John Terning

Curriculum Vitae

Address:
Dept. of Physics
University of California
Davis. CA 95616-8677

Phone and E-mail:
530-231-2540 (office)
530-752-4717 (fax)
terning@physics.ucdavis.edu

Education:

Ph.D. in Physics, University of Toronto, "Nonlocal models of Goldstone bosons in asymptotically free gauge theories;" advisor: Professor Bob Holdom, 1985-1990.

M.Sc. in Physics, University of Toronto, "Cosmological implications of weakly interacting massive particles;" advisor: Professor Bob Holdom, 1984-1985.

B.Sc. in Physics, University of Alberta, 1980-1984.

Professional Experience

Professor	UC Davis	2008-
Associate Professor	UC Davis	2005-2008
Staff Member	LANL	2001-2004
Lecturer/Researcher	Harvard University	1999-2001
Research Associate	U. of California, Berkeley	1996-1999
Research Associate	Boston University	1993-1996
Postdoctoral Fellow	Yale University	1990-1993
Teaching Assistant	University of Toronto	1984-1990

Scholarships and Fellowships

Fellow of the American Physical Society	2007-
Japan Society for the Promotion of Science Fellowship	Apr. 96
Superconducting Super Collider Fellowship	Sep. 92 - Aug. 93
Natural Sciences and Engineering Research Council of Canada (NSERC) Postdoctoral Fellowship	Sep. 90 - Aug. 92
University of Toronto Open	Sep. 89 - Dec. 89
University of Toronto Open	Sep. 88 - Aug. 89
NSERC Postgraduate Scholarship 1-4:	Sep. 84 - Aug. 88
NSERC Undergraduate Student Research Award	May 84 - Aug. 84
NSERC Undergraduate Student Research Award	May 83 - Aug. 83
University of Alberta Bursary	Sep. 82 - Apr. 83
F. A. Scherrer Bursary in Science	Sep. 81 - Apr. 82

Invited Plenary Conference Talks

“The Quantum Critical Higgs, LHC Run 2, Santa Fe 2016 Summer Workshop July 4-8, 2016.

“Experimental Tests of Vacuum Energy, The lesson from the first results of Run 2 of the LHC, New Physics @ Korea Institute, June 12-17, 2016.

“Inflation from Broken Scale Invariance,” Physics from Run 2 of the LHC, Jeju South Korea, Sept. 13-20 2014.

“Inflation from Broken Scale Invariance,” International Conference on New Frontiers in Physics, Crete, July 31-Aug. 6, 2014.

“Dilatons and Fine Tuning,” Beyond the Standard Model 2014, KEK Japan, March 3-7, 2014.

“Dilatons and Fine Tuning,” Beyond the Standard Model after the first run of the LHC, GGI Florence Italy, Jul. 9-12, 2013.

“Planck Data and Axions,” Fundamental Questions in Cosmology, Planck Collaboration Conference at UC Davis, May 20-24, 2013.

“A Light Composite Stop,” Frontiers Beyond the Standard Model III, U. of Minnesota, Oct. 11-13, 2012.

“Monopoles and Electroweak Symmetry Breaking,” 23rd Rencontres de Blois Particle Physics and Cosmology, May 29-June 3, 2011.

“Monopoles and Electroweak Symmetry Breaking,” 2011 Aspen Winter Conference ”New Data from the Energy Frontier,” Feb. 13-18, 2011.

“Monopoles, Anomalies, and Electroweak Symmetry Breaking,” MC4BSM, Copenhagen Denmark, Apr.14-16, 2010.

“Higgsless Models,” Rencontres de Moriond, La Thuile Italy, Mar. 6-13, 2010.

“Monopoles, Anomalies, and Electroweak Symmetry Breaking,” Rencontres de Physique des Particules, Lyon France, Jan 25-27, 2010.

“The AdS/CFT/Unparticle Correspondence,” International Workshop on Supersymmetry and Supersymmetry Breaking, IPPP, Durham, UK, Apr. 20-24, 2009.

“Theoretical Summary Talk,” Aspen Winter Conference on Particle Physics, Feb. 9-14, 2009.

“The unHiggs,” Aspen Winter Conference on Particle Physics, Feb. 9-14, 2009.

“The AdS/CFT/Unparticle Correspondence,” Planck ’08, Barcelona, Spain, May 19-23, 2008.

“Beyond the Standard Model,” Heraeus-Seminar Physics at the Terascale - Physikzentrum Bad Honnef, Germany, Apr. 27-30, 2008.

“Realistic Higgsless Models,” Radcliffe Institute Seminar: Higgsless Electroweak Symmetry Breaking in the LHC Era, Boston, July 31-Aug. 4, 2007.

“Unparticles,” Eötvös-Cornell 2007 Summer Workshop on Particle Theory, Budapest, Hungary, June 25-29, 2007.

“Field Theory on Multi-Throat Backgrounds,” Planck ’06, Paris, France, May 29-June 2, 2006.

“The accelerated acceleration of the Universe, New Ideas Beyond the Standard Model, College of William and Mary, Oct. 8-10, 2005.

“Life without a Higgs,” CP and non-standard Higgs working group meeting, SLAC, Mar. 24-25, 2005.

“Life without a Higgs,” New Directions in Physics Beyond the Standard Model, Pisa, May 31 2-June 5, 2004.

“Life without a Higgs,” Aspen Winter Conference, Jan. 2-7, 2004.

“What’s so Little about the Little Higgs?” COSMO-03, Ambleside, UK, Aug. 25-29, 2003.

“Glueballs and AdS/CFT,” Phenomenology of Large N_c QCD,” Tempe Arizona, Jan. 8-11, 2002.

“Duality Meets Phenomenology,” SUSY 2000, CERN, June 26 - Jul. 1, 2000.

“Glueball mass spectrum from supergravity,” New Directions in QCD, Korea, June 21-25, 1999.

“Glueball mass spectrum from supergravity,” Aspen Winter Conference, Jan. 11-16, 1999.

“The End of Technicolor,” Recent Developments in Phenomenology, U. of Wisconsin-Madison, Mar. 17-19, 1997.

“Tightwad tests of technicolor,” Aspen Winter Conference, Jan. 17-23, 1994.

“An extended technicolor model,” New Physics at New Facilities, Case Western Reserve U., Oct. 15-17, 1993.

“Technicolor and precision electroweak measurements,” Aspen Winter Conference, Jan. 10-16, 1993.

“Extended technicolor model building,” International Workshop on Electroweak Symmetry Breaking, Hiroshima, Japan, Nov. 12-15, 1991.

Invited Conference Talks

“Life without a Higgs,” APS Meeting, Denver, May 1-4, 2004.

“Beyond Orbifolds: Life without a Higgs,” Quantum Theory and Symmetries, U. of Cincinnati, Sep. 10-14, 2003.

“Dimming Extragalactic Supernovae via Axions,” COSMO-02, Chicago, Illinois, Sep. 18-21, 2002.

“Single sector supersymmetry breaking,” Division of Particles and Fields, Los Angeles, Jan. 5-9, 1999.

“Glueball Mass Spectrum from Supergravity,” Division of Particles and Fields, Los Angeles, Jan. 5-9, 1999.

“Comments on technicolour model building,” Beyond the Standard Model III, Carleton U., Ottawa, Canada, June 22-24, 1992.

“Mass enhancement and critical behavior in technicolor theories,” The Vancouver Meeting: Particles and Fields ’91, Vancouver, Canada, Aug. 18-22, 1991.

Summer Schools

“The Theory of Mass Generation,” Maria Laach School for High Energy Physics, Maria Laach Abbey, Germany, Sept. 2013.

“Beyond the Standard Model,” Physics at TeV colliders: from Tevatron to LHC, Cargese France, July 2010.

“The Standard Model,” CERN Summer Program, June 2010.

"Introduction to Compositeness, Strong Electroweak Symmetry Breaking and Extended Gauge Theories," PSI: New Ideas in Particle Physics, Zuoz, Switzerland, July 13 to 19, 2008
"SUSY Gauge Theories," Perimeter Institute: Strings, Gravity and Cosmology, U. of British Columbia, Vancouver, Canada Aug. 2006.
"Particle Cosmology" Santa Fe Comsology Workshop, July 2002.
"Non-perturbative Methods in Supersymmetry," TASI, June 2002.

Colloquia

"Quantum Phase Transitions and the Higgs", Cornell, Nov. 16, 2015.
"Quantum Phase Transitions and the Higgs," ETH Zurich, Nov. 9, 2014.
"The Origin of Mass," Technion, Israel, Nov. 4, 2013.
"Alternatives to the Standard Model Higgs," U. Valencia, Spain, Feb. 16, 2010.
"Extra Dimensions," U. Oregon, Nov. 29, 2007.
"Extra Dimensions," U. Connecticut, Mar. 30, 2007.
"Extra Dimensions," UC Irvine, Feb. 1, 2007.

Seminars

"S-duality and Helicity Amplitudes," Perimeter Institute, Waterloo, Canada Mar. 11, 2016.
"The Quantum Critical Higgs, SLAC Feb. 19, 2016.
"Experimental Tests of Vacuum Energy, LBNL Feb. 3, 2016.
"The Quantum Critical Higgs," U. of Toronto, Nov. 13, 2015.
"Experimental Tests of Vacuum Energy," NYU, Oct. 8, 2015.
"Experimental Tests of Vacuum Energy," U. of Minnesota, Sep. 18, 2015.
"The Quantum Critical Higgs," Munich Institute for Astro and Particle Physics, Jul. 20, 2015.
"The Quantum Critical Higgs," Harvard U., Feb. 24, 2015.
"Experimental Tests of Vacuum Energy," Stanford U., Feb. 12, 2015.
"The Quantum Critical Higgs," UC Irvine, Feb. 4, 2015.
"The Quantum Critical Higgs," Cornell, Nov. 21, 2014.
"The Quantum Critical Higgs," Perimeter Institute, Waterloo Canada, Nov. 14, 2014.
"The Quantum Critical Higgs," NYU, Nov. 12, 2014.
"Seiberg-Witten Theory," U. Autonoma Barcelona, Spain, Oct. 17, 2014.
"Seiberg Duality," U. Autonoma Barcelona, Spain, Oct. 16, 2014.
"Planck Data and Axions," Cornell, Nov. 13, 2013.
"Dilatons and Fine Tuning," Newe Shalom , Israel, Nov. 5, 2013.
"Dilatons and Fine Tuning," Boston U., Oct. 9, 2013.
"Dilatons and Fine Tuning," Aspen Center for Physics, Aug. 13, 2013.
"Dilatons and Fine Tuning," SLAC, May 1, 2013.
"Dilatons and Fine Tuning," Cornell, Mar. 27, 2013.
"A Light Composite Stop," Fermilab, Oct 10, 2012.
"A Light Composite Stop," U. of Oregon, Sep. 25, 2012
"A Light Composite Stop," SLAC, Stanford, Dec. 2, 2011

“Monopoles and Electroweak Symmetry Breaking,” Dirac Lecture, Florida State University, Tallahassee, Nov. 30, 2011
“Seiberg-Witten Monopoles,” Dirac Lecture, Florida State University, Tallahassee, Nov. 29, 2011
“Electric-Magnetic Duality to Seiberg Duality,” Dirac Lecture, Florida State University, Tallahassee, Nov. 28, 2011
“A Light Composite Stop,” Cornell, Nov. 18, 2011
“Monopoles and Electroweak Symmetry Breaking,” Institute for Advanced Study, Princeton, Oct. 27, 2011
“Monopoles and Electroweak Symmetry Breaking,” U. Pittsburgh, Oct. 25, 2011
“Unitarity and Nonlinear Boundary Conditions,” Cornell, Mar. 16, 2011
“Monopoles, Anomalies, and Electroweak Symmetry Breaking,” Cornell, Nov. 23, 2010
“Monopoles, Anomalies, and Electroweak Symmetry Breaking,” UC Berkeley, Sep. 20, 2010.
“Monopoles, Anomalies, and Electroweak Symmetry Breaking,” U. Southampton, England, Apr. 26, 2010.
“Monopoles, Anomalies, and Electroweak Symmetry Breaking,” EPFL, Lausanne Switzerland, Apr. 26, 2010.
“Monopoles, Anomalies, and Electroweak Symmetry Breaking,” U. di Roma La Sapienza, Italy, Apr. 23, 2010.
“Monopoles, Anomalies, and Electroweak Symmetry Breaking,” U. Warsaw, Poland, Apr. 19, 2010.
“Monopoles, Anomalies, and Electroweak Symmetry Breaking,” CERN, Feb 5, 2010.
“Monopoles, Anomalies, and Electroweak Symmetry Breaking,” SLAC, Dec. 4, 2009.
“Unparticles,” Cornell U., Sep. 23, 2009.
“The AdS/CFT/Unparticle Correspondence,” UC Irvine, Apr. 8, 2009.
“The AdS/CFT/Unparticle Correspondence,” Harvard U., Sep.. 16, 2008.
“Unparticles or Just Un-physics?” UC Berkeley, Sep. 17, 2007.
“The Gaugephobic Higgs,” Caltech, April 23, 2007.
“Realistic Higgsless Models,” U. Toronto., Sep. 11, 2006.
“Field Theory on Multi-Throat Backgrounds,” SLAC, Apr. 21, 2006.
“The Accelerated Acceleration of the Universe,” Cornell U., Sep. 21, 2005.
“Life without a Higgs,” UC Berkeley, May. 2, 2005.
“Life without a Higgs,” KITP Santa Barbara, Dec. 14, 2004.
“Life without a Higgs,” Greater Chicagoland High Energy Seminar, Northwestern U., Nov. 1, 2004.
“Life without a Higgs,” UC Santa Cruz, Mar. 29, 2004.
“Life without a Higgs,” Michigan State U., Mar. 17, 2004.
“A new phase of SUSY gauge theories,” U. Washington, Seattle, Mar. 9, 2004.
“Life without a Higgs,” U. Texas Austin, Feb. 24, 2004.
“Life without a Higgs,” Argonne National Lab., Nov. 11, 2003.
“Life without a Higgs,” Harvard U., Oct.. 22, 2003.
“Life without a Higgs,” Yale U., Oct.. 15, 2003.
“Beyond Orbifolds: Life without a Higgs,” Aspen July 1, 2003.

“Beyond Orbifolds: Life without a Higgs,” U.C. Davis May 23, 2003.
“Beyond Orbifolds: Life without a Higgs,” U.C. Berkeley May 19, 2003.
“Extra Dimensions: A Reality Check,” Boston U., Oct. 23, 2002.
“Extra Dimensions: A Reality Check,” Yale U., Oct. 23, 2002.
“Dimming Supernaovae by Axions,” U. Maryland, Apr. 29, 2002.
“The Randall-Sundrum Model and Electroweak Physics,” Cornell U. Apr. 23, 2002.
“Dimming Supernaovae by Axions,” SLAC, Feb. 27, 2002.
“Dimming Supernaovae by Axions,” U.C. Berkeley, Nov. 19, 2001.
“S-color and the μ problem,” U. of Toronto, May. 31, 2001.
“Supersymmetric electroweak symmetry breaking,” Yale, Sep. 26, 2000.
“Holographic RG and Cosmology,” Aspen, Aug. 22, 2000.
“Holographic RG and Cosmology,” Los Alamos/Santa Fe Workshop, Aug. 8, 2000.
“Holographic RG and Cosmology,” CERN, Jul. 5, 2000.
“Holographic RG and Cosmology,” McGill, Apr.18, 2000.
“Holographic RG and Cosmology,” U. of Cincinnati, May 22, 2000.
“Supersymmetric electroweak symmetry breaking,” Boston U., Mar. 22, 2000.
“Supersymmetric electroweak symmetry breaking,” William and Mary, Mar. 17, 2000.
“Supersymmetric electroweak symmetry breaking,” Los Alamos, Feb. 28, 2000.
“Orbifolds and the hierarchy problem,” SLAC, Aug. 2, 1999.
“Single sector supersymmetry breaking,” Harvard U., Feb. 24, 1999.
“Glueball mass spectrum from supergravity,” MIT, Feb. 22, 1999.
“Glueball mass spectrum from supergravity,” U. Arizona, Jan. 26, 1999.
“Glueball mass spectrum from supergravity,” U.C. Irvine, Nov. 24, 1998.
“Glueball mass spectrum from supergravity,” U.C. San Diego, Jun. 22, 1998.
“Glueball mass spectrum from supergravity,” Stanford, Jun. 18, 1998.
“Composite quarks and leptons from dynamical SUSY breaking,” U.C. Santa Cruz, Jun. 4, 1998.
“Composite quarks and leptons from dynamical SUSY breaking,” U. Oregon, Jun. 2, 1998.
“Composite quarks and leptons from dynamical SUSY breaking,” U. Rochester, May 11, 1998.
“Composite quarks and leptons from dynamical SUSY breaking,” Yale, April 21, 1998.
“Composite quarks and leptons from dynamical SUSY breaking,” Fermilab, Feb. 26, 1998.
“Composite quarks and leptons from dynamical SUSY breaking,” Michigan State U., Feb. 24, 1998.
“Composite quarks and leptons from dynamical SUSY breaking,” Carnegie Mellon, Feb. 23, 1998.
“Composite quarks and leptons from dynamical SUSY breaking,” U. Michigan, Feb. 19, 1998.
“Composite quarks and leptons from dynamical SUSY breaking,” SUNY Stony Brook, Feb. 2, 1998.
“New mechanisms of dynamical SUSY breaking and direct gauge mediation,” Stanford, Nov. 24, 1997.
“New mechanisms of dynamical SUSY breaking and direct gauge mediation,” U.C. Davis, Oct. 7, 1997.

“The zero temperature chiral phase transition in QCD,” Rutgers, May 20, 1997.
“The zero temperature chiral phase transition in QCD,” IAS, Princeton, May 19, 1997.
“Self-duality and the confinement Transition,” U. Toronto, Mar. 21, 1997.
“The zero temperature chiral phase transition in QCD,” U. Washington, Mar. 11, 1997.
“Self-duality and the confinement Transition,” U.C. San Diego, Feb. 24, 1997.
“Self-duality and the confinement Transition,” Yale, Feb. 14, 1997.
“The zero temperature chiral phase transition in QCD,” Kanazawa U., Apr. 22, 1996.
“SUSY duals with adjoint matter,” Tokyo Metropolitan U., Apr. 19, 1996.
“The zero temperature chiral phase transition in QCD,” KEK, Japan, Apr. 18, 1996.
“The zero temperature chiral phase transition in QCD,” Tohoku U., Apr. 16, 1996.
“The zero temperature chiral phase transition in QCD,” Nagoya U., Apr. 10, 1996.
“SUSY duals with adjoint matter,” Nagoya U., Apr. 9, 1996.
“SUSY duals with adjoint matter,” Kyoto U., Apr. 4, 1996.
“SUSY duals with adjoint matter,” U. Cincinnati, Feb. 26, 1996.
“The zero temperature chiral phase transition in QCD,” Fermilab, Feb. 15, 1996.
“SUSY duals with adjoint matter,” Harvard, Feb. 7, 1996.
“Phase transitions in particle physics,” Duke, Feb. 5, 1996.
“Precision electroweak measurements,” Ohio State U., Feb. 15, 1995.
“Precision electroweak measurements,” McGill, Feb. 10, 1995.
“Symmetry breaking in three dimensional QED,” Harvard, Jan. 11, 1995.
“Precision electroweak measurements and technicolor,” U.C. Santa Cruz, Nov. 8, 1994.
“Precision electroweak measurements and technicolor,” LBNL, Nov. 4, 1994.
“Precision electroweak measurements and technicolor,” Brookhaven, Nov. 2, 1994.
“Low energy tests of technicolor,” ITP, Santa Barbara, Mar. 14, 1994.
“Low energy tests of technicolor,” MIT, Apr. 20, 1994.
“Low energy tests of technicolor,” Columbia, Feb. 23, 1994.
“Extended technicolor and neutrinos,” Carnegie Mellon, Oct. 13, 1993.
“Extended technicolor and precision electroweak measurements,” U.C. Santa Cruz, Nov. 24, 1992.
“A chiral Lagrangian from quarks with dynamical masses,” U. Cincinnati, May 15, 1992.
“Monopole non-annihilation at the electroweak scale,” U. Cincinnati, May 18, 1992.
“Extended technicolor model building,” Nagoya U., Nov. 18, 1991.
“A chiral Lagrangian from quarks with dynamical masses,” CEBAF, Newport News, May 31, 1991.
“A chiral Lagrangian from quarks with dynamical masses,” U. Mass.-Amherst, Nov. 13, 1990.
“A chiral Lagrangian from quarks with dynamical masses,” ITP, Santa Barbara, June 20, 1990.
“A model for low-energy QCD,” TRIUMF, Vancouver, Feb. 6, 1990.

Additional Activities

“23rd International Conference on Supersymmetry and Unification of Fundamental Interactions,” (Co-organizer) Granlibakken, Lake Tahoe, Aug. 2015
“Gunion Fest,” (Co-organizer) UC Davis, Mar. 2014.

“The LHC Higgs Signal: Fits, Models and BSM Implications,” (Co-organizer) UC Davis, Apr. 2013.
“Dark Matter in Collision,” (Co-organizer) UC Davis, Apr. 2012.
“Hidden SUSY,” (Co-organizer) UC Davis, Nov. 2011.
“SUSY-Recast,” (Co-organizer) UC Davis, Apr. 2011.
“The Tau Portal,” (Co-organizer) UC Davis, Apr. 2011.
“Top @ Tevatron 4 LHC,” (Co-organizer) UC Davis, Nov. 2009.
“The Particle Cosmology Frontier,” (Co-organizer) UC Davis, May 2009.
“MC4BSM,” (Co-organizer) UC Davis, Apr. 2009.
“Missing Energy,” (Co-organizer) UC Davis, Apr. 2009.
“LHC New Physics Forum,” (Co-organizer) Heidelberg, Feb 2009.
“New Paradigms for Dark Matter,” (Co-organizer) UC Davis, Dec. 2008.
“Finding the Hidden, Light Higgs,” (Co-organizer) UC Davis, May 2008.
“Detecting the Unexpected,” (Co-organizer) UC Davis, Nov. 2007.
“Revealing the Nature of Electroweak Symmetry Breaking,” Aspen Winter Conference, (Co-organizer) Jan. 2008.
“West Coast LHC Meeting,” (Co-organizer) UC Davis, Dec. 2006.
“New Approaches to Electroweak Symmetry Breaking,’” Aspen Summer Workshop (Co-organizer) June 2005.
“Beyond the Higgs,” Santa Fe Summer Workshop (Co-organizer) Aug. 2004.
“Physics in $D \geq 4$,” TASI (Co-organizer), Boulder CO, June 2004.
“Extra Dimensions and Beyond” Santa Fe Summer Workshop (Co-organizer) Aug. 2002.

Publications

1) R. Houtz, K. Colwell and J. Terning, “Little Conformal Symmetry,” arXiv:1603.00030 [hep-ph].
2) C. Csáki, J. Hubisz, S. Lombardo and J. Terning, “Gluon vs. Photon Production of a 750 GeV Diphoton Resonance,” Phys. Rev. D**93** (2016) no.9, 095020, arXiv:1601.00638 [hep-ph].
3) C. Csáki, J. Hubisz and J. Terning, “Minimal model of a diphoton resonance: Production without gluon couplings,” Phys. Rev. D **93** (2016) no.3, 035002, arXiv:1512.05776 [hep-ph].
4) C. Csáki, C. Grojean and J. Terning, “Alternatives to an Elementary Higgs,” arXiv:1512.00468 [hep-ph].
5) B. Bellazzini, C. Csáki, J. Hubisz, S. J. Lee, J. Serra and J. Terning, “The Quantum Critical Higgs,” arXiv:1511.08218 [hep-ph].
6) K. F. Cleary and J. Terning, “A Light Stop with a Heavy Gluino: Enlarging the Stop Gap,” JHEP **1605** (2016) 151, arXiv:1511.08216 [hep-ph].
7) K. F. Cleary and J. Terning, “Marginal Breaking of Conformal SUSY QCD,” JHEP **1607** (2016) 096, arXiv:1510.08065 [hep-th].
8) K. Colwell and J. Terning, “S-Duality and Helicity Amplitudes,” JHEP **1603** (2016) 068, arXiv:1510.07627 [hep-th].
9) B. Bellazzini, C. Csáki, J. Hubisz, J. Serra and J. Terning, “Cosmological and Astrophysical Probes of Vacuum Energy,” JHEP **1606** (2016) 104, arXiv:1502.04702 [astro-ph.CO].
10) K. A. Olive *et al.* [Particle Data Group Collaboration], “Review of Particle Physics,” Chin. Phys. C **38** (2014) 090001.
11) C. Csáki, M. Martone, Y. Shirman, P. Tanedo and J. Terning, “Dynamics of 3D SUSY Gauge Theories with Antisymmetric Matter,” JHEP **1408** (2014) 141, arXiv:1406.6684 [hep-th].
12) C. Csáki, N. Kaloper, J. Serra and J. Terning, “Inflation from Broken Scale Invariance,” Phys. Rev. Lett. **113** (2014) 161302, arXiv:1406.5192 [hep-th].
13) C. Csáki, N. Kaloper and J. Terning, “Planck Data and Ultralight Axions,” JCAP **1506** (2015) 06, 041 arXiv:1405.1725 [astro-ph.CO].
14) B. Bellazzini, C. Csáki, J. Hubisz, J. Serra and J. Terning, “A Naturally Light Dilaton and a Small Cosmological Constant,” Eur. Phys. J. C **74** (2014) 2790, arXiv:1305.3919 [hep-th].
15) B. Bellazzini, C. Csáki, J. Hubisz, J. Serra and J. Terning, “A Higgslike Dilaton,” Eur. Phys. J. C **73** (2013) 2333, arXiv:1209.3299 [hep-ph].
16) J. Beringer *et al.* [Particle Data Group Collaboration], “Review of Particle Physics (RPP),” Phys. Rev. D **86** (2012) 010001.
17) B. Bellazzini, C. Csáki, J. Hubisz, J. Serra and J. Terning, “Composite Higgs Sketch,” JHEP **1211** (2012) 003, arXiv:1205.4032 [hep-ph].
18) C. Englert, D. G. Netto, M. Spannowsky and J. Terning, “Constraining the Unhiggs with LHC data,” Phys. Rev. D **86** (2012) 035010, arXiv:1205.0836 [hep-ph].
19) C. Englert, M. Spannowsky, D. Stancato and J. Terning, “Unconstraining the Unhiggs,” Phys. Rev. D **85** (2012) 095003, arXiv:1203.0312 [hep-ph].

20) C. Csáki, L. Randall and J. Terning, “Light Stops from Seiberg Duality,” Phys. Rev. D **86** (2012) 075009, arXiv:1201.1293 [hep-ph].
21) C. Csáki, D. Curtin, V. Rentala, Y. Shirman and J. Terning, “Supersymmetry Breaking Triggered by Monopoles,” Phys. Rev. D **85** (2012) 045014 arXiv:1108.4415 [hep-th].
22) H. Cai, H. -C. Cheng, A. D. Medina and J. Terning, “SUSY Hidden in the Continuum,” Phys. Rev. D **85** (2012) 015019, arXiv:1108.3574 [hep-ph].
23) C. Csáki, Y. Shirman and J. Terning, “A Seiberg Dual for the MSSM: Partially Composite W and Z,” Phys. Rev. D **84** (2011) 095011, arXiv:1106.3074 [hep-ph].
24) K. Nakamura *et al.* [Particle Data Group Collaboration], “Review of particle physics,” J. Phys. G **G37**, 075021 (2010).
25) C. Csáki, Y. Shirman, J. Terning, “Electroweak Symmetry Breaking From Monopole Condensation,” Phys. Rev. Lett. **106**, 041802 (2011), arXiv:1003.1718 [hep-ph].
26) C. Csáki, Y. Shirman and J. Terning, “Anomaly Constraints on Monopoles and Dyons,” Phys. Rev. D **81** (2010) 125028, arXiv:1003.0448 [hep-th].
27) D. Stancato and J. Terning, “Constraints on the Unhiggs Model from Top Quark Decay,” Phys. Rev. D **81** (2010) 115012, arXiv:1002.1694 [hep-ph].
28) H. Cai, H. C. Cheng, A. D. Medina and J. Terning, “Continuum Superpartners from Supersymmetric Unparticles,” Phys. Rev. D **80** (2009) 115009, arXiv:0910.3925 [hep-ph].
29) G. D. Kribs, T. S. Roy, J. Terning and K. M. Zurek, “Quirky Composite Dark Matter,” Phys. Rev. D **81** (2010) 095001, arXiv:0909.2034 [hep-ph].
30) J. Galloway, B. McElrath, J. McRaven and J. Terning, “Gaugephobic Higgs Signals at the LHC,” JHEP **0911** (2009) 031 arXiv:0908.0532 [hep-ph].
31) H. Cai, H. C. Cheng and J. Terning, “A Quirky Little Higgs Model,” JHEP **0905** (2009) 045 arXiv:0812.0843 [hep-ph].
32) C. Csáki, M. Reece and J. Terning, “The AdS/QCD Correspondence: Still Undelivered,” JHEP **0905** (2009) 067 arXiv:0811.3001 [hep-ph].
33) C. Amsler *et al.* [Particle Data Group], “Review of particle physics,” Phys. Lett. B **667** (2008) 1.
34) D. Stancato and J. Terning, “The Unhiggs,” JHEP **0911** (2009) 101 arXiv:0807.3961 [hep-ph].
35) H. Cai, H. C. Cheng and J. Terning, “A Spin-1 Top Quark Superpartner,” Phys. Rev. Lett. **101** (2008) 171805 arXiv:0806.0386 [hep-ph].
36) J. Galloway, J. McRaven and J. Terning, “Anomalies, Unparticles, and Seiberg Duality,” Phys. Rev. D **80** (2009) 105017 arXiv:0805.0799 [hep-ph].
37) G. Cacciapaglia, G. Marandella and J. Terning, “The AdS/CFT/Unparticle Correspondence,” JHEP **0902** (2009) 049 arXiv:0804.0424 [hep-ph].
38) G. Cacciapaglia, G. Marandella and J. Terning, “Dimensions of Supersymmetric Operators from AdS/CFT,” JHEP **0906** (2009) 027 arXiv:0802.2946 [hep-th].
39) G. Cacciapaglia, C. Csáki, J. Galloway, G. Marandella, J. Terning and A. Weiler, “A GIM Mechanism from Extra Dimensions,” JHEP **0804** (2008) 006 arXiv:0709.1714 [hep-ph].
40) G. Cacciapaglia, G. Marandella and J. Terning, “Colored Unparticles,” JHEP **0801**

(2008) 070 arXiv:0708.0005 [hep-ph].
41) N. Kaloper and J. Terning, "How black holes form in high energy collisions," Gen. Rel. Grav. **39** (2007) 1525 [Int. J. Mod. Phys. D **17** (2008) 665] arXiv:0705.0408 [hep-th].
42) J. Terning, C. E. M. Wagner and D. Zeppenfeld, *Theoretical Advance Study Institute in Elementary Particle Physics (TASI 2004): Physics in D* ≥ 4, *Boulder, Colorado, 6 Jun - 2 Jul 2004*
43) C. Csáki, Y. Shirman and J. Terning, "A simple model of low-scale direct gauge mediation," JHEP **0705** (2007) 099 arXiv:hep-ph/0612241.
44) G. Cacciapaglia, C. Csáki, G. Marandella and J. Terning, "The gaugephobic Higgs," JHEP **0702** (2007) 036 arXiv:hep-ph/0611358.
45) W. M. Yao *et al.* [Particle Data Group], "Review of particle physics," J. Phys. G **33** (2006) 1.
46) E. Accomando *et al.*, "Workshop on CP Studies and Non-Standard Higgs Physics," arXiv:hep-ph/0608079.
47) G. Cacciapaglia, C. Csáki, G. Marandella and J. Terning, "A New Custodian for a Realistic Higgsless Model," Phys. Rev. D **75** (2007) 015003 arXiv:hep-ph/0607146.
48) G. Cacciapaglia, C. Csáki, C. Grojean and J. Terning, "Field theory on multi-throat backgrounds," Phys. Rev. D **74** (2006) 045019 arXiv:hep-ph/0604218.
49) J. Terning, "Modern supersymmetry: Dynamics and duality," *Oxford, UK: Clarendon (2006) 324 p*
50) C. Grojean, W. Skiba and J. Terning, "Disguising the oblique parameters," Phys. Rev. D **73** (2006) 075008 arXiv:hep-ph/0602154.
51) T. Bhattacharya, R. Gupta, M. R. Martin, Y. Shirman, C. Csáki and J. Terning, "Towards a chiral gauge theory by deconstruction in AdS(5)," PoS **LAT2005** (2006) 136 arXiv:hep-lat/0510073.
52) C. Csáki, N. Kaloper and J. Terning, "The Accelerated Acceleration of the Universe," JCAP **0606** (2006) 022 arXiv:astro-ph/0507148.
53) G. Cacciapaglia, C. Csáki, C. Grojean and J. Terning, "Higgsless electroweak symmetry breaking," eConf **C040802** (2004) FRT004 Czech. J. Phys. **55** (2005) B613.
54) G. Cacciapaglia, C. Csáki, C. Grojean, M. Reece and J. Terning, "Top and bottom: A brane of their own," Phys. Rev. D **72** (2005) 095018 arXiv:hep-ph/0505001.
55) T. Bhattacharya, C. Csáki, M. R. Martin, Y. Shirman and J. Terning, "Warped domain wall fermions," JHEP **0508** (2005) 061 arXiv:hep-lat/0503011.
56) C. Csáki, N. Kaloper and J. Terning, "Exorcising $w < -1$," Ann. Phys. 317 (2005) 410, astro-ph/0409596.
57) G. Cacciapaglia, C. Csáki, C. Grojean and J. Terning, "Curing the ills of Higgsless models: The S parameter and unitarity," Phys. Rev. D71 (2005) 035015, hep-ph/0409126.
58) S. Eidelman *et al.* [Particle Data Group], "Review of particle physics," Phys. Lett. B592 (2004) 1.
59) C. Csáki, P. Meade and J. Terning, "A mixed phase of SUSY gauge theories from a-maximization," JHEP 0404 (2004) 040, hep-th/0403062.
60) G. Cacciapaglia, C. Csáki, C. Grojean and J. Terning, "Oblique corrections from Higgsless models in warped space," Phys. Rev. D70 (2004) 075014, hep-ph/0401160.

61) C. Csáki, C. Grojean, J. Hubisz, Y. Shirman and J. Terning, "Fermions on an interval: Quark and lepton masses without a Higgs," Phys. Rev. D70 (2004) 015012, hep-ph/0310355.
62) C. Csáki, C. Grojean, L. Pilo, J. Terning, "Towards a realistic model of Higgsless electroweak symmetry breaking," Phys. Rev. Lett. 92 (2004) 101802, hep-ph/0308038.
63) J. Terning, TASI-2002 lectures: Non-perturbative supersymmetry, "The Quest for Physics Beyond the Standard Model(s)," World Scientific, Singapore, 2004), hep-th/0306119.
64) W. Skiba and J. Terning, "A simple model of two little Higgses," Phys. Rev. D68 (2003) 075001, hep-ph/0305302.
65) C. Csáki, C. Grojean, H. Murayama, L. Pilo, J. Terning, "Gauge theories on an interval: Unitarity without a Higgs," Phys. Rev. D69 (2004) 055006, hep-ph/0305237.
66) C. Csáki, J. Hubisz, G. D. Kribs, P. Meade, J. Terning, "Variations of little Higgs models and their electroweak constraints," Phys. Rev. D68 (2003) 035009, hep-ph/0303236.
67) C. Csáki, N. Kaloper, M. Peloso, J. Terning, "Super-GZK photons from photon axion mixing," JCAP 0305 (2003) 005, hep-ph/0302030.
68) K. Hagiwara *et al.* [Particle Data Group Collaboration], "Review Of Particle Physics," Phys. Rev. D66 (2002) 010001.
69) C. Csáki, J. Hubisz, G. D. Kribs, P. Meade, J. Terning, "Big corrections from a little Higgs," Phys. Rev. D67 (2003) 115002, hep-ph/0211124.
70) C. Csáki, J. Erlich, J. Terning, "Seiberg-Witten description of the deconstructed 6D (0,2) theory," Phys. Rev. D67 (2003) 025019 hep-th/0208095.
71) C. Csáki, J. Erlich, G. D. Kribs, J. Terning, "Constraints on the $SU(3)$ Electroweak Model," Phys. Rev. D66 (2002) 075008, hep-ph/0204109.
72) J. Terning, "Glueballs and AdS/CFT," Proceedings of the Institute of Nuclear Theory-Vol.12, Phenomenology of Large N_c QCD, R.F. Lebed ed. (World Scientific, Singapore, 2002), hep-ph/0204012.
73) C. Csáki, J. Erlich, and J. Terning, "The effective Lagrangian in the Randall-Sundrum model and electroweak physics," Phys. Rev. D66 (2002) 064021, hep-ph/0203034.
74) C. Csáki, N. Kaloper, and J. Terning, "Effects of the intergalactic plasma on supernova dimming via photon axion oscillations," Phys. Lett. B535 (2002) 33, hep-ph/0112212.
75) C. Csáki, N. Kaloper, and J. Terning, "Dimming supernovae without cosmic acceleration," Phys. Rev. Lett. 88 (2002) 161302, hep-ph/0111311.
76) C. Csáki, G. D. Kribs, and J. Terning, "4-D models of Scherk-Schwarz GUT breaking via deconstruction," Phys. Rev. D65 (2002) 015004, hep-ph/0107266.
77) M. Luty, J. Terning, and A. Grant, "Electroweak symmetry breaking by strong supersymmetric dynamics at the TeV scale," Phys. Rev. D63 (2001) 075001, hep-ph/0006224.
78) C. Csáki, J. Erlich, T. Hollowoood, and J. Terning, "Holographic RG and Cosmology in theories with quasilocalized gravity," Phys. Rev. D63 (2001) 065019, hep-ph/0003076.
79) C. Csáki, M. Graesser, L. Randall, and J. Terning, "Cosmology of brane models with radion stabilization," Phys. Rev. D62 (2000) 045015, hep-ph/9911406.
80) C. Csáki, M. Graesser, C. Kolda, and J. Terning, "Cosmology of one extra dimension

with localized gravity," Phys. Lett. B462 (1999) pp. 34-40, hep-ph/9906513.
81) C. Csáki, W. Skiba, and J. Terning, "β functions of orbifold theories and the hierarchy problem," Phys. Rev. D61 (2000) 025019, hep-th/9906057.
82) M. Luty and J. Terning, "Single sector supersymmetry breaking," APS—Division of Particles and Fields 99 Proceedings, hep-ph/9903393.
83) C. Csáki and J. Terning, "Glueball mass spectrum from supergravity," APS—Division of Particles and Fields 99 Proceedings, hep-th/9903142.
84) C. Csáki, M. Graesser, and J. Terning, "Late inflation and the moduli problem of sub millimeter dimensions," Phys. Lett. B456 (1999) pp. 16-21, hep-ph/9903319.
85) C. Csáki, J. Russo, K. Sfetsos, J. Terning, "Supergravity models for 3+1 dimensional QCD," Phys. Rev. D60 (1999) 044001, hep-th/9902067.
86) M. Luty and J. Terning, "Improved single sector supersymmetry breaking," Phys. Rev. D60 (1999) 044001, hep-ph/9812290.
87) C. Csáki, Y. Oz, J. Russo, and J. Terning, "Large N QCD from rotating branes," Phys. Rev. D (1999) 065012, hep-ph/9810186.
88) T. Appelquist, A. Ratnaweera, J. Terning, and L.C.R. Wijewardhana, "The phase structure of an $SU(N)$ gauge theory with N_f flavors," Phys. Rev. D58 (1998) 105017, hep-ph/9806472.
89) C. Csáki, H. Ooguri, Y. Oz, and J. Terning, "Glueball mass spectrum from supergravity," JHEP 9901 (1999) 017, hep-th/9806021.
90) Y. Oz and J. Terning, "Orbifolds of $\mathrm{AdS}_5 \times S^5$ and 4D conformal field theories," Nucl. Phys. B532 (1998) pp. 163-180, hep-th/9803167.
91) C. Csáki, M. Schmaltz, W. Skiba, and J. Terning, "Gauge theories with tensors from branes and orientifolds," Phys. Rev. D57 (1998) pp. 7546-7560, hep-th/9801207.
92) J. Terning, "Duals for $SU(N)$ SUSY gauge theories with antisymmetric tensors: five easy flavors," Phys. Lett. B422 (1998) pp. 149-157, hep-th/9712167.
93) N. Arkani-Hamed, M.A. Luty, and J. Terning, "Composite quarks and leptons from dynamical supersymmetry breaking without messengers," Phys. Rev. D58 (1998) 015004, hep-ph/9712389.
94) M.A. Luty and J. Terning, "New mechanisms of dynamical supersymmetry breaking and direct gauge mediation," Phys. Rev. D57 (1998) pp. 6799-6806, hep-ph/9709306.
95) B.A. Dobrescu and J. Terning, "Negative contributions to S in an effective field theory," Phys. Lett. B416 (1998) pp. 129-136, hep-ph/9709297.
96) J. Terning, "'t Hooft anomaly matching in QCD," Phys. Rev. Lett. 80 (1998) pp. 2517-2520, hep-th/9706074.
97) T. Appelquist, J. Terning, and L.C.R. Wijewardhana, "Postmodern technicolor," Phys. Rev. Lett. 79 (1997) pp. 2767-2770, hep-ph/9706238.
98) T.L. Barklow, G. Burdman, R. S. Chivukula, B.A. Dobrescu, P.S. Drell, N. Hadley, W.B. Kilgore, M.E. Peskin, J. Terning, and D.R. Wood, "Strong coupling electroweak symmetry breaking," 1996 DPF/DPB Summer Study on New Directions for High-Energy Physics (Snowmass 96), hep-ph/9704217.
99) C. Csáki, M. Schmaltz, W. Skiba, and J. Terning, "Self-dual N=1 SUSY gauge theories," Phys. Rev. D56 (1997) pp. 1228-1238, hep-th/9701191.
100) R. S. Chivukula and J. Terning, "Precision electroweak constraints on top-color as-

sisted technicolor," Phys. Lett. B385 (1996) pp. 209-217, hep-ph/9606233.
101) M.A. Luty, M. Schmaltz, and J. Terning, "A sequence of duals for $Sp(2N)$ supersymmetric gauge theories with adjoint matter," Phys. Rev. D54 (1996) pp. 7815-7824, hep-th/9603034.
102) T. Appelquist, J. Terning, and L.C.R. Wijewardhana, "The zero temperature chiral phase transition in QCD," Phys. Rev. Lett. 77 (1996) pp. 1214-1217, hep-ph/9602385.
103) E. H. Simmons, R. S. Chivukula, and J. Terning, "Direct tests of dynamical electroweak symmetry breaking," Proceedings of the International Symposium on Heavy Flavor and Electroweak Theory in Beijing, Aug., 1995, and Proceedings of the Yukawa International Seminar in Kyoto, Aug., 1995, hep-ph/9511439.
104) J. Terning, "Naturally light scalars," Phys. Rev. D53 (1996) pp. 2284-2287, hep-ph/9510225.
105) E. H. Simmons, R.S. Chivukula, and J. Terning, "Testing extended technicolor with R_b," Prog. Theor. Phys. Suppl. 123 (1996) pp. 87-96, hep-ph/9509392.
106) R.S. Chivukula, B.A. Dobrescu, and J. Terning, "Isospin breaking and the top quark mass in models of dynamical electroweak symmetry breaking," Prog. Theor. Phys. Suppl. 123 (1996) pp. 105-112, hep-ph/9506450.
107) R.S. Chivukula, E. H. Simmons, and J. Terning, "Limits on non-commuting extended technicolor," Phys. Rev. D53 (1996) pp. 5258-5267, hep-ph/9506427.
108) R. S. Chivu-kula, R. Rosenfeld, E.H. Simmons, and J. Terning, "Strongly coupled electroweak symmetry breaking: implications of models," subgroup report for the DPF long range planning study, Electroweak Symmetry Breaking and New Physics at the TeV Scale, T.L. Barklow et. al. eds. (World Scientific, Singapore, 1996), hep-ph/9503202.
109) R.S. Chivukula, B.A. Dobrescu, and J. Terning, "Isospin breaking and fine tuning in top-color assisted technicolor," Phys. Lett. B353 (1995) pp. 289-294, hep-ph/9503203.
110) R.S. Chivukula, E.H. Simmons, and J. Terning, "Limits on the ununified standard model," Phys. Lett. B346 (1995) pp. 284-290, hep-ph/9412309.
111) J. Terning, "Chiral technicolor and precision electroweak measurements," Phys. Lett. B344 (1995) pp. 279-286, hep-ph/9410233.
112) R.S. Chivukula, E.H. Simmons, and J. Terning, "A heavy top quark and the $Zb\bar{b}$ vertex in non-commuting extended technicolor," Phys. Lett. B331 (1994) pp. 383-389, hep-ph/9404209.
113) T. Appelquist, J. Terning, and L.C.R. Wijewardhana, "2+1 dimensional QED and a novel phase transition," Phys. Rev. Lett. 71 (1995) pp. 2081-2084, hep-ph/9402320.
114) T. Appelquist and J. Terning, "An extended technicolor model," Phys. Rev. D50 (1994) pp. 2116-2126, hep-ph/9311320.
115) L.M. Krauss, J. Terning, and T. Appelquist, "Neutrino cosmology and limits on extended technicolor," Phys. Rev. Lett. 71 (1993) pp. 823-826, hep-ph/9305265.
116) T. Appelquist and J. Terning, "Revenge of the one-family technicolor models," Phys. Lett. B315 (1993) pp. 139-145, hep-ph/9305258.
117) R.S. Chivukula, E. Gates, E.H. Simmons, and J. Terning, "Walking technicolor and

the $Zb\bar{b}$ vertex," Phys. Lett. B311 (1993) pp. 157-162, hep-ph/9305232.
118) T. Appelquist and J. Terning, "Limits of chiral perturbation theory," Phys. Rev. D47 (1993) pp. 3075-3078, hep-ph/9211223.
119) T. Appelquist and J. Terning, "Comments on technicolour model building," Beyond the Standard Model III, S. Godfrey and P. Kalyniak eds., (World Scientific, Singapore, 1993) pp. 406-410.
120) T. Appelquist and J. Terning, "Extended technicolor model building," International Workshop on Electroweak Symmetry Breaking, W. Bardeen et. al. eds., (World Scientific, Singapore, 1992) pp. 68-74.
121) E. Gates, L.M. Krauss, and J. Terning, "Monopole non-annihilation at the electroweak scale," Phys. Lett. B284 (1992) pp. 309-316, hep-ph/9203208.
122) T. Appelquist, J. Terning, and L.C.R. Wijewardhana, "Mass enhancement and critical behavior in technicolor theories," The Vancouver Meeting: Particles and Fields '91, vol. 2, D. Axen et. al. eds., (World Scientific, Singapore, 1992) pp. 796-800.
123) E. Gates and J. Terning, "Negative contributions to the radiative-correction parameter S from Majorana particles," Phys. Rev. Lett. 67 (1991) pp. 1840-1843.
124) J. Terning, "Gauging nonlocal Lagrangians," Phys. Rev. D44 (1991) pp. 887-897.
125) T. Appelquist, J. Terning, and L.C.R. Wijewardhana, "Mass enhancement and critical behavior in technicolor theories," Phys. Rev. D44 (1991) pp. 871-877.
126) B. Holdom and J. Terning, "Large corrections to electroweak parameters in technicolor theories," Phys. Lett. B247 (1990) pp. 88-92.
127) B. Holdom, J. Terning, and K. Verbeek, "Chiral Lagrangian from quarks with dynamical mass," Phys. Lett. B245 (1990) pp. 612-618.
128) B. Holdom, J. Terning, and K. Verbeek, "A nonlocal model of chiral dynamics," Phys. Lett. B232 (1989) pp. 351-356.
129) B. Holdom and J. Terning, "No light dilaton in gauge theories," Phys. Lett. B200 (1988) pp. 338-342.
130) B. Holdom and J. Terning, "A light dilaton in gauge theories?" Phys. Lett. B187 (1987) pp. 357-361.
131) M. Razavy and J. Terning, "Quantum radiation in a one-dimensional cavity with moving boundaries," Phys. Rev. D31 (1985) pp. 307-313.
132) M. Razavy and J. Terning, "Quantized Klein-Gordon field in a cavity of variable length," Lett. al Nuovo Cim. 41 (1984) pp. 561-566.

Research Highlights

My research has focused primarily on quantum field theory and particle physics phenomenology. My goal is to address some of the fundamental questions of particle physics: What is the source of electroweak symmetry breaking? Why are there different flavors of quarks and leptons? Why do they have different masses? To answer these questions I have worked on extra dimensions, supersymmetry, particle cosmology, and precision electroweak tests of the standard model.

Extra Dimensions

The realization of the feasibility of millimeter or inverse TeV sized extra dimensions has opened up new classes of theories, especially in the area of electroweak symmetry breaking. Most of my recent work has focused on the possibility of higgsless electroweak symmetry breaking in extra dimensions [1,4,7,8,9,12]. My collaborators and I have shown that WW scattering is unitary [12] in a five dimensional theory without a Higgs, provided that the gauge symmetry breaking is achieved through Dirichlet boundary conditions. In a warped anti-de Sitter (AdS) background (like the Randall-Sundrum model) a custodial symmetry can ensure the correct ratio for the W and Z masses [9]. We found that these higgsless models can be consistent with precision constraints on oblique parameters through either brane kinetic terms [7] or requiring the light fermions to be roughly uniformly distributed in the extra dimension [4]. Maintaining the correct $Zb\bar{b}$ coupling while getting the correct top quark mass is a more serious problem. We proposed two solutions based on the idea that the third generation may couple to a different conformal field theory (CFT) or, equivalently through the AdS/CFT correspondence, live in a different warped space from the first two generations and have a separate TeV brane [1]. Separately we analyzed how quark and lepton masses can be produced in a higgsless theory via boundary conditions in the extra dimension [8].

We were also able to use these model building ideas to propose a warped five dimensional lattice construction of a four dimensional chiral gauge theory [2]. This may be a solution of a long-standing problem in lattice gauge theory, and open up new directions of research.

Earlier we showed how deconstruction [23] (a.k.a. latticization) of a five dimensional Grand Unified Theory (GUT) allows the GUT gauge symmetry to be broken by an analogue of the Scherk-Schwarz mechanism, and also allows the doublet-triplet splitting problem to be resolved in a simple way.

Supersymmetry (SUSY)

Our understanding of supersymmetric gauge theories has been revolutionized by the work of Seiberg, Witten, and Maldacena. I have devoted some effort to studying $\mathcal{N} = 1$ SUSY gauge theories with the new non-perturbative tools that have become available. With my collaborator [80] I found a new mechanism for dynamical SUSY breaking that can produce realistic masses for the superpartners (squarks, sleptons, and gauginos) of the observed standard model particles. We also developed a class of models in which new strongly coupled gauge interactions both dynamically break SUSY and form composite quarks, squarks, leptons, and sleptons [68,72,79]. Previously realistic models have relied on messenger (gravitational or gauge) interactions to communicate the SUSY breaking from a strongly coupled sector to the weakly coupled superpartners. In our models these particles couple directly to the SUSY breaking dynamics so there is no need for intermediate messengers at all. In addition to this economy, these models can solve the SUSY flavor problem and also predict a unification of squark and slepton masses independent of gauge coupling unification. We also worked on a SUSY model that breaks electroweak symmetry by strong SUSY dynamics, which can be analyzed using Seiberg duality, and solves the μ problem [63].

Following the work of Maldacena and others on the correspondence between M-theory/supergravity on AdS backgrounds and conformal $\mathcal{N} = 4$ SUSY gauge theories, we have tested the correspondence between orbifolded AdS theories and conformal gauge theories with fewer SUSY charges, including non-SUSY theories [76]. Using the correspondence between M-theory/supergravity on blackhole AdS backgrounds and non-SUSY QCD, we calculated ratios of glueball masses [69,71,73,75] in three and four dimensions in a strong coupling, large N_c limit of QCD. We found that these ratios are in unexpectedly good agreement with the available lattice data. We also found a method to decouple some of the extra Kaluza-Klein modes that do not correspond to bound states of QCD.

We have also found exact results arising as a consequence of duality. We found a set of SUSY gauge theories that were self-dual [85], i.e. theories with dual descriptions that had different fundamental fields and different interactions, but with the same gauge structure. It had been conjectured that SUSY theories with matter in the adjoint representation of the gauge group and no superpotential were related to string theories. My collaborators and I found an infinite sequence of dual descriptions for such theories [87]. We also found evidence for a new type of non-perturbative phenomena: as the number of matter fields is varied, an interacting conformal theory splits into interacting and free sectors [87]. I also constructed a new dual description for certain chiral SUSY gauge theories [78]. It was previously known that these theories confine with three of four flavors; I demonstrated that with five flavors they simultaneously possess both an interacting infrared fixed point and a free sector. We recently found a class of theories [45] where a-maximization can be used to explicitly show that the IR splits into such a mixed phase. We also produced new D-brane constructions of related SUSY gauge theories with matter in tensor representations [77] and examined how duality is related to D-brane motions in M-theory.

We also studied [56] the Seiberg-Witten curve for the deconstructed version of the 6D $(0, 2)$ theory on a torus, which clarified the nature of the low-energy effective field theory.

Particle Cosmology

Cosmology offers particle physicists a method of testing models that is complementary to accelerator experiments. Particles that cannot be produced easily in accelerators can have drastic effects in the early universe. This can be seen in the new theories of gravity that involve sub-millimeter extra dimensions. My collaborators and I put severe constraints on a class of such theories [70]. In these models, oscillations of the light field (the radion, a particular type of modulus field) that determines the size of the extra dimensions can over-close the universe. It had been proposed that a period of late inflation could solve this problem, however we found that the required inflaton scale is so low that it cannot successfully reheat the universe. We also found that in a five dimensional AdS scenario (the Randall-Sundrum model) for solving the hierarchy problem, the extra dimensional gravity can force the universe to collapse shortly after becoming matter dominated [66], thus such theories cannot describe our universe. We later found that when such models are stabilized by additional interactions, they can be cosmologically viable and the radion must have Higgs-like interactions [65]. We also used string theory techniques to analyze certain models where gravity is four dimensional at intermediate distances, but five dimensional at long distances [64].

Recently we showed that axions can explain the dimming of distant supernovae [60,61] just as well as an accelerating Universe. We also found that axions may play a role in generating trans-GZK cosmic rays [53]. It has been argued that a dark energy equation of state parameter $w < -1$ may be slightly favored by the data, although no consistent theory actually has so negative a w. We recently showed [42] that the combination of a cosmological constant and axion effects can mimic $w < -1$.

Precision Electroweak Tests

My early research emphasized studying the effects of non-standard-model physics on precision electroweak measurements. These measurements are important for constraining and ruling out a variety of models that purport to be more fundamental than the standard model of particle physics. This work often involved building effective field theories to describe the most important degrees of freedom at a particular energy, and relating the properties of such theories to the underlying dynamics.

Early on I studied the effects of technicolor interactions on precision electroweak measurements [112]. Such contributions to electroweak vacuum polarizations are now conventionally described by the parameters S and T. The S parameter describes a momentum-dependent (kinetic) mixing of the electroweak gauge bosons, while the T parameter involves isospin breaking, which splits the W and Z masses We found that QCD-like technicolor models give large corrections to electroweak physics; in other words, they give contributions to S of order 1. Current measurements of S can thus rule out a large class of technicolor models.

Present data tend to give central values for S and T which are small, or negative. Most theories of non-standard physics give rise to positive values for S and T. We also showed that heavy Majorana fermions (i.e. fermions whose masses violate the conservation of fermion number) can give negative contributions to the S and T parameters [109].

I have also examined corrections that are complementary to S and T [103]. The corrections from S and T are flavor blind, since they arise from vacuum polarization effects. Thus measurements of S and T are insensitive to new, flavor-dependent physics that can appear in vertex corrections. Generally we expect the heaviest family of fermions to couple most strongly to flavor physics. Generically, extended technicolor gauge boson corrections decrease the partial width from the standard model expectation, so a large class of such models can be ruled out by current measurements. I have also looked at models where two gauge groups mix to produce the electroweak gauge group [93,98]. In these models, the extended technicolor corrections increase the $Z \to b\bar{b}$ width and cancel to a large extent with the corrections from extra electroweak gauge bosons, and thus can be consistent with current data.

We recently used precision electroweak measurements to tightly constraint the parameters of the Randall-Sundrum model [59] as well as a variety of proposed Little Higgs models [50,52,55]. We also analyzed the constraints on higgsless extra dimensional models [40,43,46] .

Most of the work described above has been done with collaborators at several universities; I expect that these very fruitful collaborations will continue in the future.

Current Research Interests

Csaba Csáki, Yuri Shirman, and I are working on alternative models of electroweak symmetry breaking. I am working with Witold Skiba on non-perturbative effects in QED. Csaba Csáki and I are also working on new applications of conformal field theories to electroweak symmetry breaking.