Ian Ruchlin

A physicist, mathematician, and developer…
a creator, problem solver, and curious mind.

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Research Interests

In pursuing a lifelong passion for simulation and visualization, I have accrued a diverse tool set in the fields of physics, mathematics, and computer programming. As a professional scientist, I contribute to several research projects, most notably in developing advanced numerical models of orbiting and colliding black holes. The amalgamation of these diverse skill sets makes me an indispensable asset for any computational research group.

Education

2010/09–2015/08	Ph. D.	Astrophysical Sciences and Technology, Rochester Institute of Technology, Rochester, NY, USA.
2007/09–2010/05	B. Sc.	Physics, Syracuse University, Syracuse, NY, USA.
2007/09–2010/05	B. Sc.	Mathematics, Syracuse University, Syracuse, NY, USA.

Employment

2015/09–2018/06	Postdoctoral Research Associate, Department of Mathematics, West Virginia University.
2011/06–2015/08	Graduate Research Associate, Center for Computational Relativity and Gravitation, Rochester Institute of Technology.
2010/09–2011/05	Graduate Teaching Assistant, College of Science, Rochester Institute of Technology.
2008/02–2010/08	Laboratory Assistant, Cryogenic Dark Matter Search, Syracuse University.

Publications

1. Zachary J. Silberman, Thomas R. Adams, Joshua A. Faber, Zachariah B. Etienne, and **Ian Ruchlin** (2018). Numerical generation of vector potentials from specified magnetic fields. Submitted to J Comp Phys. arXiv:1803.10207.
2. Vassilios Mewes, Yosef Zlochower, Manuela Campanelli, **Ian Ruchlin**, Zachariah B. Etienne, and Thomas W. Baumgarte (2018). Numerical relativity in spherical coordinates with the Einstein Toolkit. Physical Review D (97) 084059. arXiv:1802.09625.
3. **Ian Ruchlin**, Zachariah B. Etienne, and Thomas W. Baumgarte (2018). SENR/NRPy+: Numerical relativity in singular curvilinear coordinate systems. Physical Review D (97) 064036. arXiv:1712.07658.
4. James Healy, Carlos O. Lousto, **Ian Ruchlin**, and Yosef Zlochower (2018). Evolutions of unequal mass, highly spinning black hole binaries. Physical Review D (97) 104026. arXiv:1711.09041.
5. Yosef Zlochower, James Healy, Carlos O. Lousto, and **Ian Ruchlin** (2017). Evolutions of nearly maximally spinning black hole binaries using the moving puncture approach. Physical Review D (96) 044002. arXiv:1706:01980.
6. **Ian Ruchlin**, James Healy, Carlos O. Lousto, and Yosef Zlochower (2017). Puncture initial data for black-hole binaries with high spins and high boosts. Physical Review D (95) 024033. arXiv:1410.8607.
7. James Healy, **Ian Ruchlin**, Carlos O. Lousto, and Yosef Zlochower (2016). High energy collisions of black holes numerically revisited. Physical Review D (94) 104020. arXiv:1506.06153.
8. **I. Ruchlin** and R. W. Schnee (2012). Calculating a confidence interval on the sum of binned leakage. Nuclear Instruments and Methods in Physics Research Section A. Volume 664, Issue 1, Pages 336–340. arXiv:1106.6296.

Grants & Fellowships

- American Physical Society Travel Grant (APS April Meeting Travel Grant, 2015/04).
- Graduate Student Research and Creativity Grant (Rochester Institute of Technology Grant, 2014/12).
- New York Space Grant/Astrophysical Sciences & Technology Fellowship (Rochester Institute of Technology, 2013/08–2014/05).
- New York Space Grant/Astrophysical Sciences & Technology Fellowship (Rochester Institute of Technology, 2011/08—2012/05).
- Astrophysical Sciences and Technology Travel Grant (Rochester Institute of Technology Grant, 2011/11).
- Graduate Student Research and Creativity Grant (Rochester Institute of Technology Grant, 2011/11).
- Chancellor's Scholarship (Syracuse University Merit Scholarship, 2007/08—2010/05).
- Student Grant (Syracuse University Financial Aid Grant, 2007/08–2010/05).

Presentations

- "SENR/NRPy+: Black Hole Binaries on the Desktop." Talk presented at 21st East Coast Gravity Meeting, 2018/05.
- "SENR/NRPy+: Black Hole Binaries on the Desktop." Talk presented at APS April Meeting, 2018/04.
- "SENR: A Simple, Efficient Numerical Evolution Code for the Age of Multimessenger Astronomy." Talk presented at 27th Midwest Relativity Meeting, 2017/10.
- "SENR: A Super-Efficient Numerical Relativity Code for Gravitational Wave Source Modeling: Latest Results." Talk presented at APS April Meeting, 2017/01.
- "Modeling Dynamical Black Holes With Spin Parameters Larger than 0.999." Talk presented at APS April Meeting, 2016/04.
- "Celebrating 100 Years of Einstein's General Relativity." Talk presented to the Astronomy Section of the Rochester Academy of Sciences, 2015/06.
- "Puncture Initial Data for Highly Spinning Black-Hole Binaries." Talk presented at 18th East Coast Gravity Meeting, 2015/05.
- "Puncture Initial Data for Highly Spinning Black-Hole Binaries." Talk presented at APS April Meeting, 2015/04.
- "Simulating Highly Spinning Black Hole Binaries." Talk presented at 7th RIT Graduate Research and Creativity Symposium, 2015/02.
- "Puncture Initial Data for Black Hole Binaries with Nearly Extremal Spins." Talk presented at 24th Midwest Relativity Meeting, 2014/11.
- "Puncture Initial Data for Black Hole Binaries with Nearly Extremal Spins." Talk presented at 17th East Coast Gravity Meeting, 2014/05.
- "A New Look at the Early Universe through the Cosmic Background." Talk presented to the Astronomy Section of the Rochester Academy of Sciences, 2014/05.
- "Simulating Highly Spinning Black Hole Binaries." Talk presented at 6th RIT Graduate Research and Creativity Symposium, 2014/04.
- "Puncture Initial Data for Highly Spinning Black Hole Binaries." Talk presented at 16th East Coast Gravity Meeting, 2013/06.
- "Spinning Black Holes in Numerical Relativity." Talk presented at The College at Brockport Masters Graduate Research Conference, 2013/04.
- "The Dance of Highly Spinning Black Hole Binaries." Poster presented at Rochester Institute of Technology's President's Roundtable, 2013/03.
- "Initial Data for Black Hole Binaries." Talk presented at Rochester Institute of Technology Astrophysical Sciences & Technology Research Talks Jamboree, 2012/10.
- "Solving initial data for black hole binaries in trumpet slicing with spectral methods." Talk presented at 15th East Coast Gravity Meeting, 2012/04.
- "Solving black hole binary trumpet initial data with spectral methods." Talk presented at 21st Midwest Relativity Meeting, 2011/11.
- "Solving black hole binary trumpet initial data with spectral methods." Talk presented at Rochester Institute of Technology Astrophysical Sciences & Technology Research Talks Jamboree, 2011/10.
- "Black-Hole Binary Initial Data." Talk presented at Rochester Institute of Technology Center for Computational Relativity and Gravitation Lunch Seminar, 2011/10.
- "Multi-bin Confidence Intervals and Dark Matter Detection." Talk presented at Rochester Institute of Technology Astro Lunch Seminar, 2011/09.

- “Calculating Confidence Intervals on Leakage.” Talk presented at Rochester Institute of Technology Astrophysical Sciences & Technology Research Talks Jamboree, 2010/10.
- “Confidence Intervals on Misclassification.” Poster presented at Syracuse University Mayfest, 2010/04.
- “Calculating Confidence Intervals in Multi-bin Binomial Data.” Poster presented at Syracuse University Physics Undergraduate Research Day, 2008/11.

Research & Teaching Experience

- Day-to-day research activities utilize my mastery of many technical tools, including C, C++, Python, Java, Mathematica, Maple, Matlab, GSL, TensorFlow, LaTeX, bash, awk, gnuplot, Excel, HTML, CSS, and PHP.
- Projects depend on my advanced mathematical training, including tensor calculus, differential geometry, numerical analysis, nonlinear partial differential equations, linear algebra, and complex analysis.
- Built the new SENR/NRPy+ code package, designed to produce advanced, highly efficient numerical solutions to partial differential equations (arXiv:1712.07658).
    - NRPy+ is a Python-based code which translates equations written in simple notation into highly optimized C code, which is united, managed, and run by the C-based SENR.
    - OpenMP parallelization and SIMD vectorization compatible.
    - Solves equations of general relativity, electromagnetism, and scalar wave theories.
    - Able to simulate the evolution of a black hole binary through the phases of merger and ringdown in full nonlinear general relativity, including precision measurements of horizon dynamics and gravitational waves, on a consumer-grade desktop computer.
- Highly spinning black hole binary inspiral and merger simulations using full numerical relativity.
    - Constructed new initial data allowing near-extremal spins and arbitrary momenta, reduced initial spurious radiation content by an order of magnitude, performed long duration numerical evolutions, and extracted accurate gravitational waveforms (arXiv:1410.8607).
    - Measured gravitational wave energy emitted in the high momentum head-on collisions of black holes (arXiv:1506.06153).
- Statistical modeling of binomial rare-event searches in the context of direct dark matter detection experiments (arXiv:1106.6296).
- Wrote lesson plans and presented several lectures for Prof. Manuela Campanelli’s undergraduate multivariable and vector calculus course and graduate general relativity course, and Prof. Zachariah Etienne’s undergraduate integral calculus course and graduate numerical solutions to partial differential equations course.
- Worked three quarters (one academic year) as a teaching assistant, tutor, and grader for the courses University Physics II (calculus based rotational mechanics and harmonic oscillators), University Physics III (calculus based electricity and magnetism), and Matrices and Boundary Value Problems (introduction to linear algebra and partial differential equations).

Outreach

- Designed a computer applet to simulate gravitational lensing on a live stream from a webcam, allowing visitors to see and play with their warped image on a monitor, and produced signage for the cosmology exhibit at the Museum of Science and Technology, Syracuse, NY, USA 2010/07.
- Designed and 3D printed models showing various spacetime embedding diagrams for the “Celebrating 100 Years of Einstein's General Relativity” exhibit at the Imagine RIT 2015 innovation and creativity festival. Interacted with visitors ranging from young children to seniors, and explained basic concepts of length and time in the context of general relativity using posters, 3D models, and an interactive computer program.
- Gave public, hour-long lectures to a nonexpert audiences, organized by the Astronomy Section of the Rochester Academy of Sciences, on various astrophysics topics including cosmic microwave background cosmology, dark matter detection, gravitational lensing, gravitational waves, black holes, and science history.

References

Zachariah B. Etienne, Ph. D.
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