Alex Edison

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Research Interests

Scattering amplitudes at high loop order; Color-kinematics duality and the double copy for loops; Applications of amplitudes techniques to gravitational waves and cosmology; Low-energy effective action of string theory

Academic Appointments

Northwestern University, Evanston, IL, USA 2022-current
PI: Prof. John Joseph Carrasco

Uppsala Universitet, Uppsala, Sweden 2019-2022
PI: Prof. Henrik Johansson

Education

University of California, Los Angeles, Los Angeles, CA
Ph.D. in Physics, 2019
Advisor: Prof. Zvi Bern

Bowdoin College, Brunswick, ME
Bachelor of Arts in Physics, with Honors, 2013
Advisor: Prof. Stephen Naculich

Research Experience Highlights

- **Gravitational waves via scattering amplitudes [2, 4, 7]:**
  - Developed novel unitarity-inspired approach to gravitational wave tail effects
  - Established new state of the art for tails, outpacing both traditional general relativity approaches and standard EFT methods
- **Structure of super-Yang-Mills integrands [3, 5, 6, 9]:**
  - Explored construction methods, computations, and standing difficulties related to color-kinematics duality for trees and loops.
  - Invented and implemented new methods for unitarity cut construction.
  - Deployed massively parallelized evaluation routines across multiple HPC clusters
- **Low-energy expansions of string theory [1, 6, 8, 10–12]:**

- Probed low-energy limit of one-loop string theory via unitarity methods
- Constructed color-kinematics dual one-loop representations for higher-dimension operators

- **UV behavior of supergravity [13, 14]:**
  - Constructed five-loop supergravity integrand
  - Analyzed UV divergences through five loops, leading to conjecture about UV consistency relations
  - Directly computed seven-loop data in SUGRA, providing evidence for enhanced cancellations in $D = 4$

Publications

Author surnames are modified based on their career status at the time of research:

- undergraduate or master's student
- **PhD student**
- Postdoc.

[1] F. M. **Balli**, A. Edison, and O. Schlotterer, "Pinching rules in the chiral-splitting description of one-loop string amplitudes", (2024), arXiv:2410.19641 [hep-th].

[2] A. Edison, "Parting gravity's tail: quadrupole tails at fifth order and beyond via integer partitions", (2024), arXiv:2409.17222 [hep-th].

[3] J. J. M. Carrasco, A. Edison, N. Robles Del Pino, and S. **Zekioğlu**, "An exercise in Color-Dual Cut Tiling: $\mathcal{N} = 8$ Supergravity from Positivity", (2024), arXiv:2408.07780 [hep-th].

[4] A. Edison and M. Levi, "Higher-order tails and RG flows due to scattering of gravitational radiation from binary inspirals", JHEP **08**, 161 (2024), arXiv:2310.20066 [hep-th].

[5] A. Edison, J. Mangan, and N. H. **Pavao**, "Revealing the landscape of globally color-dual multi-loop integrands", JHEP **03**, 163 (2024), arXiv:2309.16558 [hep-th].

[6] A. Edison, S. He, H. Johansson, O. Schlotterer, F. Teng, and Y. Zhang, "Perfecting one-loop BCJ numerators in SYM and supergravity", JHEP **02**, 164 (2023), arXiv:2211.00638 [hep-th].

[7] A. Edison and M. Levi, "A tale of tails through generalized unitarity", Phys. Lett. B **837**, 137634 (2023), arXiv:2202.04674 [hep-th].

[8] A. Edison and M. Tegevi, "Color-kinematics dual representations of one-loop matrix elements in the open-superstring effective action", JHEP **10**, 022 (2023), arXiv:2210.14865 [hep-th].

[9] J. J. M. Carrasco, A. Edison, and H. Johansson, "Maximal Super-Yang-Mills at Six Loops via Novel Integrand Bootstrap", (2021), arXiv:2112.05178 [hep-th].

[10] A. Edison, M. Guillen, H. Johansson, O. Schlotterer, and F. Teng, "One-loop matrix elements of effective superstring interactions: α'-expanding loop integrands", JHEP **12**, 007 (2021), arXiv:2107.08009 [hep-th].

[11] A. Edison, S. He, O. Schlotterer, and F. Teng, "One-loop Correlators and BCJ Numerators from Forward Limits", Journal of High Energy Physics **2020**, 79 (2020), arXiv:2005.03639.

[12] A. Edison and F. Teng, "Efficient Calculation of Crossing Symmetric BCJ Tree Numerators", Journal of High Energy Physics **2020**, 138 (2020), arXiv:2005.03638.

[13] A. **Edison**, E. Herrmann, J. **Parra-Martinez**, and J. Trnka, "Gravity loop integrands from the ultraviolet", SciPost Physics **10**, 016 (2021), arXiv:1909.02003.

[14] Z. Bern, J. J. Carrasco, W.-M. Chen, A. **Edison**, H. Johansson, J. **Parra-Martinez**, R. Roiban, and M. Zeng, "Ultraviolet Properties of N = 8 Supergravity at Five Loops", Physical Review D **98**, 10.1103/PhysRevD.98.086021 (2018), arXiv:1804.09311.

[15] Z. Bern, H.-H. **Chi**, L. Dixon, and A. **Edison**, "Two-Loop Renormalization of Quantum Gravity Simplified", Physical Review D **95**, 10.1103/PhysRevD.95.046013 (2017), arXiv:1701.02422.

[16] Z. Bern, A. **Edison**, D. Kosower, and J. **Parra-Martinez**, "Curvature-Squared Multiplets, Evanescent Effects and the U(1) Anomaly in N = 4 Supergravity", Physical Review D **96**, 10.1103/PhysRevD.96.066004 (2017), arXiv:1706.01486.

[17] A. Edison and S. G. Naculich, "SU(N) group-theory constraints on color-ordered five-point amplitudes at all loop orders", Nuclear Physics B **858**, 488 (2012), arXiv:1111.3821.

[18] A. Edison and S. G. Naculich, "Symmetric-group decomposition of SU(N) group-theory constraints on four-, five-, and six-point color-ordered amplitudes", Journal of High Energy Physics **2012**, 10.1007/JHEP09(2012)069 (2012), arXiv:1207.5511.

Talks and Seminars

- EFTs for Gravitational Waves,
  Effective Field Theories Across the Universe Workshop,
  Instituto de Fisica, UNAM, Mexico City, Mexico, Sept/Oct 2024

- Gravitational wave tails via particle theory,
  Particle physics in Indiana, Kentucky, Illinois, Michigan, and Ohio (PIKIMO),
  UIUC, Champaign-Urbana, IL, USA, May 2024

- A tale of tails via generalized unitarity,
  ETH Zurich, Zurich, Switzerland, Feb 2024

- Gravitational wave tails via particle theory,
  Physics and Astronomy Early Career Research Seminar,
  Northwestern University, Evanston, IL, USA, Nov 2023

- A tale of tails via generalized unitarity,
  UCLA, Los Angeles, CA, USA, Oct 2023

- A tale of tails via generalized unitarity,
  Pennsylvania State University, State College, PA, USA, Jan 2023

- Pushing the Loop Frontier in non-planar $\mathcal{N} = 4$ sYM,
  Humboldt University, Berlin, Germany, Dec 2022

- A tale of tails via generalized unitarity,
  Albert Einstein Institute, Potsdam, Germany, Dec 2022

- A tale of tails via generalized unitarity,
  DESY, Zeuthen, Germany, Dec 2022

- Pushing the Loop Frontier in non-planar $\mathcal{N} = 4$ sYM,
  Amplitudes 2022, YouTube recording
  Charles University, Prague, Czechia, Aug 2022

- Novel Methods for Cuts and Integrands applied to Six Loops in $\mathcal{N} = 4$ super-Yang-Mills,
  Niels Bohr Institute, Copenhagen, Denmark, June 2022

- Novel Methods for Cuts and Integrands applied to Six Loops in $\mathcal{N} = 4$ super-Yang-Mills,
  QCD Meets Gravity,
  UCLA, Los Angeles, CA, USA, Dec 2021

- Novel Methods for Cuts and Integrands applied to Six Loops in $\mathcal{N} = 4$ super-Yang-Mills,
  Nordic Network Meeting "Strings, Fields and Branes",
  Nordita, Stockholm, Sweden, Nov 2021

- Constructing the 6 Loop 4 Point N = 4 sYM Integrand,
  Center for Theoretical Physics Seminar,
  Queen Mary University London, London, UK, Oct 2021

- Constructing the 6 Loop 4 Point N = 4 sYM Integrand,
  Bright ideas for a dark universe: Strings & Mathematical Physics Parallel Session,
  DESY, Hamburg, Germany, Sept 2021

- One-loop Matrix Elements of Effective Superstring Interactions from Forward Limits,
  HEP Seminar,
  UCLA, Los Angeles, CA, USA, March 2021

- Gravity Loop Integrands from the Ultraviolet,
  Supergravity Divergences and Modular Graph Forms,
  Uppsala Universitet, Uppsala, Sweden, June 2019

- Five Loops in $\mathcal{N} = 8$ Supergravity,
  QCD Meets Gravity,
  Nordita, Stockholm, Sweden, Dec 2018

- Beyond Five Loops Using Ultraviolet Consistency Relations,
  Supergravity and M/Superstring Theory in the Ultraviolet and Double Copy,
  Pennsylvania State University, State College, PA, USA Sept. 2018

- Ultraviolet Consistency Relations in super-Yang–Mills,
  California Amplitudes,
  SLAC, Menlo Park, CA, USA, April 2018

- Evanescent Operators in Half-Maximal SUGRA,
  QCD Meets Gravity,
  UCLA, Los Angeles, CA, USA, Dec 2016

Teaching and Mentoring Experience

- Northwestern University 2022-Present
  - "Mentoring Up + Down" workshop series:
    - Maintaining Communications and Aligning Expectations
    - Enacting Equity and Inclusion
    - Building Self-Efficacy and Developing Professionally
  - "Inclusive STEM teaching" course.
  - "Responsible Conduct of Research" class. Included sections on mentorship and DEI in the research environment.
  - Supervising graduate student projects
  - Day-to-day mentoring of undergraduates during funded summer research

- Uppsala Universitet 2019-2022
  - Supervising masters project:
    "Color-kinematics dual representations of one-loop matrix elements in the open-superstring effective action"
  - Mentoring PhD students

- UCLA Teaching Assistant 2013-2019
  - Physics 126: Undergraduate particle physics; twice
  - Physics 1A,B,C: Introductory physics for majors; once each
  - Physics 4AL: Introductory physics lab for majors; once

- Physics 6B,C: Introductory physics for life-science majors; multiple times each
- Physics 10: Physics for non-scientists; once
- Physics 221C: Elective graduate quantum mechanics; once

Service

- Referee for: Journal of High Energy Physics, SIGMA (Symmetry, Integrability, and Geometry: Methods and Applications), Physical Review D, Physical Review Letters
- Volunteer mentor at Howard Area Community Center Youth Clubhouse – Mentor and tutor to at risk high-school students. Helped introduce students to practical STEM skills like 3D printing, game design and programming, computer assembly, and design and execution of small-scale construction projects.

Technical Skills

- Computer algebra systems: Mathematica; Singular; Sage
- Programming languages: Rust; C++; Python; Lua
- Other: PyTorch; High performance/cluster computing: Slurm, UGE; LaTeX; Git