaser Galaxy IRAS17526 + 3253," Monthly Notices of the Royal Astronomical Society, 486, 3350-3367 (2019)

7. B. Husemann, J. Scharwachter, T. A. Davis, M. Perez-Torres, I. Smirnova-Pinchukova, G. R. Tremblay, M. Krumpe, F. Combes, S. A. Baum, G. Busch, T. Connor, S. M. Croom, M. Gaspari, R. P. Kraft, C. P. O'Dea, M. Powell, M. Singha, T. Urrutia, "The Close AGN Reference Survey (CARS). A massive multi-phase outflow impacting the edge-on galaxy HE 1353-1917," Astronomy & Astrophysics, 627, 53-81 (2019)

8. Y. A. Gordon, K. A. Pimbblet, S. Kaviraj, M. S. Owers, C. P. O'Dea, M. Walmsley, S. A. Baum, J. P. Crossett, A. Fraser-McKelvie, C. J. Lintott, J. C.S. Pierce, "The Effect of Minor and Major Mergers on the Evolution of Low-excitation Radio Galaxies," The Astrophysical Journal, 878, 88-101 (2019)

9. I. Smirnova-Pinchukova, B. Husemann, G. Busch, P. Appleton, M. Bethermin, F. Combes, S. Croom, T. A. Davis, C. Fischer, M. Gaspari, B. Groves, R. Klein, C. P. O'Dea, M. Perez-Torres, J. Scharwachter, M. Singha, G. R. Tremblay, and T. Urrutia, "The Close AGN Reference Survey (CARS). Discovery of a global [C II] 158 μm line excess in AGN HE 1353-1917," Astronomy & Astrophysics, 626, L3-10 (2019)

10. T. Rose, A. C. Edge, F. Combes, M. Gaspari, S. Hamer, N. Nesvadba, H. Russell, G. R. Tremblay, S. A. Baum, C. O'Dea, A. B. Peck, C. Sarazin, A. Vantyghem, M. Bremer, M. Donahue, A. C. Fabian, G. Ferland, B. R. McNamara, R. Mittal, J. B. R. Oonk, P. Salomé, A. M. Swinbank, M. Voit, "Deep and narrow CO absorption revealing molecular clouds in the Hydra-A brightest cluster galaxy," Monthly Notices of the Royal Astronomical Society, 485, 229-238 (2019)

11. M. S. Calzadilla, H. R. Russell, M. McDonald, A. C. Fabian, S. A. Baum, F. Combes, M. Donahue, A. C. Edge, B. R. McNamara, P. E. J. Nulsen, C. P. O'Dea, J. B. Raymond Oonk, G. R. Tremblay, A. N. Vantyghem, "Revealing a Highly-Dynamic Cluster Core in Abell 1664 with Chandra," Astrophysical Journal, 875, 65-78 (2019)

12. S. Vaddi, P. Kharb, R.A. Daly, C.P. O'Dea, S.A. Baum, D.K. Deo, T.C. Barbusca, C. Murali, "A VLA-GMRT look at 11 powerful FR II quasars," Monthly Notices of the Royal Astronomical Society, 484, 385-408 (2019)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

41. G. R. Tremblay, **C. P. O'Dea**, S. A. Baum, R. Mittal, M. A. McDonald, F. Combes, Y. Li, B. R. McNamara, M. N. Bremer, T. E. Clarke, M. Donahue, A. C. Edge, A. C. Fabian, S. L. Hamer, M. T. Hogan, J. B. R. Oonk, A. C. Quillen, J. S. Sanders, P. Salome, and G. M. Voit, "Far Ultraviolet Morphology of Star Forming Filaments in Cool Core Brightest Cluster Galaxies," *Monthly Notices of the Royal Astronomical Society*, 451, 3768-3800 (2015)

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

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

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

S. Plosker

Peer-Reviewed Journal Articles

1. D. Farenick, F. Huntinghawk*, A. Masanika*, and S. Plosker, *Complete order equivalence of spin unitaries*, Linear Algebra and its Applications, accepted.

2. A. Chan, S. Fallat, J.C.-H. Lin, S. Kirkland, S. Nasserasr, and S. Plosker. *Complex Hadamard diagonalisable graphs*, Linear Algebra and its Applications, accepted.

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

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

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

6. 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.

7. 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.

8. 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.

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

10. S.J. Harris, R.H. Levene, V.I. Paulsen, S. Plosker, M. Rahaman. *Schur multipliers and mixed unitary maps*, Journal of Mathematical Physics, **59**, 112201 (2018).

11. S. Kirkland, D. Mclaren*, R. Pereira, S. Plosker, and X. Zhang*. *Perfect quantum state transfer in weighted paths with potentials (loops) using orthogonal polynomials*, Linear and Multilinear Algebra, pp. 1-19, 2018.

12. N. Johnston, C.-K. Li, S. Plosker, Y.T. Poon., and B. Regula. *Evaluating the robustness of k-coherence and k-entanglement*, Physical Review A, **98**, 022328, 2018

13. N. Johnston, C.-K. Li, and S. Plosker. *The modified trace distance of coherence is constant on most pure states*, Journal of Physics A: Mathematical and Theoretical, **51**, 414010, 2018.

14. N. Johnston, S. Kirkland, S. Plosker, R. Storey*, and X. Zhang*. *Perfect quantum state transfer using Hadamard diagonalizable weighted graphs.* Linear Algebra and its Applications, **531**, pp. 375–398, 2017.

15. J. Chen, S. Grogan, N. Johnston, C.-K. Li, and S. Plosker. *Quantifying the coherence of pure quantum states.* Physical Review A, **94**, 042313, 2016.

16. W. Gordon*, S. Kirkland, C.-K. Li, S. Plosker, and X. Zhang*. *Bounds on probability of state transfer with respect to readout time and edge weight.* Physical Review A **93**, 022309, 2016.

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

Peer-Reviewed Conference Proceedings

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

Invited Lectures

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

20. *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.

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

22. *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.

23. *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.

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

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

26. *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.

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

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

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

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

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

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

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A. Prymak

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S. Safi-Harb

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

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- *CSA's Topical team in High-Energy Astrophysics*. Canadian Scientific Priorities for the CSA Space Exploration Strategy. S. Safi-Harb acted as Chair of the Diffuse Emission sub-committee. Report submitted to the Canadian Space Agency in June (2017).

Conference Presentations

- *Pulsar Wind Nebulae at High Energies* by Safi-Harb, S., COSPAR ASSEMBLY to take place in 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 to take place in 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)
- *Colibrì: 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 summer school), Washington, D.C. (2 Invited talks), Waterloo (invited talk), Italy (Invited talk)

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

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

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

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

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

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

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

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

- *Pulsar Wind Nebula G21.5–0.9* by B. Guest & S. Safi-Harb, Modelling Nebulae workshop, Sant Cugat Forum on Astrophysics, Barcelona, Spain, June 14–17 (2016)

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

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

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

Invited Talks

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

- *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)

- *Neutron Stars–Supernova Remnants associations*; Workshop on 'The Theories of Astrophysical Big Bangs', Riken, Japan, Nov. 6–10 (2017)

- *Neutron stars: Observational diversity and evolution*; Physics of Neutron Stars conference celebrating 50 years since the discovery of neutron stars, ST Petersburg, Russia, July 10–14 (2017)

- *Supernova Remnants and Neutron Stars: an Astrophysical Laboratory for Probing the Physics of the Extreme*, B.C Tour: U. Victoria and TRIUMF colloquia, March 15–16 (2017)

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

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

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

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

Media, Outreach and Press Releases

- 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)
- How do Sun-like stars explode? Hitomi Mission Glimpses Cosmic Recipe for Nearby Universe, UofM/NASA/JAXA press releases, Nov (2017)
- Une recette cosmique pour un univers pres du notre, RCI Radio Canada, Nov. 18 (2017)
- Presentation for the CFI event attended by Minister of Science Kristy Duncan, UofM downtown campus, Oct 12 (2017)
- Discover your Future in Science Presentations, UofM, 08 Feb (2017) and 08 Feb (2018).
- Presentation at the UofM Faculty of Science Homecoming event, 19 Sep. (2016)
- Opening new windows into our universe, UofM and other press releases on the Hitomi first Nature paper on Perseus Cluster, July 2016
- Expanding molecular bubble unveils the mysterious origin of Tycho's supernova; UofM press release (and others including ESA), 19 July (2016).
- Hitomi press releases: several press releases and interviews highlighting the pre- and post-launch of the X-ray mission, ASTRO-H (renamed to Hitomi), including interviews with Safi-Harb on Discovery Channel, CBC, Manitoba news and others; Feb.–Mar. (2016).

Conference Organization

- Organizing committee member, 2022 North America Indigenous Science Conference to be hosted at the U. of Manitoba
- Chair, Women in Physics Canada Conference (WIPC2020), U. of Manitoba, Winnipeg, MB, 7-10 July (2020), postponed due to COVID-19

- Scientific Organizing Committee, Gamma2020: International Symposium on gamma-ray astronomy, Madrid (Spain), July (2020), postponed due to COVID-19
- Scientific Organizing Committee, IAU Symposium: Neutron Star Astrophysics at the Crossroads: Magnetars and the Multi-messenger revolution, to take place in L'Aquila (Italy) 22–26 June (2020), postponed due to COVID-19
- 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)
- Scientific Organizing Committee, 'Future of Canadian Radio Astronomy', McGill, Montreal, Sep. (2017)
- Scientific Organizing Committee, International Astronomical Union (IAU) Symposium 331 on 'SN1987A, 30 years later', Reunion Island (France), Feb. (2017)
- Scientific Organizing Committee member and rapporteur speaker, Sixth International Symposium on Gamma-ray Astronomy, Gamma2016, Heidelberg (Germany), June (2016)
- Organizing Committee member for CASCA 2016, Winnipeg (May 30-June 2, 2016)

Astrophysics Missions science working groups

- Neutron Stars Science working group lead for the Colibrì mission concept study, Canada's Flagship X-ray mission (2018–present)
- Science working group member for the proposed ESA's Athena X-ray mission (since Apr. 2015)
- Member of the Cherenkov Telescope Array (CTA) future gamma-ray mission (since Dec. 2014)
- Associate member of the H.E.S.S. gamma-ray collaboration (since Oct. 2011)
- 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

- Canadian Astronomical Society's Vice-President/President-Elect (2020–present)
- European Space Agency's Time Allocation Committee for the XMM-Newton Satellite (2020)
- Equity, Diversity and Community Lead for the Faculty of Science (May 2019–present)
- NSERC Discovery Grants Physics Evaluation Group (Fall 2019–present)
- NASA Senior Review for the Chandra X-ray Observatory (2018)
- CASCA Board of Directors (2018–2019)
- NRC's Covington Fellowship Search Committee (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
- Chair of the Canadian Space Agency's high-energy astrophysics Diffuse Emission Subcommittee (2015–2017)
- Member of NASA's Chandra Users Committee (2014–2017)
- CASCA local representative (2017–present)
- Member of the ACURA Advisory Committee for the Square Kilometre Array (2016-2018)

E. Schippers

Publications

1. Schippers, E.; and Staubach, W. "Analysis on quasidisks; a unified approach through transmission and jump problems". Submitted. arXiv:2009.01954
2. Radnell, D.; Schippers, E.; Shirazi, M.; and Staubach, W. "Schiffer operators and computation of a determinant line in conformal field theory". Submitted.
3. Schippers, E.; Shirazi, M.; and Staubach, W. "Schiffer operators and approximations on Riemann surfaces bordered by quasicircles". J. Geom. Anal. (2020). https://doi.org/10.1007/s12220-020-00508-w
4. Schippers, E.; and Staubach, W. "Transmission of harmonic functions through quasicircles on compact Riemann surfaces". Annales Academiae Scientiarum Fennicae **45** (2020), 1111–1134

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

6. Radnell, D.; Schippers, E.; and Staubach, W. "Dirichlet spaces of domains bounded by quasicrcles". To appear in Communications in Contermporary Mathematics.. arXiv:1705.01279v1.

7. 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

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

9. 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.

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

11. 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.

12. Radnell, D.; Schippers, E.; Staubach, W. "Dirichlet problem and Sokhotski-Plemelj jump formula on Weil-Petersson class quasidisks." Annales Academiae Scientiarum Fennicae. **41** (2016), 1–9.

13. Radnell, D.; Schippers, E.; and Staubach, W. "Convergence of the Weil-Petersson metric on the Teichmueller space of bordered Riemann surfaces", Communications in Contemporary Mathematics **19**, No. 01, 1650025 (2017).

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

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

16. Schippers, E.; and Staubach, W. "A symplectic functional analytic proof of the conformal welding theorem." Proceedings of the American Mathematical Society **143** (2015), 265 – 278.

17. Radnell, D.; Schippers, E.; and Staubach, W. "A Hilbert manifold structure on the Weil-Petersson class Teichmueller space of bordered Riemann surfaces. Communications in Contemporary Mathematics **17** no 4, 1550016 (2015) DOI: http://dx.doi.org/10.1142/S0219199715500169.

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

Book Chapter

19. 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.

Refereed Conference Proceedings

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

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

Research Presentations

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

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

24. Uppsala University Mathematics Colloquium, May 2018.

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

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

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

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

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

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

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

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

A. Shalchi

1. 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)

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

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

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

5. 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)

6. 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)

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

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

9. 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)

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

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

12. Shalchi, A., Analytical forms of the cosmic ray perpendicular diffusion coefficient with implicit contribution of slab modes, Advances in Space Research **62**, 2817 (2018)

13. Shalchi, A., Analytical Description of the Time-dependent Perpendicular Transport of Energetic Particles, The Astrophysical Journal **864**, 155 (2018)

14. Arendt, V. & Shalchi, A., Time-dependent transport of energetic particles in magnetic turbulence: computer simulations versus analytical theory, Advances in Space Research **363**, 116 (2018)

15. Lasuik, J. & Shalchi, A., The influence of non-Gaussian distribution functions on the time-dependent perpendicular transport of energetic particles, Advances in Space Research **61**, 2827 (2018)

16. Shalchi, A., Analytical Forms of the First 14 Moments of the Cosmic Ray Fokker-Planck Equation, Journal of Plasma Physics **83**, 905830603 (2017)

17. Negrea, M., Petrisor, I., & Shalchi, A., Stochastic field-line wandering in magnetic turbulence with shear. II. Decorrelation trajectory method, Physics of Plasmas **24**, 112303 (2017)

18. Gammon, M. & Shalchi, A., Simple Analytical Forms of the Perpendicular Diffusion Coefficient for Two-Component Turbulence, III. Damping Model of Dynamical Turbulence, The Astrophysical Journal **847**, 118 (2017)

19. Lasuik, J. & Shalchi, A., Time-Dependent Perpendicular Transport of Energetic Particles for Different Turbulence Configurations and Parallel Transport Models, The Astrophysical Journal **847**, 9 (2017)

20. Lasuik, J. & Shalchi, A., Solutions of the Cosmic Ray Velocity Diffusion Equation, Advances in Space Research **60**, 1532 (2017)

21. Shalchi, A., Time-dependent perpendicular transport of energetic particles in magnetic turbulence with transverse complexity, Physics of Plasmas Letters **24**, 050702 (2017)

22. Heusen, M. & Shalchi, A., Numerical Test of Analytical Theories for Perpendicular Diffusion in Small Kubo Number Turbulence, The Astrophysical Journal **839**, 2 (2017)

23. Acero, F., . . . , Shalchi, A., et al., Prospects for Cherenkov Telescope Array Observations of the young supernova remnant RX J1713.7-3946, The Astrophysical Journal **840**, 74 (2017)

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

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

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

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

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

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

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

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

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

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

Khodr M. Shamseddine

Refereed Journal Publications

1. 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, special volume in **STEAM-H: Science, Technology, Engineering, Agriculture, Mathematics & Health**, accepted for publication.

2. 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**, accepted for publication.

3. On computational applications of the Levi-Civita field, *Darren Flynn and Khodr Shamseddine*, **Journal of Computational and Applied Mathematics**, Volume 382, 2021.

4. 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.

5. 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.

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

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

Edited Proceedings

8. 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.

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

Refereed Conference Proceedings

10. 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.

11. 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.

12. Calculus on a non-Archimedean field extension of the real numbers: inverse function theorem, intermediate value theorem and mean value theorem, *Gidon Bookatz and Khodr Shamseddine*, **Contemporary Mathematics, American Mathematical Society**, Volume 704 (Advances in Ultrametric Analysis), 2018, pp. 49-67.

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

Invited Talks at Conferences

14. 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.

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

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

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

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

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

Contributed Talks at Conferences

20. 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

21. Department of Physics and Astronomy and Winnipeg Institute for Theoretical Physics (joint colloquium), University of Manitoba, March 8, 2019.

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

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

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

Conference and Workshop Organization

- Member of the International Organizing Committee, Eighth International Conference on p-adic Mathematical Physics and its Applications, Online Conference (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)

- Co-Organizer, Winnipeg Institute of Theoretical Physics Summer Symposium, U of Manitoba (July 31-August 1, 2017)
- Member of the International Scientific Committee, 14th International Conference on p- Adic Functional Analysis, France (July 2016)
- Member of the International Scientific Committee, NUMTA2016: Numerical Computations: Theory and Algorithms, Italy (June 2016)

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).

11. M. Kiefer-Emmanouilidis, J. Sirker,
"Current reversals and metastable states in the infinite Bose-Hubbard chain with local particle loss",
Phys. Rev. A **96**, 063625 (2017).

12. Y. Zhao, S. Ahmed, J. Sirker, "Localization of fermions in coupled chains with identical disorder", Phys. Rev. B **95**, 235152 (2017).

13. T. Enss, F. Andraschko, J. Sirker, "Many-body localization in infinite chains", Phys. Rev. B **95**, 045121 (2017).

14. D. Morath, N. Sedlmayr, J. Sirker, S. Eggert, "Conductance in inhomogeneous quantum wires: Luttinger liquid predictions and quantum Monte Carlo results", Phys. Rev. B **94**, 115162 (2016).

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

16. M. Harder, L. Bai, C. Match, J. Sirker, C.-M. Hu, "Study of the cavity-magnon-polariton transmission line shape", Sci. China Phys. Mech. Astron. **59**, 117511 (2016).

Talks

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

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

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

20. '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

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

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

23. "Transport from Integrability",
Les Houches Summer School, Lectures, September 2018

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

25. "Many-body localization in infinite chains",
Theory seminar, NPU, Xi'an, June 2018

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

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

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

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

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

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

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

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

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

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

B.W. Southern

Refereed Publications

1. 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)

2. 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).

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

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

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

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

Conference Contributions

7. A.R. Way, K.P.M. Hall, M. Plumer, I. Saika-Voivodi and B.W Southern. "Continuous Degeneracy in Dipolar Magnets". Magnetic North, Gimli, Canada (2019).

8. Bassel Alkadour, B.W. Southern, J.P. Whitehead and J. van Lierop. "Triangular array of gamma- Fe2O3 nanoparticles: A simulation study of intra- and inter-particle magnetism". Magnetic North, Gimli, Canada (2019).

9. B. Alkadour, B.W. Southern, J.P. Whitehead and J. van Lierop. "Triangular array of gamma-Fe2O3 nanoparticles: A simulation study of intra- and inter-particle magnetism". Manitoba Institute of Materials Conference, Winnipeg, Canada (2019).

10. B. Alkadour, B.W. Southern, J.P. Whitehead and J. van Lierop. "Triangular array of gamma-Fe2O3 nanoparticles: A simulation study of intra- and inter-particle magnetism". Winnipeg Institute for Theoretical Physics Symposium, Winnipeg, Canada (2019).

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

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

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

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

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

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

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

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

J.P. Svenne

No update provided for this report

No Current Refereed Publications

G.C. Tabisz

No Current Refereed Publications

J.M. Vail

No update provided for this report

Last Refereed Publications

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

M. Whitmore

No update provided for this report

Last Refereed Publications

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

J.G. Williams

1. T.A. Harriott and J.G. Williams, "Petrov type-N solution for the null-surface formulation in 2+1 dimensions," General Relativity and Gravitation, **51**, 98 (2019).

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

3. T.A. Harriott and J.G. Williams, "Solutions for the null-surface formulation of general relativity," in Proceedings of the 14th Marcel Grossmann Meeting on General Relativity, edited by M. Bianchi, R.T. Jantzen and R. Ruffini (World Scientific, Singapore), pp. 2525–2528 (2017).

4. T.A. Harriott and J.G. Williams, "Petrov type-N solution for the null-surface formulation of general relativity in 2+1 dimensions," 22nd International Conference on General Relativity and Gravitation. Valencia, Spain, 7–12 July 2019

J Ziprick

Refereed Journal Articles:

1. G. Kunstatter, J. Ziprick, V. McNab, A. Rennie, J. Toews, C. Speidel, "Escape from the Quantum Pigeon Conundrum," Physics Letters A **384**126686 (2019) arXiv:2002.01876 [quant-ph].

2. S.M. Hassan, V. Husain and J. Ziprick, "Quantum gravitational collapse as a Fermi system," Phys. Rev. D **97** 104032 (2018), arXiv:1707.02585 [gr-qc].

3. J. Ziprick, J. Gegenberg and G. Kunstatter, "Polymer Quantization of a Self-Gravitating Thin Shell," Phys. Rev. D **94** 104076 (2016), arXiv:1609.06665 [gr-qc].

4. M. Ali, V. Husain, S. Rahmati and J. Ziprick, "Linearized gravity with matter time," Class. Quant. Grav. **33** 105012 (2016), arXiv:1512.07854 [gr-qc].

5. V. Husain, S. Rahmati and J. Ziprick, "Linearized 3D gravity with dust," Phys. Rev. D **93** 024039 (2016), arXiv:1509.06091 [gr-qc].

6. J. Ziprick and J. Gegenberg, "Discrete Hamiltonian for general relativity," Phys. Rev. D **93** 041502(R) (2016), arXiv:1507.07591 [gr-qc].

Popular Articles:

1. J. Ziprick, G. Kunstatter, "Gravitational Wave Detections Usher in a New Era of Astronomy," Physics in Canada **74** (2018).

Research Presentations:

1. "Autonomous Camera Systems for High Throughput Plant Imaging," University of Manitoba, AIMday (2020).
2. "High Throughput Plant Imaging," University of Winnipeg, High Performance Computing (2019).
3. "Gravitational waves: a new window to the universe," University of Winnipeg, Physics Colloquium (2017).
4. "Polymer quantization," University of Winnipeg, Physics Colloquium (2017).
5. "Discrete General Relativity," CCGRRA[5], Vancouver, BC (2016).
6. "Basic elements of loop quantum gravity," CAP[6] Congress, Ottawa, ON (2016).
7. "Discrete General Relativity," Atlantic General Relativity, Halifax, NB (2016).

4 Financial

4.1 Statement of Income and Expenditures

Income

Income Source	Amount
UWinnipeg Dean of Science & VP Research	$2000.00
UManitoba Dean of Science	$3000.00
Total Income	$5000.00

Expenditures

Activity	Amount Spent
DTP/WITP PhD Thesis Prize	$250
WIPC 2021 conference commitment	$2500
Total Expenditures	$2750

The income listed above represents commitments to WITP funding from the three major universities in Manitoba from which the WITP draws its members. For the five-year period 2018-19 to 2022-23, the University of Winnipeg has commited $2000 per annum and the University of Manitoba has committed $3000 per annum. Brandon University contributed $1000 in 2018-19.

In addition to the supporting funds indicated above, it should be pointed out that the members of the Institute use their individual NSERC discovery grants to subsidize Institute activities. As of 2016-17, the members from the three universities drew upon more than $700,000 of individual NSERC Research Grants. These funds have a significant fortifying effect on the level of activities in which we are able to engage.

The Institute has neither endowment nor trust fund support. The Institute has no significant space requirements. The occasional long term visitor requires a desk, but these needs have been accommodated by the space available to the physics departments at the member Universities. The host departments also supply occasional secretarial support such as that required for the preparation of seminar notices and research papers.

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

The following represents an estimated budget for WITP activities in the five-year period from 2018-19 to 2022-23. It is important to note that the most costly WITP activity, the visitor program, is primarily funded by Member research grants, and those funds are not included in the proposed budget. The following expenditures are for activities that fall outside the usual purview of a research grant and which are more properly and efficiently organized as a collective. In addition, a small fraction of WITP funding will be used to supplement the visitor program by providing partial funding to extend the stay of some visitors or to make it possible for Members to extend an invitation.

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

- Conference support: $1500

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

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

- Summer School and Summer Symposium for graduate and undergraduate student researchers: $2500

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

- Visitor Support: $1750

  The WITP visitor program is primarily funded by Members; this funding is to allow visits that individual Members may not otherwise be able to afford or to increase the length of time that visitors can stay in Manitoba.

- DTP/WITP P. R. Wallace PhD Thesis Prize: $250

Total: $6000 per annum

4.2 Financial Stability and Growth

The Institute has no substantial fixed costs and for this reason it is intrinsically stable. It can operate in a productive fashion at a variety of funding levels. All of the funds that the Institute receives are transformed directly into its research enhancing activities. The funds allocated to the Institute by the three universities in Manitoba are fortified by the individual NSERC research grants of members. This is a strong commitment to the Institute by the Institute members. In view of its overall research productivity, in terms of published papers and supervised graduate students, its capacity for running very successful conferences and workshops, and the demonstrated ability to attract excellent short-term and long-term visiting scientists, the Institute is achieving its goals.

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

The report guidelines suggest that some indication be given of the percentage of time that members spend on Institute research. Since the Institute's programs enhance the ongoing research interests of its members, there is no distinction between individual research and Institute research. The director has spent less than 5% of his time with the administrative aspects of the Institute.

1 Appendix: Research Interests of Members

M.E. Alexander

My principal research interests are:

Dynamics of exoplanet systems. (1) (Manuscript in preparation) Together with Dr. E. Budding, a theoretical model to explain anomalies in photometric and spectroscopic measurements of exoplanet transits in several systems, using data primarily from the Kepler mission. This past year, the model has been developed to include interaction of the normal mode oscillations of a rotating host star with the orbiting exoplanet, without the assumption that the rotation and orbital axes are aligned - as has been the case in the literature. Interaction of rotational and orbital motion causing resonance effects between the stellar precession and nutation and orbital motion of the transiting exoplanet. These interactions are expected to be dynamically complex, and will be studied analytically and numerically, to compare with available obsrvational data on the growing list of systems with unaligned rotaion and orbital axes. This work is based on earlier (1987-88) work on resonant rotational/orbital interactions in binary star systems, published in Monthly Notices of the Royal Astronomical Society.

(2) **Effects of stellar winds on orbital period changes in sdOB-type binary systems** In collaboration with Dr. D. Kilkenny (Univ. Western Cape, South Africa) and Dr. A.E. Lynas-Gray (Univ. College London, UK), I am developing a model for stellar winds in subdwarf B-type binary systems, in order to explain observational data on orbital period changes in these systems. This work is and a continuation of a project on the effects of stellar winds arising from the late-type secondary in these systems caused by irradiation by the hot subdwarf primary component. We are attempting to model the interaction of the wind with the magnetic field of the secondary, to try to explain the observed period changes in these systems, several of which cannot be explained by other mechanisms (e.g., Applegate mechanism, exoplanets, gravitational radiation). A simple model has previously been derived, but a more comprehensive one is under investigation.

P.G. Blunden

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

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

Precision low-energy experiments in atomic parity-violation and in parity-violating electron-proton scattering are a vital complement to direct tests of the Standard Model. They also give information about the structure of the proton, such as its weak charge and strangeness content. These low-energy measurements have the potential to give constraints on new physics, provided that the critical radiative corrections involving hadronic contributions are understood.

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

M.E. Carrington

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

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

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

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

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

I am also starting a program of research into understanding the relation of quantum gravity to information theory in the context of string theory. Most of this work occurs in AdS gravity and the AdS/CFT correspondence, but I am interested in developing connections to dS and string compactifications.

Finally, I maintain a long-standing interested 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

In February of 2016, the LIGO (Light Interference Gravitational wave Observatory) Scientific Collaboration announced the detection of gravitational waves emitted by the merger of two massive black holes a

billion years ago. This observation provided astounding confirmation of the validity of Einstein's theory of gravity in the strong field region as well as the first direct evidence for the existence of black holes.

According to Einstein's theory, at the center of every black hole there exists a "singularity", a region of infinite density and curvature, where the known laws of physics break down. Such singularities do not pose a threat as long as they are concealed beneath the event horizon of a black hole. In the mid 1970's Stephen Hawking showed that quantum processes near the event horizon allow energy to leak out in the form of thermal radiation. This radiation causes the black hole to shrink and eventually disappear without revealing any information about the matter that fell into the black hole. Consequently black holes appear to have the capacity to irreversibly destroy information, leading to the so-called "black hole information loss conundrum". It is commonly believed that the information loss conundrum can only be fully resolved once quantum mechanics is successfully unified with gravitation theory, something that has eluded theoretical physicists for many decades.

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

P.D. Loly

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

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

C. O'Dea

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

S. Plosker

My research interests fall under the general umbrella of operator theory and matrix analysis, with applications to quantum information theory. Quantum information theory is the study of quantum properties

that can be used to store, transmit, and process information in an efficient, accurate, and secure way. My approach is to build up the mathematical foundations for physical realizations in quantum mechanics through operator theory and matrix algebra techniques with the end goal of advancing the mathematics behind quantum information theory. My current focus is on quantum coherence, positive operator valued measures (POVMs), quantum fidelity (probability of state transfer), and various generalizations of majorization as they pertain to entanglement transformations and other problems in quantum information theory.

A. Prymak

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

S. Safi-Harb

My research is focused on the study of supernova remnants (SNRs) and associated phenomena. These include neutron stars, pulsar wind nebulae, the interaction of these objects with the interstellar medium, and the acceleration of cosmic rays at supernova shocks. The science goals of my research program are targeted to understand the aftermath of a supernova explosion, the growing diversity of neutron stars (including magnetars), their relativistic outflows and magnetic field evolution, their evolution and interaction with their hosting supernova remnant shells, nucleosynthesis, and the acceleration of cosmic rays to extremely high energies. My program makes use of multi-wavelength observations from radio to very high-energies, with focus on X-ray data acquired with NASA's Chandra and NuSTAR and ESA's XMM-Newton satellites, combined with modelling. I played a leadership role on the international, JAXA-led, ASTRO-H (renamed to Hitomi) X-ray satellite, serve on the science team for the future ESA-led ATHENA X-ray mission, and currently lead the neutron stars' science working group for the first Canadian X-ray telescope (Colibri) concept study approved by CSA in Sep. 2018. In radio, I serve on the ACURA Advisory Committee for the Square Kilometre Array (SKA). In optical, I was selected for the TMT International Science Development Team for the Milky Way & Nearby Galaxies. At gamma-ray energies, I am an associate member of the currently operating H.E.S.S. mission and a member of the upcoming Cherenkov Telescope Facility (CTA). My team also includes numericists/theorists/computer scientists developing models to interpret and catalogue data, performing state-of-the-art numerical simulations to apply to data, and making use of a local CFI-funded computing cluster. Lastly, with the latest LIGO discovery of the Gravitational Wave Neutron Stars Merger event (aka kilonova), my research is branching out into this new direction.

E. Schippers

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

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

Friedan/Shenker and Vafa considered moduli spaces of Riemann surfaces with extra data, formulated either as boundary parametrizations or collections of non-overlapping mappings. With David Radnell, I showed that this moduli space is in fact the quasiconformal Teichmuller space. This allowed the resolution of certain analytic problems in the programme of construction of 2D conformal field theory: for example,

we showed that the moduli space has a complex structure and the sewing operation is holomorphic. In further work with W. Staubach, we constructed a Teichmuller space modelled on square-integrable local deformations, which we conjecture to be the correct space for the existence of a determinant line bundle of dbar operators with boundary data, which is central to the construction of CFT from moduli spaces of Riemann surfaces.

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

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

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

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

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

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

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

A. Shalchi

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

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

Khodr M. Shamseddine

My research interests and activities include various areas of non-Archimedean Analysis: 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 $\mathcal{R}$) 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, $\mathcal{R}$ is small enough so that the numbers of the field can be implemented on a computer; and this allows for many useful applications, one of which is the fast and accurate computation of the derivatives of real-valued functions up to high orders.

We have studied in my research group two topologies on $\mathcal{R}$: 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 $\mathcal{R}$, that the valuation topology is not a vector topology while the weak topology is, and that $\mathcal{R}$ is complete in the valuation topology while it is not in the weak topology. Then we studied the properties of both topologies in detail; in particular, we gave simple characterizations of open, closed, and compact sets in both topologies. Finally, we showed that the metric which induces the weak topology is translation invariant.

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 $\mathcal{R}$. We introduced a measure that proved to be a natural generalization of the Lebesgue measure on the field of the real numbers and 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 $\mathcal{R}^2$ (resp. $\mathcal{R}^3$). 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 $\mathcal{C} := \mathcal{R} + i\mathcal{R}$, where c_0 denotes the space of all null sequences

of elements of $\mathcal{C}$. The natural inner product on c_0 induces the sup-norm of c_0. We showed that c_0 is not orthomodular; then we characterized those closed subspaces of c_0 with an orthonormal complement with respect to the inner product. 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 $\mathcal{R}$ 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 $\mathcal{R}$ 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.

J. P. Svenne

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

G. Tabisz

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

J.M. Vail

My principal research area has been in developing and applying methods to simulate the properties of solid materials. Reliable simulation is an important complement to experiment in studying material properties where subtle variations of chemical composition, crystal structure, electronic configuration, and disorder are crucial, or where time scales, and temperature and pressure regimes are experimentally inaccessible. In 1984, with collaborators, we made a major advance in the atomistic simulation of point defects in ionic materials by combining accurate electronic structure methods for the defect with total energy analysis of the crystal. The method includes physically consistent boundary conditions, the quantum-mechanical ion-size effect, and lattice distortion and polarization, and is embodied in an automated user-friendly program. The method has been applied to charge state and structural stability of defect complexes, optical and spin resonance properties of color centers and impurities, local modification of valence and conduction band edges by impurities, derivation of effective interatomic forces, hole trapping and electron loss by impurities in oxides, local phonon mode frequencies, and classical and quantum diffusion. I maintain an interest in my recent publication, on the properties of anionic site defects in AlN, a wide band-gap insulator.

My most recent published research has been on Charge density waves having the electronic properties of graphene: stability conditions. It examines the physical limitations for stability of such CDWs, and the dependence of the total energy upon the parameter which defines the effective electron-electron interaction, including the phonon-mediated component.

D.W. Vincent

My general research interests lie in gravitation theory and early universe cosmology. I am currently involved with calculations on multidimensional cosmology solutions of Einstein's equations, which have relevance to the cosmological constant problem, the Anthropic Principle, and the Many-Worlds approach to quantum cosmology .

M. Whitmore

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

J.G. Williams

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.

J. Ziprick

One of my main current interests is in developing and applying machine learning algorithms for problems in industry. I am working to develop a Q-learning algorithm that uses sensor input for autonomous vehicle control as well as light-weight algorithms that can run on single board computers to monitor equipment performance based on sensor input.

I continue to work in quantum information and quantum computing. The development of quantum neural networks is still in its infancy, and I am very interested to work in this area as it is undoubtedly going to become a prominent field of study in the near future as quantum computing technology continues to become more powerful and more accessible.

I have an ongoing fascination with general relativity and quantum gravity as the greatest gap in our theoretical understanding of nature. Black hole singularities and the information loss paradox demonstrate the need for quantum effects in gravity, and I continue to work on non-singular, dynamical solutions to black hole formation to uncover clues toward a theory of gravity.