

Yi-Zen Chu

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Research Interests

- Gravitation, (Quantum) Field Theory, Cosmology and Particle Physics.

Employment

- September 2011 - ○ Postdoctoral Fellow, Center for Particle Cosmology, University of Pennsylvania
- September 2010 - August 2011 ○ Postdoctoral Scholar, Arizona State University

Education

- August 2010 ○ Case Western Reserve University: Doctor of Philosophy, Physics
- May 2006 ○ Yale University: Master's in Science, Physics
- May 2003 ○ University of California, Berkeley: Bachelor of Arts, Physics and Mathematics
 - Spring 2000: Dean's Honors List at UC Berkeley

Publications and Refereeing

- Yi-Zen Chu, Glenn D. Starkman, "Retarded Green's Functions In Perturbed Spacetimes For Cosmology and Gravitational Physics," Phys. Rev. D **84**, 124020 (2011); arXiv: 1108.1825
- Yi-Zen Chu, James B. Dent, Tanmay Vachaspati, "Magnetic Helicity In Sphaleron Debris," Phys. Rev. D **83**, 123530 (2011); arXiv: 1105.3744
- Yi-Zen Chu, David M. Jacobs, Yifung Ng, Glenn D. Starkman, "It's Hard to Learn How Gravity and Electromagnetism Couple," Phys. Rev. D **82**, 064022 (2010); arXiv: 1007.3992
- Yi-Zen Chu, Harsh Mathur, Tanmay Vachaspati, "Aharonov-Bohm Radiation of Fermions," Phys. Rev. D **82**, 063515 (2010); arXiv: 1003.0674
- Yi-Zen Chu and Tanmay Vachaspati, "Capacitor Discharge and Vacuum Resistance in Massless QED₂," Phys. Rev. D **81**, 085020 (2010); arXiv: 1001.2559 [hep-th]
- Yi-Zen Chu, "The n-body problem in General Relativity up to the second post-Newtonian order from perturbative field theory," Phys. Rev. D **79**, 044031 (2009); arXiv: 0812.0012 [gr-qc]
- Yi-Zen Chu and Tanmay Vachaspati, "Fermions On One Or Fewer Kinks," Phys. Rev. D **77**, 025006 (2008); arXiv: 0709.3668 [hep-th]
- Yi-Zen Chu and Marco Cirelli, "Sterile neutrinos, lepton asymmetries, primordial elements: How much of each?," Phys. Rev. D **74**, 085015 (2006); arXiv: astro-ph/0608206
- Yi-Zen Chu, Walter D. Goldberger, and Ira Z. Rothstein, "Asymptotics of d-dimensional Kaluza-Klein black holes: Beyond the newtonian approximation," JHEP **0603**, 013 (2006); arXiv: hep-th/0602016
- Referee for: Physics Letters B.

Research Experiences

- Summer-Fall 2011: Center for Particle Cosmology, University of Pennsylvania; Dept. of Physics, Arizona State University.
 - Developed TensoriaCalc, a Mathematica package for tensor calculations within a Riemannian geometry framework.
 - Available at <http://www.stargazing.net/yizen/Tensoria.html>
- 2007-2011: Center for Particle Cosmology, University of Pennsylvania; Dept. of Physics, Arizona State University; and CERCA, Case Western Reserve University, with Glenn Starkman
 - Developed perturbation theory for solving retarded Green's functions of field theories with hermitian actions in perturbed spacetimes $g_{\mu\nu} = \bar{g}_{\mu\nu} + h_{\mu\nu}$, in terms of the Green's functions in the un-perturbed background $\bar{g}_{\mu\nu}$.
 - Via conformal symmetry and the computation of the photon Green's function in perturbed Minkowski spacetime, showed that light does not travel solely on the light cone in our inhomogeneous spatially flat FLRW universe.
 - Computed the massless scalar, photon and graviton retarded Green's functions in the weak field Kerr black hole geometry, up to first order in its mass and angular momentum.
- Spring 2011: Dept. of Physics, Arizona State University, with James B. Dent and Tanmay Vachaspati
 - Developed analytic techniques and evaluated magnetic helicity produced from sphaleron transitions.
- 2007-2010: CERCA, Case Western Reserve University, with David M. Jacobs, Yifung (Bess) Ng and Glenn Starkman
 - Enumerated the most general set of couplings between electromagnetic fields $F_{\mu\nu}$ and geometric tensors – Riemann and Ricci tensors – up to mass dimension 6.
 - Showed that the propagation of light over cosmological distances and solar system tests of General Relativity do not provide useful constraints on their coefficients.
- 2009-2010: CERCA, Case Western Reserve University, with Harsh Mathur and Tanmay Vachaspati
 - Computed fermion pair production rates due to a thin magnetic flux tube in motion – *i.e.* the Aharonov-Bohm interaction – for a infinite straight solenoid and cosmic string loops.
 - Obtained general solutions to the Dirac equation with a gauge potential in the presence of a thin, infinite, straight solenoid.
- 2008, 2009: Institute for Advanced Study, Princeton, and CERCA, Case Western Reserve University; with Tanmay Vachaspati
 - Considered two toy models for capacitors within 1+1 dimensional quantum electrodynamics, and examined their discharge due to the Schwinger process: the electric field decayed as $t^{-1/2}$ and the vacuum obeyed Ohm's law.
 - Implemented on Mathematica, the implicit Crank-Nicholson numerical algorithm for evolving PDEs.
- Summer 2006, and Spring, Fall 2008

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- Used perturbative field theory methods to compute, up to certain integrals, the n -body general relativistic effective lagrangian to the second post-Newtonian order (2 PN).
- Developed algorithm that would in principle be able to generate the Feynman diagrams contributing to the n -body effective langrangian to an arbitrary PN order. Implemented some Mathematica code to this end.
- Summer 2007 to Fall 2007: CERCA, Case Western Reserve University, with Tanmay Vachaspati
 - Solved the full spectrum of bound state energy eigenstates of the Dirac equation, $(i\cancel{\partial} - g\phi)\psi = 0$, in kink and antikink ($\phi = \pm \tanh[z]$) backgrounds.
 - Proved, contrary to recent claims that kink-antikink bound states do not exist at all, that at least one fermion bound state has to exist for all non-zero values of the Yukawa coupling g and that the ground state energy goes to zero faster than e^{-aL} for some $a > 0$ as the kink-antikink distance L increases to infinity.
 - Numerically solved the fermion ground and excited states on the kink-antikink ($\phi = \tanh[z+L] - \tanh[z-L] - 1$) for a range of Yukawa couplings and kink-antikink separations.
- Summer 2004, Spring 2006 to Summer 2006: Particle Theory Group at Yale University with Marco Cirelli
 - Computed the excess of anti-neutrinos over neutrinos needed in the early universe to suppress sufficiently the production of the LSND sterile neutrino to reconcile its possible existence with the observed abundances of ^4He and deuterium. (Having more than 3 species neutrinos in the early universe would alter the light element formation rates.)
 - Introduced neutrino density matrix equations that took into account scattering and annihilation processes while preserving lepton number conservation.
- Summer 2005 to Spring 2006: Particle Theory Group at Yale University with Walter Goldberger
 - Used effective field theory techniques to compute mass, tension, and thermodynamics of black holes in $\mathbb{R}^{1,d-2} \times \mathbb{S}^1$ spacetimes.
 - Devised algorithm and implemented Mathematica code to generate the Feynman rule for the N graviton vertex in Minkowski space, where N is an arbitrary integer greater than one.
- Spring 2002 to Spring 2003: Solenoidal Tracker at RHIC (STAR) group at Lawrence Berkeley National Laboratory (LBNL) with Nu Xu, Kai Schweda, and Eugene Yamamoto
 - Analyzed ϕ meson, proton and anti-proton production rates from proton-proton collisions at the Relativistic Heavy Ion Collider (RHIC)
- Summer 2001: BaBar Group at Lawrence Berkeley National Laboratory (LBNL) with Yury Kolomensky
 - Calibrated the silicon wafers of the BaBar SVT at the Stanford Linear Accelerator Center (SLAC)
- Fall 2000 to Spring 2001: E158 Experiment at SLAC with Gilbert Shapiro
 - Designed and oversaw construction of an electron beam monitor

Professional Activities

- Fall 2011-present at the Center for Particle Cosmology, University of Pennsylvania

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- Organized Case-Columbia-NYU-UPenn December 13, 2011 meeting hosted by UPenn.
- Co-organizer of weekly High Energy Theory Seminar series.
- Fall 2010-Spring 2011 at Arizona State University (ASU)
 - Member of organizing committee for Primordial Magnetism Workshop (30 March - 2 April 2011).
 - Co-organizer of the ASU Particle Astrophysics and Cosmology Seminar.
 - Set up and maintained Wiki and listserv for the ASU Cosmology Group.

Skills

- Computing
 - Extensive experience with Mathematica: Certified at the Advanced Foundations Level, with an outstanding score of 95.3%.
 - Some experience with: C / C++, ROOT, \LaTeX , UNIX and MS Office software
- Languages
 - Fluent in English and Mandarin

Talks

- Light Does Not Always Propagate On The Light Cone
 - 25 April 2012: Case-Columbia-Penn-NYU Meeting, New York University, NY
 - 22 April 2012: 15th East Coast Gravity Meeting, Syracuse University, Syracuse, NY
 - 14 November 2011: Particle Astrophysics Seminar, Case Western Reserve University
 - 1 October 2010: Particle Astrophysics and Cosmology Friday Talks, Arizona State University
 - 10 April 2009: CERCA Seminar, Case Western Reserve University
- The N Body Problem In General Relativity From Perturbative Field Theory
 - 7 February 2011: Fermilab, Center for Particle Astrophysics (Part II of II)
 - 8 December 2010: UCLA, High Energy Physics Seminar (Part II of II)
 - 30 November 2010: Perimeter Institute, Cosmology Seminar (Part II of II)
 - 29 November 2010: University of Toronto, High Energy Physics Seminar (Part II of II)
 - 11 November 2010: Columbia University, ISCAP Seminar
 - 1 September 2010: National University of Singapore, Physics Department Seminar
 - 28 May 2010: Princeton University, Gravity Group Astrophysics/Cosmology Lunch
 - 30 June 2009: Perimeter Institute Summer School 2009, Student Talks
 - 22 January 2009: Theory Seminar, Washington University in St. Louis.
 - 9 December 2008: Buffalo-Case-Cornell-Syracuse Workshop on Cosmology and Astro-Particle Physics, Case Western Reserve University
 - 24 June 2008: Prospects in Theoretical Physics (PiTP) 2008 Participants' Talks, Institute for Advanced Study, Princeton
- Don't Shake That Solenoid Too Hard: Particle Production From Aharonov-Bohm

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- 7 February 2011: Fermilab, Center for Particle Astrophysics (Part I of II)
- 8 December 2010: UCLA, High Energy Physics Seminar (Part I of II)
- 30 November 2010: Perimeter Institute, Cosmology Seminar (Part I of II)
- 29 November 2010: University of Toronto, High Energy Physics Seminar (Part I of II)
- 4 November 2010: Tufts Institute of Cosmology Seminar, Tufts University
- 6 October 2010: Particle Astrophysics and Cosmology Seminar, Arizona State University.
- Fermions On One Or Fewer Kinks
 - 2 November 2007: CERCA Seminar, Case Western Reserve University
- Asymptotics of Kaluza-Klein black holes
 - 22 February 2007: Cosmology Seminar, Tufts University
 - 16 January 2007: Syracuse University
 - 10 January 2007: Cosmo Lunch, University of California, Irvine
 - 10 November 2006: CERCA Seminar, Case Western Reserve University

Summer Schools and Conferences

- Perimeter Institute for Theoretical Physics Summer School: Exploring the Cosmological Frontiers, June 24 - July 1, 2009
- 34th International Conference on High Energy Physics, July 29-August 5 2008 (Philadelphia, PA)
- Prospects in Theoretical Physics, "Strings and Phenomenology," July 14-July 25 2008 (Institute for Advanced Study, Princeton, NJ)
- SOHO 14 - GONG 2004 Workshop, "Helio- and Asteroseismology: Towards a Golden Future" (Yale University, New Haven, CT)

Teaching

- Fall 2003 through Spring 2008: Graduate Teaching Assistant at Case Western Reserve University and Yale University
 - Quantum Field Theory, Modern Cosmology, Mathematical Methods and Laboratory Sections.
- Fall 2001, Spring 2002
 - Founder and Instructor of official amateur astronomy class at UC Berkeley (Astro 99)
- 1997 to present
 - Rich experience tutoring physics and mathematics, including: training a high school sophomore for Physics Olympiad qualifying exams; official tutor at UC Berkeley dormitory.

Leadership Experiences, Community Service

- Spring 2005, Spring 2006
 - Organized star parties for people with disabilities, in collaboration with STARRY, Yale's undergraduate astronomy club.

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- Spring 2000 to Summer 2002
 - Founder and Leader of Astronomers at Berkeley, an amateur astronomy club at UC Berkeley. Organized frequent on-campus stargazing sessions and off-campus dark sky observing trips; ran official amateur astronomy class; initiated telescope making project.
- 1995 to 1996
 - High School Chief Photographer.