Nils Deppe

Theoretical Astrophysics
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Major Fields of Interest

Binary neutron star mergers, accretion disks, multimessenger astronomy, numerical methods for partial differential equations, critical behavior in general relativity

Education

Ph.D. Physics, *Cornell University (CU)*   2020
   Advisor: Prof. Saul Teukolsky
   Dissertation Title: "Computational advances in general relativity"

M.S. Physics, *Cornell University (CU)*   2017

B.S. mathematical physics, *University of Winnipeg (UW)*   2014

Experience

Sherman Fairchild Postdoc in Theoretical Astrophysics, Caltech   2020–
- *Advisors: Prof. Mark Scheel, Prof. Saul Teukolsky*
- Implementing discontinuous Galerkin-finite-difference hybrid methods for MHD binary neutron star merger simulations in open-source task-parallel code SpECTRE (github.com/sxs-collaboration/spectre)
- Performed first-ever rotating & magnetized neutron star simulations using discontinuous Galerkin methods [7, 8]
- SpECTRE is used in 15 papers, including [1, 3–11, 13–15, 17, 18]
- Developed new initial data resulting 2× speed up of spin-0.99 binary black hole simulations with Cornell graduate student [12]
- Mentoring 3 undergraduate and 5 graduate students

Graduate Research Assistant, CU   2015–2020
- *Advisors: Prof. Saul Teukolsky, Dr. Lawrence Kidder*
- Development of SpECTRE, an open-source exascale relativistic astrophysics code (github.com/sxs-collaboration/spectre)
- First high-accuracy simulations of scalar field critical collapse in 3d general relativity [22]
- Studied whether black hole formation is inevitable in anti-de Sitter space [19, 20, 24–26]

Software Engineering Intern, Uber Advanced Technologies Group   5/2018–8/2018
- Developed new mapping infrastructure for autonomous vehicles in C++

NSERC **Undergraduate Student Research Award**, UW   2012–2014
- *Advisor: Prof. Gabor Kunstatter*
- Studied gravitational collapse in anti-de Sitter spacetime in Einstein-Gauss-Bonnet theory [26]
- Studied critical behavior in spherically symmetric scalar field collapse in Einstein-Gauss-Bonnet theory [27]

Undergraduate Honours Thesis, UW   9/2013–4/2014
- *Advisors: Prof. Gabor Kunstatter, Prof. Murray Alexander*
- On the initial value problem of general relativity

Grants, Awards, and Honors

– Computer Time, Co-PI, NSF XSEDE, Gravitational Waves From Compact Binaries: Computational Contributions to LIGO, *8.7 million CPU-hours to the Simulating eXtreme Spacetimes collaboration*	2021–2022
– Sherman Fairchild Postdoctoral **Prize Fellowship**	2020–2023
– John and David Boochever **Prize Fellowship** in Fundamental Theoretical Physics	2019
– NSERC **Postgraduate Scholarship** — Doctoral Program	2015–2018
– XSEDE International High Performance Computing Summer School Full Funding	2016
– Fields Institute Funding for Focus Week Workshop	2015
– Golden Key Undergraduate Student Achievement Award	2014
– McKenzie King Open Scholarship — Partial Award	2014
– NSERC **Canadian Graduate Scholarship** — declined	2014
– 3× NSERC **Undergraduate Student Research Award**	2012–2014
– Duckworth Scholarship in Physics	2013
– Sir William Stephenson Scholarship	2013
– Dean's Honour List, Student of Highest Distinction	2013
– Canadian Association of Physicists, Division of Theoretical Physics Best Student Oral Presentation Award, Second Prize	2013
– B.G. Hogg Scholarship in Physics	2012
– Dr. Donald Kydon Prize in Physics	2012
– Academic Proficiency Scholarship (Robert Bruce Fund)	2012
– Dean's Honour List, Student of Highest Distinction	2012

Teaching/Mentoring Experience

– Mentored Caltech graduate students in the numerical relativity group	2020–
– Mentored Cornell graduate students in Prof. Teukolsky's research group	2018–
– Mentored Cornell undergraduates in Prof. Teukolsky's research group	2017–
– Teaching assistant and grader, CU, heat & electromagnetism, computational physics	8/2014–5/2016
– Student Research Assistant Mentor, UW, Mentor of student working in physics department	5/2012–8/2012
– Student Research Assistant Mentor, UW, Mentor of collaborator's student at the University of Waterloo	1/2013–3/2013
– Teaching Assistant, UW, Intro to physics lab, Mathematical physics I & II, Quantum mechanics I	2011–2014

Invited Colloquia and Seminars

20. Computational Astrophysics Club, 2022, Princeton University   10/2022
    "Hybrid discontinuous-Galerkin-finite-difference methods for computational astrophysics"

19. Astrophysics Coffee, 2022, Institute for Advanced Study, Princeton   10/2022
    "SpECTRE: A relativistic computational astrophysics code"

18. Exploring extreme matter and spacetimes with gravitational waves, 2022, California State University Fullerton   9/2022
    "The SpECTRE numerical-relativity code: goals, progress, and future directions"

17. Frontiers in Numerical Relativity, 2022, University of Jena   7/2022
    "A high-order discontinuous Galerkin-finite-difference hybrid method for numerical relativity"

16. Physics Special Colloquium, Cornell University   4/2022
    "The Curious Case of Gravity: From Microscopic to Supermassive"

15. Scientific Computing Seminar, Durham University   3/2022
    "SpECTRE: A task-based framework for astrophysics"

14. Gravity Seminar, Harvard, Lisbon, & Chinese Academy of Sciences   3/2022
    "Seeing In Detail: High-order discontinuous Galerkin-finite-difference hybrid methods for numerical relativity"

13. Theoretical Physics Seminar, University of Winnipeg   3/2022
    "Challenges for accurate gravitational wave astrophysics predictions"

12. Physics Colloquium, Montana State University   3/2022
    "Keeping Up With Experimentalists: Accurate predictions for multimessenger gravitational wave astrophysics"

11. LIGO Seminar, California Institute of Technology   2/2022
    "Keeping Up With Experimentalists: Accurate predictions for multimessenger gravitational wave astrophysics"

10. LEPP Seminar, Cornell University   2/2022
    "Keeping Up With Experimentalists: Accurate predictions for multimessenger gravitational wave astrophysics"

9. Astronomy Colloquium, University of California, Berkeley   2/2022
    "Keeping Up With Experimentalists: Accurate predictions for multimessenger gravitational wave astrophysics"

8. Astronomy Seminar, University of California, Berkeley   2/2022
    "Taming the Extreme: Improvements for high-spin binary black hole merger simulations"

7. ICERM Numerical Relativity Workshop, Brown University   9/2020
    "SpECTRE: Towards high-order hydrodynamics and exascale numerical relativity"

6. Theoretical Astrophysics Seminar, California Institute of Technology   1/2020
    "SpECTRE: Rethinking simulations of relativistic magnetohydrodynamics"

5. University of Jena, Jena, Germany   3/2019
    "SpECTRE: Towards improved simulations of relativistic astrophysical systems"

4. Max Planck Institute for Gravitational Physics (Albert Einstein Institute),   3/2019
   Potsdam-Golm, Germany
   "SpECTRE: Towards improved simulations of relativistic astrophysical
   systems"

3. Fields Institute, University of Toronto, Black Hole Stability Focus Week,   6/2015
   "Two-Mode Data and Massive Scalars in AdS"

2. University of Michigan,   5/2015
   "(In)stability of Anti-de Sitter Spacetime"

1. University of Waterloo,   6/2013
   "Gravitational Collapse in Lovelock Gravity Using Adaptive Mesh Refinement"

Conference Presentations

20. Charm++ Workshop 2022,   10/2022
    "SpECTRE: A task-based spectral code for relativistic astrophysics"

19. American Physical Society April Meeting,   4/2022
    "Simulating a magnetized neutron star with discontinuous Galerkin methods"

18. American Physical Society April Meeting, Virtual,   4/2021
    "Robust adaptive-order methods for relativistic magnetohydrodynamics"

17. Pacific Coast Gravity Meeting, Virtual,   3/2021
    "Robust adaptive-order methods for relativistic magnetohydrodynamics"

16. Eastern Gravity Meeting, University of Massachusetts Dartmouth,   5/2019
    "Simulating Disks With Discontinuous Galerkin Methods"

15. 17th Annual Charm++ Workshop, University of Illinois Urbana-Champaign,   5/2019
    "SpECTRE: Towards improved simulations of relativistic astrophysical
    systems"

14. American Physical Society April Meeting, Denver, Colorado, "Simulating Disks   4/2019
    With Discontinuous Galerkin Methods"

13. American Physical Society April Meeting, Columbus, Ohio,   4/2018
    "Critical Collapse of a Massless Scalar Field in 3+1D General Relativity"

12. 16th Annual Charm++ Workshop, University of Illinois Urbana-Champaign,   4/2018
    "A SpECTRE With a New Face"

11. Eastern Gravity Meeting, Pennsylvania State University,   6/2017
    "Critical Collapse of a Massless Scalar Field in 3+1D General Relativity"

10. 15th Annual Charm++ Workshop, University of Illinois Urbana-Champaign,   4/2017
    "SpECTRE: A Next-Generation Relativistic Astrophysics Code"

9. Canadian Association of Physicists Annual Congress, Laurentian University,   6/2014
   "Critical Phenomena in Higher Dimensional Gravity Using Adaptive Mesh Re-
   finement"

8. CCGRRA, University of Winnipeg,   5/2014
   "Critical Phenomena in Higher Dimensional Gravity Using Adaptive Mesh Re-
   finement"

7. WITP Summer Symposium, University of Winnipeg,   8/2013
   "Adaptive Mesh Refinement for Constrained 1D Hyperbolic Systems"

6. 16th Eastern Gravity Meeting, University of Toronto,   6/2013
   "Gravitational Collapse in Higher Dimensional Lovelock Gravity"

5. Canadian Association of Physicists Annual Congress, Université de Montréal,   5/2013
   "Gravitational Collapse in Higher Dimensional Lovelock Gravity"
4. Theory Canada 8 Conference, Université de Sherbrooke,   5/2013
   "Gravitational Collapse in Higher Dimensional Lovelock Gravity"
3. Canadian Undergraduate Physics Conference, University of British Columbia,   10/2012
   "Critical Phenomena in Einstein-Gauss-Bonnet Gravity"
2. WITP Summer Symposium, University of Winnipeg,   8/2012
   "Critical Phenomena in Einstein-Gauss-Bonnet Gravity"
1. 3rd Conference of the CPTPN, First Nations University,   8/2012
   "Critical Phenomena in Einstein-Gauss-Bonnet Gravity"

Professional Service

– **Peer referee**: *Canadian Journal of Physics*, and *European Physics*   2017–present
  Journal A

Professional Societies

– American Physical Society   2015–present
– Golden Key International Honour Society   2013–present

Volunteer Work

– University of Winnipeg Physics Students' Association, Co-President &   2011–2014
  Fundraiser Organization
– Volunteer Note Taker, Accessibility Services UW   2011–2014
– Let's Talk Science and University of Winnipeg Physics Department,   2012–2014
  Science Rendezvous, Demonstrator and In Costume Volunteer
– Let's Talk Science, Demonstrator   2012–2014

Publications

Submitted

[1] Keefe Mitman, . . . , **Nils Deppe**, et al. Nonlinearities in black hole ringdowns. 8 2022.

[2] Yitian Chen, . . . , **Nils Deppe**, et al. Multipole moments on the common horizon in a binary-black-hole simulation. 8 2022.

[3] Nils L. Fischer, . . . , **Nils Deppe**, et al. High-accuracy numerical models of Brownian thermal noise in thin mirror coatings. 11 2021.

[4] Jordan Moxon, Mark A. Scheel, Saul A. Teukolsky, **Nils Deppe**, et al. The SpECTRE Cauchy-characteristic evolution system for rapid, precise waveform extraction. 10 2021.

Peer reviewed

[5] Keefe Mitman, . . . , **Nils Deppe**, et al. Fixing the BMS frame of numerical relativity waveforms with BMS charges. *Phys. Rev. D*, 106(8):084029, 2022.

[6] Sizheng Ma, ..., **Nils Deppe**, et al. Quasinormal-mode filters: A new approach to analyze the gravitational-wave ringdown of binary black-hole mergers. *Phys. Rev. D*, 106(8):084036, 2022.

[7] **Nils Deppe**, François Hébert, Lawrence E. Kidder, and Saul A. Teukolsky. A high-order shock capturing discontinuous Galerkin-finite-difference hybrid method for GRMHD. *Class. Quant. Grav.*, Accepted, 2022.

[8] **Nils Deppe** et al. Simulating magnetized neutron stars with discontinuous Galerkin methods. *Phys. Rev. D*, 105(12):123031, 2022.

[9] Sizheng Ma, ..., **Nils Deppe**, et al. Gravitational-wave echoes from numerical-relativity waveforms via spacetime construction near merging compact objects. *Phys. Rev. D*, 105(10):104007, 2022.

[10] Lorena Magaña Zertuche, ..., **Nils Deppe**, et al. High Precision Ringdown Modeling: Multimode Fits and BMS Frames. *Phys. Rev. D*, 105:104015, 2022.

[11] Nils L. Fischer, ..., **Nils Deppe**, et al. A scalable elliptic solver with task-based parallelism for the SpECTRE numerical relativity code. *Phys. Rev. D*, 105:084027, 11 2021.

[12] Yitian Chen, **Nils Deppe**, Lawrence E. Kidder, and Saul A. Teukolsky. Efficient simulations of high-spin black holes with a new gauge. *Phys. Rev. D*, 104:084046, 2021.

[13] Keefe Mitman, ..., **Nils Deppe**, et al. Fixing the BMS frame of numerical relativity waveforms. *Phys. Rev. D*, 104(2):024051, 2021.

[14] Dante A. B. Iozzo, ..., **Nils Deppe**, et al. Comparing Remnant Properties from Horizon Data and Asymptotic Data in Numerical Relativity. *Phys. Rev. D*, 103(12):124029, 2021.

[15] Keefe Mitman, ..., **Nils Deppe**, et al. Adding gravitational memory to waveform catalogs using BMS balance laws. *Phys. Rev. D*, 103(2):024031, 2021.

[16] Dante A. B. Iozzo, ..., **Nils Deppe**, et al. Extending gravitational wave extraction using Weyl characteristic fields. *Phys. Rev. D*, 103(2):024039, 2021.

[17] Francois Foucart, ..., **Nils Deppe**, et al. High-accuracy waveforms for black hole-neutron star systems with spinning black holes. *Phys. Rev. D*, 103(6):064007, 2021.

[18] Keefe Mitman, ..., **Nils Deppe**, et al. Computation of displacement and spin gravitational memory in numerical relativity. *Phys. Rev. D*, 102(10):104007, 2020.

[19] Brad Cownden, **Nils Deppe**, and Andrew R. Frey. Phase diagram of stability for massive scalars in anti–de Sitter spacetime. *Phys. Rev. D*, 102(2):026015, 2020.

[20] **Nils Deppe**. Resonant dynamics in higher dimensional anti-de Sitter spacetime. *Phys. Rev.*, D100(12):124028, 2019.

[21] Michael Boyle, ..., **Nils Deppe**, et al. The SXS Collaboration catalog of binary black hole simulations. *Class. Quant. Grav.*, 36(19):195006, 2019.

[22] **Nils Deppe**, Lawrence E. Kidder, Mark A. Scheel, and Saul A. Teukolsky. Critical behavior in 3D gravitational collapse of massless scalar fields. *Phys. Rev.*, D99(2):024018, 2019.

[23] Lawrence E. Kidder, . . . , **Nils Deppe**, et al. SpECTRE: A Task-based Discontinuous Galerkin Code for Relativistic Astrophysics. *J. Comput. Phys.*, 335:84–114, 2017.

[24] **Nils Deppe**, Allison Kolly, Andrew R. Frey, and Gabor Kunstatter. Black Hole Formation in AdS Einstein-Gauss-Bonnet Gravity. *JHEP*, 10:087, 2016.

[25] **Nils Deppe** and Andrew R. Frey. Classes of Stable Initial Data for Massless and Massive Scalars in Anti-de Sitter Spacetime. *JHEP*, 12:004, 2015.

[26] **Nils Deppe**, Allison Kolly, Andrew Frey, and Gabor Kunstatter. Stability of AdS in Einstein Gauss Bonnet Gravity. *Phys. Rev. Lett.*, 114:071102, 2015.

[27] **Nils Deppe**, C. D. Leonard, T. Taves, G. Kunstatter, and R. B. Mann. Critical Collapse in Einstein-Gauss-Bonnet Gravity in Five and Six Dimensions. *Phys. Rev. D*, 86:104011, 2012.

Educational

[28] **Nils Deppe**. *Foundations of Physics II Instructors Lab Manual PHYS. 2303/6.* University of Winnipeg, Department of Physics, 2011.

[29] Stephen Klassen and **Nils Deppe**. *Foundations of Physics II Lab Manual PHYS. 2303/6.* University of Winnipeg, Department of Physics, 2011.

References

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