

PAUL G. LANGACKER

Present Position

Emeritus Professor of Physics and Astronomy
University of Pennsylvania, Philadelphia, PA
(pgl@upenn.edu)

Personal Information

Birth: July 14, 1946, Evanston, Illinois
Married: Irmgard Langacker

Research Interests

Theoretical High Energy Physics (weak interactions, neutrino physics, cosmology, grand unification, supersymmetry, superstring physics, chiral symmetry).

Positions

- 9/06 - 8/19:** Member/Visitor, Institute for Advanced Study
- 1/11 - 6/18:** Senior Scientist/Lecturer, Princeton University
- 7/85 - 8/06:** Professor of Physics, University of Pennsylvania
- 1/96 - 6/01:** Chair, Department of Physics and Astronomy, University of Pennsylvania
- 7/93 - 7/98:** William Smith Term Professor of Physics, University of Pennsylvania
- 8/87 - 7/88:** Alexander von Humboldt-Stiftung, Senior Scientist, DESY, Hamburg, Germany
- 7/81 - 6/85:** Associate Professor, University of Pennsylvania
- 9/75 - 6/81:** Assistant Professor, University of Pennsylvania
- 9/74 - 9/75:** Research Associate, University of Pennsylvania
- 9/72 - 9/74:** Research Associate, Rockefeller University

Education

- Ph.D. (Physics):** University of California at Berkeley, 1972
- M.A. (Physics):** University of California at Berkeley, 1969
- B.A. (Physics):** Massachusetts Institute of Technology, 1968

Honors

- American Physical Society Outstanding Referee Award, 2015
- LangackerFest, 60th birthday celebration, University of Pennsylvania, 2006
- Henry Primakoff Lecturer, University of Pennsylvania, 2006
- Fermilab Frontier Fellow, 2005
- Keck Distinguished Visiting Professor, Institute for Advanced Study, 2001
- William Smith Term Professor of Physics, University of Pennsylvania, 1993-1998
- Fellow, American Association for the Advancement of Science, 1992
- Fellow, American Physical Society, 1987
- Alexander von Humboldt-Stiftung, Senior U.S. Scientist Award, 1987-1988
- Honorary Master of Arts, University of Pennsylvania, 1982

Affiliations

- American Physical Society
- American Association for the Advancement of Science

Books

- Editor (with H. A. Weldon and P. J. Steinhardt), *Fourth Workshop on Grand Unification* (Birkhäuser, Boston, 1983).
- Editor (with M. Cvetič), *Testing the Standard Model* (Proceedings of TASI-90), (World, Singapore, 1991).
- Editor, *Precision Tests of the Standard Electroweak Model*, (World Scientific, Singapore, 1995).

- Editor (with M. Cvetič), *SUSY '97, Proceedings of the Fifth International Conference on Supersymmetries in Physics*, Nucl. Phys. **B** (Proc. Suppl.) 62 (1998) (North Holland, 1998).
- Editor, *Neutrinos in Physics and Astrophysics: From 10^{-33} to 10^{+28} cm*, (Proceedings of TASI-98), (World, Singapore, 2000).
- *The Standard Model and Beyond* (CRC Press, New York, 2009).
- *Can the Laws of Physics be Unified?* (Princeton University Press, 2017).
- *The Standard Model and Beyond, 2nd edition* (CRC Press, 2017).

Lecture Series and Schools

- Lecturer, *2014 Tri-Institute Summer School on Elementary Particles (TRISEP)*, Sudbury, Canada, June 2014
- Lecturer, *Perimeter Scholars International*, Waterloo, Canada, January 2014
- Lecturer, *Foundations and New Methods in Theoretical Physics*, Saalburg, Germany, September 2013
- Lecturer, *Augusto Garcia Visiting Professorship*, Cinvestav (Center for Research and Advanced Studies), Mexico City, October 2012
- Lecturer, *22nd Chris Engelbrecht Summer School*, Stellenbosch, South Africa, January, 2011
- Lecturer, *SLAC Summer Institute*, August 2010
- Lecturer, *Taiwan Spring School*, March, 2010
- Lecturer, *International Summer School and Conference on High Energy Physics*, Mugla, Turkey, August 2009
- Lecturer, *Theoretical Advanced Study Institute*, Boulder, June 2008
- Lecturer, *The Standard Model and Beyond*, Institute for Advanced Study, July 2007
- Lecturer, *Fermilab Academic Lecture series*, November-December 2005
- Lecturer, *Mexican School of Particles and Fields*, Veracruz, August 2004
- Lecturer, *DESY Theory Workshop*, Hamburg, Germany, September 2003
- Lecturer, *Cosmology, Particles, and Strings*, Institute for Advanced Study, July 2003
- Lecturer, *Theoretical Advanced Study Institute*, Boulder, June 2003

- Lecturer, *Topical Seminar on Frontier of Particle Physics 2002: Neutrinos and Cosmology*, Beijing, China, August 2002
- Lecturer, *Theoretical Advanced Study Institute*, Boulder, June 1998
- Lecturer, *CTEQ (The Coordinated Theoretical-Experimental Project on QCD) 1997 Summer School*, Lake Como, Wisconsin, June 1997
- Lecturer, *II Mexican School of Particles and Field*, Merida, Mexico 1996
- Lecturer, *Advanced School of Electroweak Physics*, Menorca, Spain 1996
- Lecturer, *Theoretical Advanced Study Institute*, Boulder, June 1995
- Lecturer, *VIII J. A. Swieca School*, Rio de Janeiro, February 1995
- Lecturer, *CERN Academic Training Program*, Geneva, October 1994
- Lecturer, *Fifteenth UK Institute for Theoretical High Energy Physics*, Southampton, August, 1994
- Lecturer, *International School of Subnuclear Physics: From Superstring to Present-Day Physics*, Erice, July, 1994
- Lecturer, *International School of Subnuclear Physics: From Supersymmetry to the Origin of Space-Time*, Erice, July, 1993
- Lecturer, *Lake Louise Winter Institute*, Lake Louise, Canada, February 1993
- Lecturer, *ICTP Summer School in High Energy Physics and Cosmology*, Trieste, Italy, July 1992
- Lecturer, *Theoretical Advanced Study Institute*, Boulder, June 1992
- Lecturer, *International School of Physics*, Leningrad, USSR, September 1991
- Lecturer, *Theoretical Advanced Study Institute*, Boulder, June 1990
- Lecturer, *China Center of Advanced Science and Technology Symposium on TeV Physics*, Beijing, China, May 1990
- Lecturer, *11th International School of Theoretical Physics*, Szczyrk, Poland, September 1987
- Lecturer, Summer School, *4th Symposium on Theoretical Physics*, Seoul, Korea, August 1985
- Distinguished Lecture Series, Texas A & M University, October 1981

Editorial Positions

- Editorial Committee, *Annual Reviews of Nuclear and Particle Science*, 2012-2015.
- Associate Editor, *Reviews of Modern Physics*, 2007-2013.
- Divisional Associate Editor, *Physical Review Letters*, 1998-2004.
- Member, Advisory Panel, *Physical Review Letters*, 1995-96.
- Member, Editorial Board, *Physical Review D*, 1986-88, 1991-93.
- Referee for *Physical Review*, *Physical Review Letters*, *Physics Letters*, *Annals of Physics*, *Nuclear Physics*, *Zeitschrift für Physik*, *Europhysics Letters*, *Modern Physics*, *Journal of High Energy Physics*, *Journal of Physics*
- Book reviewer for *Science*, *Nature*, *Physics Today*, *American Scientist*

Professional Activities

- Member, selection committee for J.J. and Noriko Sakurai Dissertation Award in Theoretical Particle Physics, 2014-2015.
- Co-convenor, Workshop on *Probing the TeV Scale and Beyond*, Mainz Institute for Theoretical Physics, July 2014.
- Co-convenor, Workshop on *First Two Years of the LHC*, Kavli Institute for Theoretical Physics in China, Beijing, Summer, 2012.
- Co-convenor, Workshop on *Strings at the LHC and in the Early Universe*, Kavli Institute for Theoretical Physics, Santa Barbara, Spring, 2010.
- Member, Organizing Committee, *International Conference on High Energy Physics*, Philadelphia, August, 2008.
- Member, Organizing Committee, *String Phenomenology, 2008*, Philadelphia, May, 2008.
- Chair, Steering Committee for the LHC Theory Initiative, 2006-2015.
- Member, HEPAP subpanel on the University Grants Program, 2006-2007.
- Co-convenor, Extra Gauge Groups section of study *CP Violation and Non-Standard Higgs*, CERN, 2004-2006.
- Member, organizing committee for International Conference on High Energy Physics, Philadelphia, 2008 (ICHEP2008).
- Member, International Advisory Committee for (Pakistan) National Centre for Physics, 2004-

- Member, organizing committee for APS Study on the Physics of Neutrinos, 2004, and member of Theory and Astrophysics subpanels.
- External review committee for CERN Theoretical Division, 2003.
- Selection Committee for J.J. Sakurai Prize of the American Physical Society: Vice-Chair, 2004; Chair, 2005.
- Co-organizer, Aspen Winter Conference *At the Frontiers of Particle Physics*, 2003.
- Member, High Energy Physics Advisory Panel (HEPAP) of the Department of Energy and National Science Foundation, 2002-2005. Subcommittee on long range goals, 2003.
- Member, program committee for meeting of Division of Particles and Fields of American Physical Society, Philadelphia, 2003.
- Adjunct Professor of Physics, Zhejiang University, Hangzhou, China, 2001-.
- Co-organizer, *Aspen Workshop on Underground Science*, 2002.
- Member, Organizing Committee, *Flavor Physics and CP Violation*, Philadelphia, May 2002.
- Chair, Department of Physics and Astronomy, University of Pennsylvania, 1996-2001.
- Member of Board of Delaware Valley Chapter of the Alexander von Humboldt Association, 2000-.
- Member, Department of Energy Review Panel for High Energy Physics Division, Argonne National Laboratory, 2000.
- National Science Foundation Review Panel on Phenomenology and Astroparticle Physics, 2000.
- Organizing Committee, meeting of Northeast Section of *American Association of Physics Teachers*, Philadelphia, October 1999.
- Organizing Committee, *New Ideas in Particle Physics and Cosmology*, Philadelphia, May 1999.
- Co-convenor, *Precision Electroweak Section of Workshop on Weak Interactions and Neutrinos*, Cape Town, January 1999.
- Director, Physics and Astronomy section of Penn Summer Science Academy (PSSA), 1998-2001.
- Scientific Director, Theoretical Advanced Study Institute (TASI) summer school on *Neutrinos in Physics and Astrophysics: from 10^{-33} to 10^{+28} cm*, University of Colorado at Boulder, June 1998.

- Member, Particle Data Group, 1998 - 2016.
- Department of Energy Advisory Panel on Outstanding Junior Investigator Awards, 1998, 1999.
- Member, Steering Committee for SUSY conferences, 1998- .
- Co-convenor, Workshop on *Solar Neutrinos*, Institute for Theoretical Physics, Santa Barbara, December 1997.
- Co-chair, *SUSY 97*, Philadelphia, May 1997.
- Co-convenor, Workshop on *Unification: From the Weak Scale to the Planck Scale*, Institute for Theoretical Physics, Santa Barbara, Fall 1995.
- Co-organizer, Conference on *Unification: From the Weak Scale to the Planck Scale*, Institute for Theoretical Physics, Santa Barbara, October 1995.
- Member, Scientific Advisory Board, Theoretical Advanced Study Institute, 1995-2001.
- Member, Planning and Priorities Committee, School of Arts and Sciences, University of Pennsylvania, 1994-95.
- Co-convenor, Division of Particles and Fields Long Range Planning Study, Neutrino Physics Section, 1994.
- Member, Advisory Committee, Particle Data Group, 1992-1994.
- Member, Department of Energy Review Panel for High Energy Physics Division, SSC Laboratory, 1993.
- Co-convenor, Section on Extended Gauge Structures, *Workshop on Physics and Experiments with Linear e^+e^- Colliders*, Hawaii, April 1993.
- Co-organizer, *Mid-Atlantic Workshop on Collider Theory*, Baltimore, September 1992.
- Member, University of Chicago's Review Committee for the High Energy Physics Division at Argonne National Laboratory, 1990-1992.
- Chair, Natural Science Association, University of Pennsylvania, 1990-1991.
- Member, Executive Committee of the Division of Particles and Fields, American Physical Society, 1989-1991.
- Scientific Director, Theoretical Advanced Study Institute (TASI) summer school on *Testing the Standard Model*, University of Colorado at Boulder, June 1990.
- Organizer, Workshop on *Tests and Extensions of the Standard Model*, Aspen Center for Physics, Aspen, Colorado, July 1990.

- Co- Organizer, *Electroweak Interactions*, 1990 DPF Summer Study, Snowmass, Colorado, June 25–July 13, 1990.
- Member, Division of Particles and Fields Committee on Needs for Theoretical Physics at the Interface with Experiment, 1989-1990.
- International Advisory Committee for the International Germanium Experiment for $\beta\beta_{0\nu}$ (IGEX), 1988-89.
- Convener, Working Group on Precision Tests of Electroweak Theory, *12th International Workshop on Weak Interactions and Neutrinos*, Ginosar, Israel, April 1989.
- Member, Selection Committee for J.J. Sakurai Prize of the American Physical Society, 1988, 1989
- Contributor: *Review of Particle Properties (Standard Model of the Electroweak Interactions)*, 1986-2012.
- Member, National Science Foundation visiting committee for CESR, Cornell University, 1987.
- Steering Committee, *Workshop on Grand Unification* series, 1984-1989.
- Chairman, Working Group on Nonstandard Higgs Bosons, *Workshop on Electroweak Symmetry Breaking*, Lawrence Berkeley Laboratory, Berkeley, CA, June 1984.
- Chairman, Study Group on Heavy Gauge Bosons, *Physics of the SSC*, 1984.
- Session organizer, *Gordon Conference on High Energy Physics*, New Hampshire, August 1983; *1991 Spring Meeting of the American Physical Society*, Washington, April 1991.
- Co-Chairman and co-editor of Proceedings, *Fourth Workshop on Grand Unification*, University of Pennsylvania, April 1983.
- Chairman, Working group on Theoretical Goals for Second Generation Detectors, *Summer Workshop on Proton Decay Experiments*, Argonne National Laboratory, June 1982.
- Organizing Committee, *Third workshop on Grand Unification*, University of North Carolina at Chapel Hill, April 1982.
- Outside Examiner for the Ph.D., City College of New York, 1982.
- Honors Examiner, Swarthmore College, May 1983.
- Participant, *Sixth Hawaii Topical Conference in Particle Physics*, Honolulu, HI, 1975.
- Teaching Assistant, University of California at Berkeley, 1969-1971.
- Research Assistant, Lawrence Berkeley Laboratory, 1970-1972.

Visiting Scientist or Professor Positions

- Institute for Advanced Study, Princeton, 2011-present.
- Department of Applied Mathematics and Theoretical Physics, Cambridge University, Cambridge, England, 1973.
- Aspen Center for Physics, Aspen, Colorado 1974, 1975, 1977, 1979, 1982, 1989, 1990, 1996, 1997, 2000, 2005, 2007, 2008, 2009, 2011, 2012, 2013, 2015
- Fermi National Accelerator Laboratory, Batavia, Illinois, 1977, 1979, 2005.
- Brookhaven National Laboratory, Upton, New York, 1976, 1978.
- Institute for Advanced Study, Princeton, N.J., 1980, 1984, 2001, 2011-.
- Lawrence Berkeley Laboratory, Berkeley, CA 1980, 1981.
- Los Alamos National Laboratory, Los Alamos, N.M., 1980.
- Stanford Linear Accelerator Center, Stanford, CA, 1975, 1979, 1980.
- University of Wisconsin, Madison, WI, 1980, 2002, 2004, 2006, 2008, 2009.
- Lewes Center for Physics, Lewes, Delaware, 1983, 1985.
- Santa Barbara Kavli Institute for Theoretical Physics, Santa Barbara, CA, 1981, 1991, 1995, 2002, 2003, 2008, 2010, 2016
- CERN, European Laboratory for Particle Physics, Geneva, Switzerland, 1978, 1979, 1981, 1984, 1986, 1988, 1994, 1999, 2000.
- Deutsches Elektronen - Synchrotron DESY, Hamburg, Germany, 1978, 1986, 1987-88, 1992.
- Weizmann Institute of Science, Rehovot, Israel, 1980.
- University of Tel-Aviv, Tel-Aviv, Israel, 1980.
- Tata Institute of Fundamental Research, Bombay, India, 1982.
- Universidad Technica Federico Santa Maria, Valparaiso, Chile, 1984.
- Max Planck Institute for Physics and Astrophysics, Munich, Germany, 1988, 1989.
- ETH, Zurich, Switzerland, 1988.
- Department of Theoretical Physics, Oxford University, Oxford, England, 1988.
- Institute for Nuclear Theory, University of Washington, 1994, 2002, 2008.

- International Centre for Theoretical Physics, Trieste, Italy, 1992.
- MIT, 2000.
- Zhejiang University, Hangzhou, China, 2002.
- Universidad Nacional Autonoma de Mexico, 2003.
- Galileo Institute for Theoretical Physics, Florence, 2006.
- Cinvestav (Center for Research and Advanced Studies), Mexico City, 2012
- Mainz Insitute for Theoretical Physics, 2014.

Bibliography

1. $\bar{p}p$ Elastic Scattering at 3.6 BeV/c. Unpublished B.A. Thesis, M.I.T. (1968).
2. Two-Body Weak Reactions of Hadrons at Very High Energies (with M. Dubovoy and M. Suzuki), Phys. Rev. **D4**, 1474-85 (1971).
3. Total Cross Section for Electron-Positron Annihilation and Hadronic Contribution to the Muon Magnetic Moment (with M. Suzuki), Phys. Rev. **D4**, 2160-2162 (1971).
4. Isovector Spectral Function and K_{l3} Decays, Phys. Rev. **D5**, 710-714 (1972).
5. s -Channel Helicity Conservation in Elastic Processes, Phys. Rev. **D5**, 2864-2868 (1972).
6. Part I: Applications of the Schwarz Inequality to Weak and Electromagnetic Processes. Part II: s -Channel Helicity Conservation in Elastic Processes. Unpublished Ph.D. Thesis, Lawrence Berkeley Laboratory Report LBL-766 (1972).
7. The πN Cross Section through an Extrapolation of Deep Inelastic Electroproduction and Photoproduction Data (with M. Suzuki), Physics Letters **40B**, 561-565 (1972).
8. The Relation between Form Factors and the Scaling Functions in Electroproduction and Neutrino Reactions (with M. Suzuki), Physics Letters **42B**, 453-456 (1972).
9. πN Total Cross Section, Neutrino Reactions, and Electroproduction in the Regge Asymptotic Region (with M. Suzuki), Phys. Rev. **D7**, 273-275 (1973).
10. Nonrenormalization Theorem in the Chiral Symmetry Limit (with H. Pagels), Phys. Rev. Letters **30**, 630-633 (1973).
11. Chiral Perturbation Theory (with H. Pagels), Phys. Rev. **D8**, 4595-4619 (1973).
12. Pion and Kaon Electromagnetic Masses in Chiral Perturbation Theory (with H. Pagels), Phys. Rev. **D8** 4620-4627 (1973).

13. Phase Transitions in Vector Gluon Models: A Solution to the $U(3)$ Problem (with H. Pagels), Phys. Rev. **D9**, 3413-3427 (1974).
14. Applications of Chiral Perturbation Theory: Mass Formulas and the Decay $\eta \rightarrow 3\pi$ (with H. Pagels), Phys. Rev. **D10**, 2904-2917 (1974).
15. Phenomenological Analysis of Total Cross Section Measurements at the Fermi National Accelerator Laboratory (with R. E. Hendrick, B. E. Lautrup, S. J. Orfanidis, and V. Rittenberg), Phys. Rev. **D11**, 536-554 (1975).
16. New Class of Bound-State Solutions in Field Theory, Phys. Rev. Letters **34**, 1592-1595 (1975).
17. Possible Interpretation of the $\rho'(1600)$ as a Threshold Enhancement (with G. Segrè), Phys. Rev. **D13**, 697-706 (1976).
18. Second-Class Currents and Their Matrix Elements in Field Theory, Phys. Rev. **D14**, 2340-2342 (1976).
19. General Treatment of Second-Class Currents in Field Theory, Phys. Rev. **D15**, 2386-2400 (1977).
20. Heavy Leptons and Trimuons in an $SU(3) \times U(1)$ Model (with G. Segrè), Phys. Rev. Letters **39**, 259-262 (1977).
21. Absolute Proton Stability in Unified Models of Strong, Weak and Electromagnetic Interactions (with G. Segrè and A. Weldon), Physics Letters **73B**, 87-90 (1978).
22. Gauge Theory of Weak and Electromagnetic Interactions with an $SU(3) \times U(1)$ Symmetry (with G. Segrè and M. Golshani), Phys. Rev. **D17**, 1402-1429 (1978).
23. Neutral-Current Constraints on Gauge Models of Weak and Electromagnetic Interaction (with D. P. Sidhu), Phys. Letters **74B**, 233-238 (1978).
24. Probe of the Hadronic Neutral Current by Final-Proton Polarization (with J. E. Kim and S. Sarkar), Phys. Rev. **D18**, 123-134 (1978).
25. Uniqueness of the $SU(N)$ Gauge Groups for Implementing Absolute Proton Stability with a Global U_1 of Color (with G. Segrè and H. Weldon), Phys. Rev. **D18**, 552-560 (1978).
26. Determining the Neutrino-Hadron Weak Neutral-Current Couplings (with D. P. Sidhu), Phys. Rev. Letters **41**, 732-735 (1978).
27. Final Proton Polarization as a Probe of the Hadronic Neutral Current (with J. E. Kim and S. Sarkar), *Neutrinos-'78*, edited by E. C. Fowler (Purdue University, West Lafayette, Indiana, 1978), p. C81.

28. Neutral-Current Constraints on Gauge Models of the Weak and Electromagnetic Interactions (with D. P. Sidhu), *Neutrinos - '78*, edited by E. C. Fowler (Purdue University, West Lafayette, Indiana, 1978), p. C74.
29. Light Quark Mass Spectrum in Quantum Chromodynamics (with H. Pagels), *Phys. Rev. D* **19**, 2070-2079 (1979).
30. Final State Polarizations in Neutrino Induced Reactions, *High Energy Physics with Polarized Beams and Targets*, edited by G. H. Thomas (American Institute of Physics, New York, 1979), p. 241-246.
31. A Superweak Gauge Theory of CP Violation (with S. Barr), *Phys. Rev. Lett.* **42**, 1654-1658 (1979).
32. Charge-Symmetry Breaking in the Nucleon-Nucleon Interaction (with D. Sparrow), *Phys. Rev. Lett.* **43**, 1559-1562 (1979).
33. Quark Mass Differences and $\rho - \omega$ Mixing, *Phys. Rev. D* **20**, 2983-85 (1979).
34. The Weak Neutral Current: A Determination of its Structure and an Analysis of the Error Due to Theoretical and Experimental Uncertainties (with J. E. Kim, M. Levine, D. P. Sidhu, and H. H. William), *Neutrino - '79*, edited by A. Haatuft and C. Jarlskog (Astvedt Industrier A/S, Norway, 1979), Vol. 1, p. 276.
35. Is the Proton Stable? (with M. Goldhaber and R. Slansky), *Science* **210**, 851 (1980).
36. Symmetry Breaking and the Decays $\psi' \rightarrow J/\psi\pi^0(\eta)$ and $J/\psi \rightarrow \eta(\eta')\gamma$, *Phys. Lett.* **90B**, 447-450 (1980).
37. Magnetic Monopoles in Grand Unified Theories (with S.-Y. Pi), *Phys. Rev. Lett.* **45**, 1-4 (1980).
38. Grand Unified Theories without Superheavy Magnetic Monopoles, *First Workshop on Grand Unification*, edited by P. H. Frampton, S. L. Glashow, and A. Yildiz (Math. Sci. Press, Brookline, 1980), p. 9-21.
39. Consequences of Majorana and Dirac Mass Mixing for Neutrino Oscillations (with V. Barger, J. P. Leveille, and S. Pakvasa), *Phys. Rev. Lett.* **45**, 692-695 (1980).
40. A Theoretical and Experimental Review of the Weak Neutral Current: A Determination of its Structure and Limits on Deviations from the Minimal $SU(2)_L \times U_1$ Electroweak Theory (with J. E. Kim, M. Levine, and H. H. Williams), *Rev. Mod. Phys.* **53**, 211-252 (1981).
41. Neutrino Oscillations of the Second Class (with V. Barger, J. P. Leveille, and S. Pakvasa), *High Energy Physics - 1980*, edited by L. Durand and L. G. Pondrom (American Institute of Physics, New York, 1981), p. 483.

42. Present Status of the Pion-Nucleon Sigma Term (with C. A. Dominguez), *Phys. Rev.* **D24**, 1905-1914 (1981).
43. Grand Unified Theories and Proton Decay, *Physics Reports* **72**, 185-385 (1981).
44. Book Review (*Proceedings of the Eighth Hawaii Topical Conference in Particle Physics*), *Science* **211**, 1153 (1981).
45. Implications of Grand Unification for Z^0 Boson Physics, *Proceedings of Z^0 Theory Workshop*, Cornell University, Feb. 1981, ed. M. E. Peskin and S.-H. H. Tye, p. 95.
46. Exotic Fermions, *Proceedings of Z^0 Theory Workshop*, Cornell University, Feb. 1981, p. 467.
47. Theoretical Expectations for Proton Decay, *Second Workshop on Grand Unification*, edited by J. P. Leveille, L. R. Sulak and D. G. Unger (Birkhäuser, Boston, 1981), p. 131.
48. Energy Loss Mechanisms and the Annihilation of Confined Monopoles (with F. A. Bais), *Nucl. Phys.* **B197**, 520 (1982).
49. Implications of Anomalous Isospin Violation for the Low Energy Nucleon-Nucleon Interaction (with D. A. Sparrow), *Phys. Rev.* **C25**, 1194-1214 (1982).
50. Grand Unified Theories, *1981 International Symposium on Lepton and Photon Interactions at Low Energy*, edited by W. Pfeil (Univ. Bonn, 1981) p. 823.
51. The Proton Lifetime and Branching Ratios, *Proceedings of the International Colloquium on Baryon Nonconservation*, edited by V. S. Narasimham et al., (Indian Academy of Sciences, Bangalore, 1982) p. 25. Updated version published in the *Proceedings of the 1982 Summer Workshop on Proton Decay Experiments*, edited by D. S. Ayres (Argonne National Laboratory ANL-HEP-PR-82-24), p. 64.
52. Goals for Second Generation Detectors, *Proceedings of the 1982 Summer Workshop on Proton Decay Experiments*, p. 5.
53. Grand Unified Theories, *The Encyclopedia of Physics, 3rd Edition*, ed. R. M. Besançon (Van Nostrand Reinhold, New York, 1985), p. 521.
54. The Lepton Asymmetry of the Universe (with G. Segrè and S. Soni), *Third Workshop on Grand Unification*, edited by P. H. Frampton, S. L. Glashow, and H. van Dam (Birkhäuser, Boston, 1982), p. 231 and *Neutrino Mass and Gauge Structure of Weak Interactions*, edited by V. Barger and D. Cline (American Institute of Physics, New York, 1983), Vol. 99, p. 76.
55. Majorana Neutrinos, Nucleosynthesis, and the Lepton Asymmetry of the Universe (with G. Segrè and S. Soni), *Phys. Rev.* **D26**, 3425-3445 (1982).
56. Comment on "Does the Standard Hot-Big-Bang Model Explain the Primordial Abundances of Helium and Deuterium?" (with G. Segrè), *Phys. Rev. Lett.* **49**, 1363 (1982).

57. On the Detection of Cosmological Neutrinos by Coherent Scattering (with J. P. Leveille and J. Sheiman), *Phys. Rev.* **D27**, 1228-42 (1983), reprinted in *SOLAR NEUTRINOS: the first thirty years*, ed. J. H. Bahcall *et al.*, (Addison-Wesley 1994).
58. Theoretical Predictions for Baryon Number Violation, *Science Underground*, ed. M. M. Nieto *et al.* (American Institute of Physics, New York 1983), Vol. 96, p. 110.
59. Baryon Number Violation at Accelerator Energies (with D. Sahdev), *Phys. Rev.* **D28**, 2248-2257 (1983).
60. Cosmological Neutrinos and Their Detection, *Proceedings of the XVIIIth Rencontre de Moriond: Vol. 2, Beyond the Standard Model*, ed. J. Tran Thanh Van (Editions Frontières, France, 1983), p. 465.
61. Proton Decay, Grand Unification, and Supersymmetry, *Particles and Fields - 1983*, ed. A. Abashian (American Institute of Physics, New York, 1984), Vol. 112, p. 251.
62. Editor (with H. A. Weldon and P. J. Steinhardt) of *Fourth Workshop on Grand Unification* (Birkhäuser, Boston, 1983).
63. A Mass Sum Rule for Higgs Bosons in Arbitrary Models (with H. A. Weldon), *Phys. Rev. Lett.* **52**, 1377-1379 (1984).
64. Forward-Backward Asymmetries in W and Z Decays (with J. L. Rosner and R. W. Robinett), *Proceedings of the DPF Workshop on $p\bar{p}$ Options for the Super Collider* (Chicago, 1984), ed. J. E. Pilcher and A. R. White, P. 202.
65. Supersymmetric Particles and the $\Delta I = 1/2$ Rule (with B. Sathiapalan), *Phys. Lett.* **144B**, 395-400 (1984).
66. Bounds on Mixing between Light and Heavy Gauge Bosons, *Phys. Rev.* **D30**, 2008-2010 (1984).
67. New Heavy Gauge Bosons in pp and $p\bar{p}$ Collisions (with R. W. Robinett and J. L. Rosner) *Phys. Rev.* **D30**, 1470-1487 (1984).
68. Book Review (*The Discovery of Subatomic Particles*, by Steven Weinberg), *Science* **224**, 729 (1984).
69. CP -Violation and the $K_L - K_S$ Mass Difference in Supersymmetric Models (with B. Sathiapalan), *Phys. Lett.* **144B**, 401-406 (1984).
70. The Present Status of Grand Unification and Proton Decay, *Proceedings of Inner Space/Outer Space*, ed. E. W. Kolb *et al.* (Univ. of Chicago, Chicago, 1986) p. 3.
71. The Production and Decay of Heavy Gauge Bosons in pp and $p\bar{p}$ Collisions (with R. W. Robinett and J. L. Rosner), *Design and Utilization of the SSC*, ed. R. Donaldson and J. G. Morfin (American Physical Society, 1984) p. 812.

72. Nonstandard Higgs Bosons, *Design and Utilization of the SSC*, 1984, p. 771.
73. Forward Backward Asymmetries in Heavy Gauge Boson Decays, *Proceedings of the XXII International Conference on High Energy Physics*, ed. A. Meyer and E. Wieczorek (Akad. der Wissenschaften der DDR, Zeuthen, 1984) Vol. I, p. 142.
74. The Status of Electroweak Theory, *Proceedings of the XXII International Conference on High Energy Physics*, Vol. II, p. 215.
75. *CP Nonconservation*, *Aspen Winter Physics Conference*, ed. M. M. Block (N.Y. Acad. Sci., New York, 1986), p. 725.
76. Grand Unification, *Comments on Nuclear and Particle Physics* **15**, 41 (1985).
77. The Electron Neutrino Mass, Double Beta Decay, and Cosmology (with B. Sathiapalan and G. Steigman), *Nucl. Phys.* **B266**, 669 (1986).
78. Neutral Current Constraints on Heavy Z Bosons (with L. S. Durkin), *Phys. Lett.* **166B**, 436 (1986).
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WWW Sites

- P. Langacker research interests: <http://www.sas.upenn.edu/~pgl/>
- Recent talks: <http://www.sas.upenn.edu/~pgl/talks/>
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Invited and Contributed Conference Talks

1. Final State Polarizations in Neutrino Induced Reactions, *High Energy Physics with Polarized Beams and Targets*, Argonne National Laboratory, October 1978.
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6. Implications of Grand Unification for Z^0 Boson Physics, *Z^0 Theory Workshop*, Cornell University, February 1981.
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13. Theoretical Perspective for Baryon Number Violation, *1982 Summer Workshop on Proton Decay Experiments*, Argonne National Laboratory, June 1982.
14. Goals for Second Generation Detectors, *1982 Summer Workshop on Proton Decay Experiments*.
15. The Lepton Asymmetry of the Universe, *Neutrino Mass and Gauge Structure of Weak Interactions*, Telemark, Wisconsin, September 1982.
16. Theoretical Predictions for Baryon Number Violation, *Science Underground*, Los Alamos National Lab., September 1982.
17. Cosmological Neutrinos and Their Detection, *18th Rencontre de Moriond*, La Plagne, France, March 1983.
18. Cosmological Neutrinos, *1983 Spring Meeting of the American Physical Society*, Baltimore, Maryland, April 1983.
19. Proton Decay, Grand Unification, and Supersymmetry, *1983 meeting of the Division of Particles and Fields of the American Physical Society*, V.P.I., Blacksburg, Virginia, September 1983.
20. Low Energy Tests of Grand Unified Theories, *22nd Eastern Theoretical Physics Conference*, Brookhaven National Laboratory, October 1983.
21. The Present Status of Grand Unified Theories and Proton Decay, *Inner Space/Outer Space*, Fermi National Accelerator Laboratory, May 1984.
22. Grand Unified Theories and Proton Decay, *1984 Annual Meeting of The American Association for the Advancement of Science*, New York, May 1984.
23. The Status of Electroweak Theory, *XXIIIth International Conference on High Energy Physics*, Leipzig, E. Germany, July 1984.

24. Forward-Backward Asymmetries in Heavy Gauge Boson Decays, *XXIIth International Conference on High Energy Physics*, Leipzig, E. Germany, July 1984.
25. *CP Nonconservation*, *Aspen Winter Conference Series*, Aspen, CO, January 1985.
26. Unified Theories, Electroweak and GUT, *1985 International Symposium on Lepton and Photon Interactions at High Energies*, Kyoto, Japan, August 1985.
27. Two Lectures on Unified Theories, at the Summer School *4th Symposium on Theoretical Physics*, Seoul, Korea, August 1985.
28. The Electron Neutrino Mass, Double Beta Decay, and Cosmology, *21st Rencontre de Moriond*, Tignes, France, January 1986.
29. The Standard Model and Beyond, *2nd Conference on the Intersections between Particle and Nuclear Physics*, Lake Louise, Canada, May 1986.
30. From the Standard Model to Superstrings, *CEBAF 1986 Summer Workshop*, Newport News, VA, June 1986.
31. The Present Status of Proton Decay and Baryon Number Nonconservation, *International Symposium on Weak and Electromagnetic Interactions in Nuclei*, Heidelberg, FRG, July 1986.
32. The Weak Neutral Current, *Workshop on Parity Violation Experiments at CEBAF*, Newport News, Virginia, December 1986.
33. The Weak Neutral Current, Extra Z Bosons, and Heavy Majorana Neutrinos, *VIIth Rencontre de Moriond on Searches for New and Exotic Phenomena*, Les Arcs, France, January 1987.
34. Neutral Current Phenomenology, *BNL Neutrino Workshop*, Brookhaven National Lab., February 1987.
35. Status of the Standard Model, *11th International Workshop on Weak Interactions*, Santa Fe, NM, June 1987.
36. Neutral Current Constraints on Neutral Gauge Bosons, *11th International Workshop on Weak Interactions*.
37. Introduction to the Standard Model, and The Weak Neutral Current, Past, Present and Future, Lectures presented at the *11th International School of Theoretical Physics*, Szczyrk, Poland, September 1987.
38. Summary Talk, *1987 DESY Workshop: Physics at HERA*, Hamburg, Germany, October 1987.
39. Massive Neutrinos and Gauge Theories, *Xth Workshop on Particles and Nuclei: Neutrino Physics*, Heidelberg, Germany, October 1987.

40. Mixing between Ordinary and Exotic Fermions, *XXIIIrd Rencontre de Moriond on Electroweak Interactions and Unified Theories*, Les Arcs, France, March 1988.
41. Neutrino Mass from the Perspective of Particle Physics, *INS International Symposium on Neutrino Mass and Related Topics*, Tokyo, Japan, March 1988.
42. Mixing between Ordinary and Exotic Fermions, *19th Spring Symposium on High Energy Physics*, Cordobang, E. Germany, April 1988.
43. Recent Aspects of GUT Phenomenology, *9th Workshop on Grand Unification*, Aix-Les-Bains, France, April 1988.
44. The Weak Neutral Current, *Quarks-88*, Tbilisi, Georgia, USSR, May 1988.
45. Mixing between Ordinary and Exotic Fermions, *Quarks-88*, Tbilisi, Georgia, USSR, May 1988.
46. Status of the Standard Electroweak Theory, *XXIV International Conference on High Energy Physics*, Munich, West Germany, August 1988.
47. Electroweak and All That, *DPF-88*, Storrs, Connecticut, August 1988.
48. Oscillations, Theory and Expectations, *New Directions in Neutrino Physics*, Fermilab, September 1988.
49. Neutrinos, *Beyond the Standard Model*, Ames, Iowa, November 1988.
50. Tests of the Standard Model, convener's summary at the *Twelfth International Workshop on Weak Interactions and Neutrinos*, Ginosar, Israel, April 1989.
51. Implications of Neutrino Mass, and Proton Decay, *Tenth and Final Workshop on Grand Unification*, University of North Carolina, April 1989.
52. The Standard Electroweak Model. How Well Does it Work?, *Weak and Electromagnetic Interactions in Nuclei, 1989*, Montreal, May, 1989.
53. Implications of Large m_t for Electroweak Parameters, *Thinking about the Top Quark*, Institute for Theoretical Physics, Santa Barbara, March, 1990.
54. Precision Tests of the Standard Model, *Conference on Particles, Strings, and Cosmology (PASCOS-90)*, Northeastern University, Boston, March, 1990.
55. Low Energy Tests of the Standard Model, *Low Energy Muon Science in the 90's*, Paul Scherrer Institute, Villigen, Switzerland, April, 1990.
56. Rare Decays and Electroweak Physics, *Annual Meeting – AGS Users Group*, Brookhaven National Laboratory, Upton, NY, May, 1990.

57. *W and Z Physics*, 4 lectures presented at the *China Center of Advanced Science and Technology Symposium on TeV Physics*, Beijing, May 1990.
58. Neutrino Mass, 2 lectures presented at the *Theoretical Advanced Study Institute*, Boulder, Colorado, June 1990.
59. Rare *K* Decays as a Probe of New Physics, *1990 DPF Summer Study on High Energy Physics Research Directions for the Decade*, Snowmass, Colorado, June 25–July 13, 1990.
60. Comments on Global Analyses, Precision Electroweak Tests, and Radiative Corrections, *Snowmass-1990*.
61. Status of the Standard Model, *1991 Aspen Winter Conference on Elementary Particle Physics*, January 1991.
62. Theory of Neutrino Oscillations, *Workshop on Accelerator-Based Low-Energy Neutrino Physics*, Los Alamos, New Mexico, January 1991.
63. High Precision Electroweak Experiments: a Global Search for New Physics, *Topical Conference on Precise Electroweak Measurements*, Institute for Theoretical Physics, Santa Barbara, February, 1991.
64. Status and Perspectives of Electroweak Precision Tests (Conference summary), *Ringberg Workshop on High Precision versus High Energies in e^+e^- Collisions*, Ringberg, Germany, April 1991.
65. Status of the Standard Model, *XIIIth International Workshop on Weak Interactions and Neutrino Physics*, Lab. Nazionali del Gran Sasso, Italy, July 1991.
66. Consequences of a 17 keV Neutrino, *XIIIth International Workshop on Weak Interactions and Neutrino Physics*.
67. Status of Neutrino Physics, *Twenty-Fifth LAMPF Users Group Meeting*, Los Alamos, August 1991.
68. Electroweak Phenomena, 3 lectures presented at the first *International School of Physics*, Leningrad, USSR, September 1991.
69. Implications of Precision Experiments, *International Workshop on Electroweak Physics: Beyond the Standard Model*, Valencia, Spain, October 1991.
70. Neutrino Mass, *1992 Aspen Winter Conference on Elementary Particle Physics*, January 1992.
71. Massive Neutrinos, *Fourth International Symposium on Neutrino Telescopes*, Venice, Italy, March 1992.

72. Scenarios for Neutrino Mass, *XXVIIth Rencontres de Moriond on Electroweak Interactions and Unified Theories*, Les Arcs, France, March 1992.
73. Conference Summary, *XXVIIth Rencontres de Moriond on Electroweak Interactions and Unified Theories*, Les Arcs, France, March 1992.
74. Extensions of the Standard Model and Supersymmetry, *Meeting of the Deutsche Physikalische Gesellschaft*, Berlin, Germany, March 1992.
75. Constraints on Beyond the Standard Model Physics, *SSC Physics Symposium*, University of Wisconsin, Madison, April 1992.
76. Proton Decay, *Franklin Symposium in Celebration of the Discovery of the Neutrino*, Philadelphia, May 1992.
77. Implications of Electroweak Theory for New Physics, *Particle Physics in the Nineties and Beyond*, Cincinnati, May 1992.
78. Precision Tests of the Standard Model, 3 lectures presented at the *1992 Theoretical Advanced Study Institute*, Boulder, Colorado, June 1992.
79. Neutrino Mass and Mixing, in *Beyond the Standard Model III*, Carlton University, Ottawa, June 1992.
80. Signatures for Heavy Z' Bosons at Hadron Colliders, in *Beyond the Standard Model III*.
81. Neutrino Physics, 4 lectures presented at the *1992 Trieste Summer School in High Energy Physics and Cosmology*, Trieste, Italy, July 1992.
82. Precision Tests of the Standard Electroweak Model, *Summer Institute in Weak Interactions and Neutrino Physics*, Kingston, Ontario, August 1992.
83. New Quarks, Leptons, Bosons, Compositeness, *Yale Workshop on High Energy Physics with Colliding Beams*, New Haven, October 1992.
84. Test of the Standard Model and Implications for Grand Unified Theories, *International Symposium on Neutrino Astrophysics*, Takayama, Japan, October 1992.
85. Implications of Solar and Atmospheric Neutrinos, *DPF92*, Fermilab, November 1992.
86. Status of the Standard Model, *Texas/PASCOS-92*, Berkeley, December 1992.
87. Precision Tests of the Standard Electroweak Model, *The Beauty of Physics*, Philadelphia, January 1993.
88. Solar Neutrinos, *Unified Symmetry in the Small and in the Large*, Coral Gables, January 1993.

89. Five Phases of Weak Neutral Current Experiments From the Perspective of a Theorist, *From Weak Neutral Currents to the (W)/Z and Beyond*, Santa Monica, February 1993.
90. Z^0 Decays: Theory, three lectures presented at the *Lake Louise Winter Institute*, Lake Louise, Canada, February 1993.
91. Neutrino Mass, *International Workshop on Supersymmetry and Unification of Fundamental Interactions – SUSY-93*, Boston, April 1993.
92. Precision Tests of the Standard Model, *Low Energy Muon Science '93*, Santa Fe, April 1993.
93. Superallowed and Neutron Decays as a Test of the Standard Electroweak Theory, *GT and Neutrino Cross Section Workshop*, Philadelphia, April 1993.
94. Constraints on New Physics From Precision Measurements, *Workshop on Physics at Current Accelerators and the Supercollider*, Argonne National Lab, June, 1993.
95. Status of Electroweak Theory, *International School of Subnuclear Physics: From Supersymmetry to the Origin of Space-Time*, Erice, July 1993.
96. Chiral Lagrangians, *International School of Subnuclear Physics: From Supersymmetry to the Origin of Space-Time*, Erice, July 1993.
97. Solar Neutrinos, *Mexican Physical Society Meeting*, Acapulco, October 1993.
98. Constraints on New Physics from Precision Experiments, *Mexican Physical Society Meeting*, Acapulco, October 1993.
99. The Standard Model and Beyond, *Particle Physics Theory Meeting*, Rutherford Appleton Laboratory, December 1993.
100. Phenomenology of Neutrino Mass and Mixing, *Strategies for the Detection of Dark Matter Particles*, Lawrence Berkeley Laboratory, February 1994.
101. Theoretical Study of the Electroweak Interactions, Present and Future, *22nd INS International Symposium on Physics with High Energy Colliders*, Tokyo, March 1994.
102. Theoretical Motivation, *Neutrino Mass Working Group Meeting of the DPF Long Range Planning Study*, Fermilab, May 1994.
103. Neutrino Properties, *Solar Neutrinos and Neutrino Astrophysics*, Institute for Nuclear Theory, Seattle, May 1994.
104. Status of the Standard Model, *Neutrino – 94*, Eilat, Israel, May 1994.
105. Supersymmetric Grand Unification, *CP Workshop*, Technion, Israel, June 1994.
106. Status of the Electroweak Sector of the Standard Model, *XIV International Conference on Physics in Collision*, University of Florida, Tallahassee, June 1994.

107. Grand Unification and the Standard Model, *Radiative Corrections: Status and Outlook*, Tennessee, June 1994.
108. Implications of Solar Neutrinos, *International School of Subnuclear Physics: From Superstring to Present-Day Physics*, Erice, Italy, July 1994.
109. In Search of Beyond the Standard Model Physics, 5 lectures presented at the *Fifteenth UK Institute for Theoretical High Energy Physics*, Southampton, August 1994.
110. Particle Astrophysics Implications of the Standard Electroweak Model, *Lake Traverse Cosmology Workshop*, Ontario, September 1994.
111. Electroweak Precision Tests, *CAM-94, Joint Meeting of the Canadian, American, and Mexican Physical Societies*, Cancun, Mexico, September 1994.
112. Electroweak Interactions, 5 lectures presented at the *CERN Academic Training Program*, Geneva, October 1994.
113. Neutrino Physics, *Beyond the Standard Model IV*, Lake Tahoe, December 1994.
114. Implications of Precision Electroweak Experiments, 5 lectures presented at the *VIII J. A. Swieca School*, Rio de Janeiro, February 1995.
115. Implications of Neutrino Mass, *Pascos/Hopkins-95*, Baltimore, March 1995.
116. Grand Unification, in the *International Conference on the Fundamental Forces and Quantum Technology (Franklin Symposium)*, The Franklin Institute, Philadelphia, May 1995.
117. Precision Experiments, Grand Unification, and Compositeness, in *SUSY-95*, Paris, May 1995.
118. Fundamentals of the Standard Model, 3 lectures, and Precision Electroweak Measurements, 2 lectures, presented at the *1995 Theoretical Advanced Study Institute*, Boulder, Colorado, June 1995.
119. What Does the Data Say About Unification Vs. Compositeness? Institute for Theoretical Physics Workshop on *Unification: from the Weak Scale to the Planck Scale*, Santa Barbara, July 1995.
120. What Can be Beyond the MS(SM)? Institute for Theoretical Physics Conference on *Unification: from the Weak Scale to the Planck Scale*, Santa Barbara, October 1995.
121. Expectations for Additional Z' Bosons and Exotic Matter from Superstring Compactifications, *CDF SUSY/Exotic Workshop*, Fermilab, Illinois, January 1996.
122. Expectations for Z' from String Theories and Implications for low Q^2 Experiments, *Moller Workshop*, Princeton, February 1996.
123. Neutrino Mass, *XXXIst Rencontres de Moriond on Electroweak Interactions and Unified Theories*, Les Arcs, France, March 1996.

124. The Standard Model and Beyond, *International Workshop on Future Prospects of Baryon Instability Search Experiments*, Oak Ridge, Tennessee, March 1996.
125. R_b, R_c , *International Symposium on Recent Developments in Phenomenology*, Madison, Wisconsin, April 1996.
126. Precision tests of the Electroweak Theory, 3 lectures presented at the *Advanced School of Electroweak Physics*, Menorca, Spain, June 1996.
127. Tests and Status of the Standard Model, *SUSY 96*, College Park, Maryland, May 1996.
128. Precision Tests of the Standard Model, *DPF-96*, Minneapolis, Minnesota, August 1996.
129. Phenomenology of Neutrino Mass, Oscillations, and Cosmology, *Fourth International Workshop on Tau Lepton Physics*, Estes Park, Colorado, September 1996.
130. Electroweak Phenomenology, four lectures presented at the *VII Mexican School of Particles and Fields*, Merida, November 1996.
131. The Standard Model and Beyond, *I Latin American Symposium on High Energy Physics*, Merida, Mexico, November 1996.
132. Unification or Compositeness?, in *Ringberg Workshop on the Higgs Puzzle*, Germany, December 1996.
133. QCD and Precision Tests of the Standard Model, two lectures presented at the *CTEQ (The Coordinated Theoretical-Experimental Project on QCD) 1997 Summer School*, Lake Como, Wisconsin, June 1997.
134. Theoretical Motivations, presented at the *Non-Accelerator Physics* session of the HEPAP subpanel meeting on the Future of High Energy Physics, SLAC, June 1997.
135. Neutrino Physics – A Review, *Workshop on New Physics at LEP-2 and the Tevatron*, Aspen, August 1997.
136. What have we learned? Where are we headed? Summary talk at *Solar Neutrinos: News About SNU's*, Institute for Theoretical Physics, Santa Barbara, December 1997.
137. Z' Physics in String Models, *Conference on Particles, Strings, and Cosmology (PASCOS-98)*, Northeastern University, Boston, March 1998.
138. Implications of Solar and Atmospheric Neutrino Data, *Neutrino '98*, Takayama, Japan, June 1998.
139. Status of the Standard Model, *Weak and Electromagnetic Interactions in Nuclei*, Santa Fe, June 1998.

140. Overview of Neutrino Physics and Astrophysics, 1 lecture, and Theories of Neutrino Mass, 6 lectures, presented at the *1998 Theoretical Advanced Study Institute*, Boulder, Colorado, June 1998.
141. Neutrino Masses and Mixings, Where Are We Going?, *Neutrino Oscillations Workshop (NOW '98)*, Amsterdam, September 1998.
142. Implications of Neutrino Mass Experiments, meeting of the *Division of Nuclear Physics of the American Physical Society (DNP '98)*, Sante Fe, October 1998.
143. Precision Electroweak Data and Implications, *Aspen Winter Conference*, Aspen, January 1999.
144. Theoretical Summary, Precision Electroweak Working Group, *Workshop on Weak Interactions and Neutrinos*, Capetown, South Africa, January 1999.
145. Neutrino Physics, *Pheno99 Symposium: Phenomenology for the Third Millennium*, Madison, Wisconsin, April 1999.
146. Vacuum Restabilization and its Physical Consequences in Perturbative and Nonperturbative String Vacua, *Planck99: From The Planck Scale to the Electroweak Scale*, Bad Honnef, Germany, April 1999.
147. The Standard Model and Beyond, *Symposium in Honor of 60th Birthday of Ugo Amaldi*, CERN, Geneva, June 1999.
148. Neutrino Physics: From 10^{-33} to 10^{+28} cm, *23rd Johns Hopkins Workshop on Current Problems in Particle Theory: Neutrinos in the Next Millennium*, Baltimore, June 1999.
149. Neutrino Physics: From 10^{-33} to 10^{+28} cm, *SLAC User's meeting*, Stanford, June 1999.
150. Neutrino Oscillations: a Phenomenological Overview, *NNN99 (Next generation Nucleon decay and Neutrino detector workshop)*, Stony Brook, New York, September 1999.
151. Extra Z' Gauge Bosons in Theory and Experiment, *Great Chicagoland Theorists' Meeting*, University of Illinois, Chicago, October 1999.
152. Neutrino Astrophysics at Penn, *Northeast Regional Meeting of American Association of Physics Teachers*, Philadelphia, October 1999.
153. Summary talk, *Neutrino Oscillation Workshop 2000*, Otranto, Italy, September 2000.
154. The Electroweak Sector, *LEP Fest 2000*, CERN, Geneva, Switzerland, October 2000.
155. Physics Implications of Precision Electroweak Experiments, *Alberto Sirlin Symposium*, New York University, October, 2000.
156. Neutrino Oscillations and the Standard Model, *Sixth Workshop on Non-Perturbative Quantum Chromodynamics*, Paris, June 2001.

157. Precision Electroweak Data: Phenomenological Analysis, *The Future of High Energy Physics*, Snowmass, CO, July 2001.
158. Mixings, CP Violation, and Masses: Quarks vs. Leptons, *The Future of High Energy Physics*, Snowmass, CO, July 2001.
159. Theory of Neutrino Masses and Mixings, *TAUP 2001, Topics in Astrophysics and Underground Physics*, Gran Sasso Laboratory, Italy, September 2001.
160. A Global Analysis of Precision Electroweak Data, *Tests of Fundamental Symmetries in Atoms and Molecules*, Harvard-Smithsonian Center for Astrophysics, November 2001.
161. Constraints on Large Dimensions from Neutrino Oscillation Experiments, *INT Miniworkshop: Neutrino Masses and Mixing*, Seattle, April 2002.
162. Conference Summany, *PHENO 2002 Symposium*, University of Wisconsin, April 2002.
163. Phenomenology of a Three-Family Standard-like String Model, *Symposium in Honor of Jogesh Pati's 65th Birthday*, University of Maryland, May 2002.
164. Phenomenology of a Three-Family Standard-like String Model, *From the Planck Scale to the Electroweak Scale*, Kazimierz, Poland, May 2002.
165. Conference Summary, *From the Planck Scale to the Electroweak Scale*, Kazimierz, Poland, May 2002.
166. Theory and Implications of Neutrino Mass, 2 lectures, *Topical Seminar on Frontier of Particle Physics 2002: Neutrinos and Cosmology*, Beijing, China, August 2002.
167. Review of Electroweak Interactions, *Miniworkshop on Current Topics in Particle Physics*, Madrid, Spain, September 2002.
168. Overview of cosmological constraints on neutrino mass, number, and types, *International Workshop on Neutrinos and Subterranean Science*, Washington, D. C., September 2002.
169. String Models, Extra Z 's, and Constraints on LEDs from Neutrino Oscillation Experiments, *Neutrinos and Implications for Physics Beyond the Standard Model*, Stony Brook, N.Y., October 2002.
170. Possible Time Variation of Physical Constants, *Dirac Centennial Symposium*, Florida State University, December, 2002.
171. TeV Physics from the Top Down, *20 Years of SUGRA and Search for SUSY and Unification (SUGRA20)*, Northeastern, Boston, March 2003.
172. Relic Neutrinos, *Argonne Workshop on Trends in Neutrino Physics*, Argonne National Laboratory, May, 2003.

173. Electroweak Physics, *Conference on the Intersections of Nuclear and Particle Physics*, New York, May, 2003.
174. Phenomenological Issues in Beyond the Standard Model, 4 lectures, *Theoretical Advanced Study Institute*, Boulder, Colorado, June 2003.
175. Beyond the MSSM, *SUSY 2003*, Tucson, Arizona, June 2003.
176. Particle Phenomenology, 4 lectures, *Cosmology, Particles, and Strings*, Institute for Advanced Study, July 2003.
177. Elements of Grand Unification, *DESY Theory Workshop*, Hamburg, Germany, September 2003.
178. Possible Surprises and New Physics, *Workshop for APS Study on the Physics of Neutrinos*, Argonne National Laboratory, December 2003.
179. Implications of a Heavy Z' Gauge Boson, *Aspen 2004 Winter Conference on Particle Physics*, February 2004.
180. Summary Talk, *From Zero to Z^0 : A Workshop on Precision Electroweak Physics*, Fermilab, May 2004.
181. Neutrinos and Astrophysics, *Heavy Quarks and Leptons, 2004*, San Juan, Puerto Rico, June 2004.
182. Status of the Standard Model, *Physics at the LHC*, Vienna, July 2004.
183. Neutrino masses in Type I and II seesaw models respecting heterotic and intersecting brane string constraints, *String Phenomenology 2004*, Ann Arbor, August 2004.
184. Neutrino Physics, 5 lectures, *Veracruz School of Physics*, August 2004.
185. Theory of Neutrino Mass, *International Conference on High Energy Physics*, Beijing, August 2004.
186. Low Energy Precision Tests, *International Conference on High Energy Physics*, Beijing, August 2004.
187. The Major Problems in Particle Physics and How We Hope to Address Them, *Symposium of New York Section of APS*, CUNY, New York, October 2004.
188. Relic Neutrinos, *Northwestern Mini-Workshop on Z-primes*, November 2004.
189. Implications of a Heavy Z' Gauge Boson, *Northwestern Mini-Workshop on Z-primes*, November 2004.
190. The Higgs Sector in a $U(1)'$ Extension of the MSSM, *Second Workshop on CP Studies and Non-Standard Higgs Physics*, CERN, December 2004.

191. TeV-Scale Signatures of String Constructions, *Workshop on String Phenomenology*, Perimeter Institute, Waterloo, Canada, March 2005.
192. The Standard Model and Beyond, *Franklin Symposium in honor of Y. Nambu*, Philadelphia, April 2005.
193. Strings, GUTs, and beyond the MSSM, *Phenomenology 2005 Symposium*, Madison, May 2005.
194. Neutrinos and strings, *Weak Interactions and Neutrinos 2005*, Greece, June 2005.
195. Global Fits to Precision Electroweak Data, *Weak Interactions and Neutrinos 2005*, Greece, June 2005.
196. Concluding talk: Weak Interactions and Neutrinos in the LHC Era, *Weak Interactions and Neutrinos 2005*, Greece, June 2005.
197. Massive Neutrinos and (Heterotic) String Theory, *String Phenomenology 2005*, Munich, June 2005.
198. The Standard Model and Beyond, *Theoretical Problems in Fundamental Neutron Physics*, USC, October 2005.
199. Why the Top?, *Top Turns Ten*, Fermilab, October 2005.
200. Beyond the MSSM, *Strings and the Real World*, OSU, November 2005.
201. Tests of the Electroweak Theory, six *Fermilab Academic Lectures*, Fermilab, November-December 2005.
202. Neutrinos: status, models, string theory expectations, *Aspen Winter Conference*, February 2006.
203. Neutrino Mass in Strings, *2nd Workshop of the International Scoping Study for a Neutrino Factory*, Boston University, March 2006.
204. Higgs, neutralinos, and exotics beyond the MSSM, *Workshop on Monte Carlo Methods for Beyond the Standard Model*, Fermilab, March 2006.
205. Neutrinos and Strings, *SteigmanFest*, OSU, May 2006.
206. Beyond the MSSM, *New Directions Beyond the Standard Model in Field and String Theory*, Galileo Institute for Theoretical Physics, Florence, June 2006.
207. Beyond the Standard Paradigm, *XII IFT-UAM/CSIC Christmas Workshop*, Madrid, December 2006.
208. Beyond the Standard Paradigm, *KaneFest*, University of Michigan, January 2007.

209. A T-odd observable sensitive to CP violating phases, *LHC Collider Workshop*, Princeton, March 2007.
210. Primeino Mediation, *String Phenomenology 2007*, Rome, June 2007.
211. Introduction to the Standard Model, 2 lectures, *The Standard Model and Beyond*, Institute for Advanced Study, July 2007.
212. Cold Dark Matter beyond the MSSM, *DUSEL Town Meeting, Washington*, November 2007.
213. Baryogenesis in a U(1) Gauge Extension of the MSSM, *Baryogenesis Confronts Experiment*, KICP, Chicago, November 2007.
214. Z' Mediation of Supersymmetry Breaking, *Ann Arbor LHC Workshop*, January 2008.
215. Electroweak Physics, 2 lectures, *36th International Meeting on Fundamental Physics*, Baeza, Spain, February 2008.
216. Introduction to the Standard Model (2 lectures) and Electroweak Physics (2 lectures), presented at the *2008 Theoretical Advanced Study Institute*, Boulder, Colorado, June 2008.
217. A Tale of Four Decades: thoughts on particle physics, theory, and experiment, 1968-2008, *INT Workshop on Low Energy Precision Electroweak Physics in the LHC Era*, Seattle, September 2008.
218. Z' Mediation of Supersymmetry Breaking, *Fifth Workshop on Particle Physics and Cosmology: the Interface*, Warsaw University, February 2009.
219. The Physics of New $U(1)'$ Gauge Bosons, *17th International Conference on Supersymmetry and the Unification of Fundamental Interactions*, Northeastern University, June 2009.
220. Beyond the Standard Model (4 lectures), *International Summer School and Conference on High Energy Physics*, Mugla, Turkey, August 2009.
221. Alternatives to the GUT Seesaw, *2009 Workshop on Lepton and Baryon Number Violation*, Madison, September 2009.
222. Beyond the Standard Model (4 lectures), *Taiwan Spring School*, March 2010.
223. Alternatives to the GUT Seesaw, *String Vacuum Project 2010 Spring Meeting*, Santa Barbara, May 2010.
224. Frontiers in Neutrino Physics, *BNL90/50/10 Celebration*, Brookhaven, June 2010.
225. Neutrinos and Fundamental Symmetries: L, CP, and CPT, *DNP Workshop on Neutrinos and Fundamental Symmetries*, Santa Fe, November 2010.
226. Neutrino Basics (3 lectures), *SLAC Summer Institute*, August 2010.

- 227. Electroweak Theory (6 lectures) and History of the Weak Interactions (1 lecture), *22nd Chris Engelbrecht Summer School*, Stellenbosch, South Africa, January 2011.
- 228. New Heavy Gauge Bosons in pp and $p\bar{p}$ Colliders, *Jon Rosner Symposium*, Chicago, April 2011.
- 229. The String Vacuum and the LHC, *String Vacuum Project* meeting, Philadelphia, May 2011.
- 230. New Physics from Type IIA Quivers, *String Phenomenology 2011*, Madison, WI, August 2011.
- 231. The Standard Model (2 lectures), *Supersymmetry 2011 PreSchool*, Chicago, August 2011.
- 232. Sterile Neutrino Theory, *Sterile Neutrinos at the Crossroads*, Blacksburg, VA, September 2011.
- 233. New Physics from the String Vacuum, *Virginia and Maryland String and Particle Theory Meeting*, Charlottesville, March 2012.
- 234. New Physics from the String Vacuum, *Origin of Mass 2012*, Nordita, June 2012.
- 235. Sterile Neutrinos from the Top Down, *BeNE 2012*, ICTP, Trieste, Italy, September 2012.
- 236. Neutrino Physics (9 lectures), *Cinvestav (Center for Research and Advanced Studies)*, Mexico City, 2012.
- 237. Sterile Neutrinos from the Top Down, *Aspen Winter Workshop—New Directions in Neutrino Physics*, Aspen, CO, February 2013.
- 238. Non-Standard Gauge Bosons, *Duke (Snowmass) Workshop on Electroweak Measurements at the Energy Frontier*, Durham, NC, February 2013.
- 239. Model Independent Z' Sensitivities (with L. Wang), *Snowmass Energy Frontier Workshop*, Brookhaven, April 2013.
- 240. Perspectives on Neutrino Physics, *International Symposium on Opportunities in Underground Physics*, Asilomar, CA, May 2013.
- 241. Remnants, *LHC-The First Part of the Journey*, KITP, Santa Barbara, July 2013.
- 242. Perturbative Physics Beyond the Standard Model (10 lectures), *Foundations and New Methods in Theoretical Physics*, Saalburg, Germany, September 2013.
- 243. Physics Beyond the MSSM from the Top-Down, *PACOFEST 2013*, Granada, Spain, November 2013.
- 244. The Standard Model (15 lectures), *Perimeter Scholars International*, Waterloo, Canada, January 2014.

245. Electroweak Theory, Spontaneous Symmetry Breaking, and the Higgs (4 lectures), *2014 Tri-Institute Summer School on Elementary Particles (TRISEP)*, Sudbury, Canada, June 2014.
246. Theory Summary, *Neutrinos: Recent Developments and Future Challenges*, KITP, Santa Barbara, November 2014.
247. Recent Results and Future Directions in Precision Physics, *Conference on the Intersections of Nuclear and Particle Physics*, Vail, Colorado, May 2015.
248. Precision Measurements & Their Sensitivity to New Physics, *FCC-ee Mini-Workshop: Physics Behind Precision*, CERN, February 2016.
249. Z'/W' Theory Overview, *ATLAS Exotic Dilepton/Lepton+MET meeting*, CERN, March 2016.
250. Summary and Outlook, ICHEP2018, *International Conference on High Energy Physics*, Seoul, South Korea, July 2018.

Additional materials, including my scientific autobiography, AIP oral history transcript, full and condensed CVs, research statement, slides of lectures and a graduate course at Princeton, videos of a lecture series at the Perimeter Institute, and supplementary materials for my graduate text can be found at web.sas.upenn.edu/pgl.