

UNIVERSITY OF MARYLAND
Department of Physics and Astronomy
College Park, Maryland 20742-4111

CURRICULUM VITAE

Oscar Wallace Greenberg

Professor of Physics

I. Education:

B.S.	Rutgers University	1952
M.A.	Princeton University	1954
Ph.D.	Princeton University	1957

Experience in Higher Education:

1956-57	Brandeis University	Instructor
1959-61	Massachusetts Institute of Technology	NSF Postdoctoral Fellow
1961-63	University of Maryland	Assistant Professor
1963-67	University of Maryland	Associate Professor
1967-	University of Maryland	Professor

During leaves of absence:

Fall semester 1964-65,	Member,	Institute for Advanced Study
Academic year 1965-66,	Visiting Associate Professor,	Rockefeller University
Academic year 1968-69,	Visiting Professor,	Weizmann Institute of Science and Tel-Aviv University
Fall semester 1977-78,	Visiting Professor,	The Johns Hopkins University
Spring semester 1977-78,	Visiting Scientist,	NASA/Goddard Space Flight Center
August 1984-July 1985,	Visiting Scientist,	Fermi National Accelerator Laboratory, and
	Visiting Scholar,	Enrico Fermi Institute, University of Chicago
Fall semester 2006-2007,	Fulbright Scholar	Dublin Institute for Advanced Studies

II. Experience Other than Higher Education:

1957-59 Air Force Cambridge Research Center, 1st Lieutenant, U.S.A.F.

III. Publications:

See attached list

IV. Professional Activities:

American Physical Society

International Association for Mathematical Physics

Association of Members of the Institute for Advanced Study

Divisional Associate Editor of Physical Review Letters 1976-1978

Vice Chair of the Prize Committee for the Dannie Heineman Prize for Mathematical Physics for 2005

Chair of the Prize Committee for the Dannie Heineman Prize for Mathematical Physics for 2006

V. Honors and Awards:

Phi Beta Kappa (Junior year)

Sigma Xi

NSF Postdoctoral Fellow, Massachusetts Institute of Technology, 1959-1961

Alfred P. Sloan Research Fellow, 1964-66

John Simon Guggenheim Memorial Fellow, 1968-69

Fellow, American Physical Society

Washington Academy of Sciences Award in Physical Sciences for 1971

Fellow, Washington Academy of Sciences, 1971

Listed in American Men and Women of Science, starting 11th edition

Listed in Who's Who in America, starting 37th edition

Listed in Who's Who in the World, starting 4th edition

Listed in Who's Who in Technology Today, starting 3rd edition

University of Maryland Faculty Research Grant, Spring 1982

University of Maryland Faculty Research Grant, Fall 1987

University of Maryland Faculty Research Grant, Fall 1992

University of Maryland Faculty Research Grant, Fall 1996

United States-Ireland Fulbright Scholar, Fall 2006

VI. Publications

A. Papers published (or accepted for publication) in refereed journals.

1. Physics research

CLOTHED PARTICLE OPERATORS IN SIMPLE MODELS OF QUANTUM FIELD THEORY, with S.S. Schweber, *Nuovo Cimento* 8, 378-406 (1958).

HAAG'S THEOREM AND CLOTHED OPERATORS, *Phys. Rev.* 115, 706-710 (1959).

HYDRODYNAMIC MODEL OF DIFFUSION EFFECTS ON SHOCK WAVE STRUCTURE IN A PLASMA, with H. K. Sen and Y. M. Treve, *Phys. Fluids* 3, 379-386 (1960).

SHOCK WAVE AND SOLITARY WAVE STRUCTURE IN A PLASMA, with Y. M. Treve, *Phys. Fluids* 3, 769-785 (1960).

GENERALIZED FREE FIELDS AND MODELS OF LOCAL FIELD THEORY, *Ann. Phys.* 16, 158-176 (1961).

LIMIT ON HIGH-ENERGY CROSS SECTION FROM ANALYTICITY IN LEHMANN ELLIPSES, with F.E. Low, *Phys. Rev.* 124, 2047-2048 (1961).

TWO FOLK LEMMAS ON THE EXPANSION OF THE S -MATRIX OR THE OUT FIELD IN NORMAL ORDERED IN FIELDS, *J. Math. Phys.* 3, 31-34 (1962).

HEISENBERG FIELDS WHICH VANISH ON DOMAINS OF MOMENTUM SPACE, *J. Math. Phys.* 3, 859-866 (1962).

COMPLETENESS IDENTITY IN FIELD THEORY, with H.J. Schnitzer and E.C.G. Sudarshan, *Nuovo Cimento* 25, 461-464 (1962).

QUANTUM FIELD THEORY WHOSE TRUNCATED VACUUM EXPECTATION VALUES VANISH BEYOND SOME ORDER, with A.L. Licht, *J. Math. Phys.* 4, 613-614 (1963).

COUPLING OF INTERNAL AND SPACE-TIME SYMMETRIES, *Phys. Rev.* 135, B1447-B1450 (1964).

SYMMETRIZATION POSTULATE AND ITS EXPERIMENTAL FOUNDATION, with A.M.L. Messiah, *Phys. Rev.* 136, B248-B267 (1964).

SPIN AND UNITARY-SPIN INDEPENDENCE IN A PARAQUARK MODEL OF BARYONS AND MESONS, *Phys. Rev. Lett.* 13, 598-602 (1964).

SELECTION RULES FOR PARAFIELDS AND THE ABSENCE OF PARA PARTICLES IN NATURE, with A. M. L. Messiah, *Phys. Rev.* 138, B1155-B1167 (1965).

HIGH-ORDER LIMIT OF PARA-BOSE AND PARA-FERMI FIELDS, with A.M.L. Messiah, *J. Math. Phys.* 6, 500-504 (1965).

INTRODUCTION TO THE N -QUANTUM APPROXIMATION IN QUANTUM FIELD THEORY, *Phys. Rev.* 139, B1038-B1049 (1965); erratum, *Phys. Rev.* 156, 1742 (1967).

EQUIVALENCE OF LOCALITY AND PARALOCALITY IN FREE PARAFIELD THEORY, with H. Araki and J. S. Toll, *Phys. Rev.* 142, 1017-1018 (1966).

MAGNETIC MOMENTS OF SPIN-ONE-HALF PARTICLES IN EXTERNAL FIELDS,
 Phys. Lett. 19, 423-424 (1965).

NON-RELATIVISTIC MOTION OF PARTICLES IN STRONGLY BOUND S-STATES,
 Phys. Rev. 147, 1077-1080 (1966).

INTRODUCTION TO THE N -QUANTUM APPROXIMATION FOR BOUND STATES:
 THE DEUTERON IN PSEUDOSCALAR MESON THEORY, with R. J. Genolio,
 Phys. Rev. 150, 1070-1076 (1966).

N -QUANTUM SOLUTION OF THE DERIVATIVE COUPLING MODEL, Phys. Rev.
 150, 1076-1078 (1966).

SATURATION IN TRIPLET MODELS OF HADRONS, with D. Zwanziger, Phys. Rev.
 150, 1177-1180 (1966).

THE SYMMETRIC QUARK MODEL OF BARYON RESONANCES, with M. Resnikoff,
 Phys. Rev. 163, 1844-1851 (1967).

$SU(3)''$ -EXCITATION IN BARYON RESONANCES, with C. A. Nelson, Phys. Rev. Lett.
 20, 604-607 (1968).

ABSENCE OF INTERACTION IN LIE FIELD THEORIES, Comm. Math. Phys. 9, 13-17
 (1968).

RE-ANALYSIS OF THE LOWEST-MASS NEGATIVE PARITY BARYON RESONANCES
 USING THE SYMMETRIC QUARK MODEL, with D.R. Divgi, Phys. Rev. 175,
 2024-2026 (1968); erratum, Phys. Rev. 178, 2487 (1969).

CONSEQUENCES OF $SU(3)''$ -EXCITATION IN BARYON RESONANCES, with C.A.
 Nelson, Phys. Rev. 179, 1354-1363 (1969).

GENERALIZED BOSE OPERATORS IN THE FOCK SPACE OF A SINGLE BOSE OP-
 ERATOR, with R. A. Brandt, J. Math. Phys. 10, 1168-1176 (1969).

THREE TRIPLET MODEL, DUALITY AND THE POMERONCHON, Phys. Lett. 29B,
 493-496 (1969).

PARTON MODEL WITH VARIABLE INTERMEDIATE STATE PARTON MASS, with
 D. Bhaumik, Phys. Rev. D 4, 2048-2055 (1971).

FINITE ENERGY SUM RULES ON HYPERBOLAS, I, with J. C. Sandusky, Nuovo Ci-
 mento 6A, 617-626 (1971).

MELLIN-TRANSFORM ANALYSIS OF LIGHT-CONE STRUCTURE AND SCALING IN
 INELASTIC ELECTRON SCATTERING, with D. Bhaumik and R. N. Mohapatra,
 Phys. Rev. D 6, 2989-2997 (1972).

DIAGONAL STRUCTURE OF THE S-MATRIX IN THE LEE MODEL, with H. Yabuki,
 Ann. Phys. 79, 146-170 (1973).

COMMENT ON AN EXACTLY SOLUBLE MODEL OF RELATIVISTIC FIELD THEORY, with I. Bialynicki-Birula and J. C. Sandusky, Phys. Rev. D 7, 1928-1929 (1973).

LIGHT-CONE VS NON-LIGHT-CONE CONTRIBUTIONS TO STRUCTURE FUNCTIONS, with D. Bhaumik, Phys. Rev. D 7, 3136-3141 (1973).

DIFFRACTIVE LEPTON SCATTERING AND CONSTANT $\sigma(e^+e^- \rightarrow \text{HADRONS})$: A NEW REGIME IN LEPTON PHYSICS, with G. B. Yodh, Phys. Rev. Lett. 32, 1473-1477 (1974).

COMPOSITE MODELS OF LEPTONS, with C. A. Nelson, Phys. Rev. D 10, 2567-2573 (1974).

ds/dX FOR $e^+e^- \rightarrow hX$ FROM DIRECT QUARK-LEPTON INTERACTIONS, with A. Raychaudhuri, Phys. Rev. D 12, 2903-2906 (1975).

NEW NARROW RESONANCES AND SEPARATE LOCALIZATION OF ORDINARY AND COLOR SU(3), Phys. Rev. Lett. 35, 1120-1123 (1975).

QUARK MODEL RELATION FOR KAON CHARGE RADII, with S. Nussinov and J. Sucher, Phys. Lett. 70B, 465-468 (1977).

INFRARED REGULARIZATION OF THE MASSLESS SCALAR FREE FIELD IN TWO-DIMENSIONAL SPACE-TIME VIA LORENTZ EXPANSION, with J. S. Kang and C. H. Woo, Phys. Lett. 71B, 363-366 (1977).

STRUCTURE OF ASYMPTOTIC FIELDS ASSOCIATED WITH PERMANENTLY-CONFINED DEGREES OF FREEDOM IN QUANTUM FIELD THEORY, Phys. Rev. D 17, 2576-2582 (1978).

PERMANENT QUARK CONFINEMENT WITHOUT VAN DER WAALS FORCES, with J. Hietarinta, Phys. Lett. 86B, 309-312 (1979).

LINK OPERATOR FORMULATION OF QUARK CONFINEMENT WITHOUT VAN DER WAALS FORCES, with J. Hietarinta, Phys. Rev. D 22, 993-998 (1980).

QUANTUM STRUCTUREDYNAMIC MODEL OF QUARKS, LEPTONS, WEAK VECTOR BOSONS, AND HIGGS MESONS, with J. Sucher, Phys. Lett. 99B, 339-343 (1981).

THE POTENTIAL MODEL OF COLORED QUARKS: SUCCESS FOR SINGLE HADRON STATES; FAILURE FOR HADRON-HADRON INTERACTIONS, with H. J. Lipkin, Nucl. Phys., A 370, 349-364 (1981).

LOCALLY GAUGE-INVARIANT FORMULATION OF PARASTATISTICS, with K. I. Macrae, Nucl. Phys. B 219, 358-366 (1983).

WEAK INTERACTION SYMMETRY AND GENERATION STRUCTURE IN THE QUASI-NAMBU-GOLDSTONE FERMION PICTURE OF QUARKS AND LEPTONS, with R.N. Mohapatra and M. Yasue, Phys. Lett. 128B, 65-68 (1983).

STRING-BREAKING DESCRIPTION OF THE BARYON-MESON INTERACTION, with R. J. Perry and R. D. Smith, Phys. Lett. 131B, 209-212 (1983).

THE INTERPLAY BETWEEN THE 'T HOOFT ANOMALY CONSTRAINTS AND THE NAMBU-GOLDSTONE MECHANISM IN SUPERSYMMETRIC COMPOSITE MODELS, with R. N. Mohapatra and M. Yasue, Nucl. Phys. B 237, 189-204 (1984).

DETERMINATION OF THE NUMBER OF GENERATIONS OF QUARKS AND LEPTONS FROM FLAVOR-COLOR SYMMETRY, with R. N. Mohapatra and M. Yasue, Phys. Rev. Lett. 51, 1737-1740 (1983).

COMMENTS ON THE SPECTRUM OF NAMBU-GOLDSTONE PARTICLES IN SUPERSYMMETRIC THEORIES, with J. Sonnenschein, Phys. Lett. 144B, 69-72 (1984).

CONSTRAINTS ON COMPOSITE MODELS DUE TO RARE PROCESSES, with R.N. Mohapatra and S. Nussinov, Phys. Lett. 148B, 465-469 (1984).

REPHASING-INVARIANT FORMULATION OF CP VIOLATION IN THE KOBAYASHI-MASKAWA FRAMEWORK, Phys. Rev. D 32, 1841-1843 (1985).

A PRIORI DEFINITION OF MAXIMAL CP VIOLATION, with I. Dunietz and Dan-di Wu, Phys. Rev. Lett. 55, 2935-2937 (1985).

N -QUANTUM APPROACH TO SYMMETRY BREAKING, Prog. Theor. Phys. Supp. No. 86, 60-64 (1986).

N -QUANTUM CALCULATION OF DYNAMICAL SYMMETRY BREAKING IN THE NAMBU-JONA-LASINIO MODEL, with P. K. Mohapatra, Phys. Rev. D 34, 1136-1140 (1986).

N -QUANTUM CALCULATION OF THE NAMBU-JONA-LASINIO MODEL WITH ISOSPIN, with L.H. Orr, Phys. Rev. D 36, 1240-1246 (1987).

LOCAL QUANTUM FIELD THEORY OF POSSIBLE VIOLATION OF THE PAULI PRINCIPLE, with R. N. Mohapatra, Phys. Rev. Lett. 59, 2507-2510 (1987). Erratum, Phys. Rev. Lett. 61, 1432 (1988).

DIFFICULTIES WITH A LOCAL QUANTUM FIELD THEORY OF POSSIBLE VIOLATION OF THE PAULI PRINCIPLE, with R. N. Mohapatra, Phys. Rev. Lett. 62, 712-714 (1989).

PHENOMENOLOGY OF SMALL VIOLATIONS OF FERMI AND BOSE STATISTICS, with R.N. Mohapatra, Phys. Rev. D 39, 2032-2038 (1989).

ON THE SURPRISING RIGIDITY OF THE PAULI EXCLUSION PRINCIPLE, Nucl. Phys. B (Proc. Suppl.) 6, 83-89 (1989).

EXAMPLE OF INFINITE STATISTICS, Phys. Rev. Lett. 64, 705-708 (1990).

PARTICLES WITH SMALL VIOLATIONS OF FERMI OR BOSE STATISTICS, Phys. Rev. D 43, 4111-4120 (1991).

INTERACTIONS OF PARTICLES HAVING SMALL VIOLATIONS OF STATISTICS, *Physica A* 180, 419-427 (1992).

SCALING LIMIT OF A NONRELATIVISTIC MODEL OF CONFINED “QUARKS,” hep-ph/9210245, *Phys. Rev. D* 47, 331-335 (1993).

N-QUANTUM APPROACH TO THE BCS THEORY OF SUPERCONDUCTIVITY, *Can. J. Phys.* 74, 574-577 (1994).

CANONICAL COMMUTATION RELATIONS IN THE SCHWINGER MODEL, with G. Gat, hep-th/9402055, *Phys. Lett. B* 328, 119-122 (1994).

COVARIANT SINGLE-TIME BOUND-STATE EQUATION, with R. Ray and F. Schlumpf, hep-ph/9504396, *Phys. Lett. B* 353, 284-288 (1995).

CONSERVATION OF STATISTICS AND GENERALIZED GRASSMANN NUMBERS, hep-ph/9507349, *Phys. Lett. A* 209, 137-142 (1995).

BOUND STATES IN GALILEAN-INVARIANT QUANTUM FIELD THEORY, with S. Corley, hep-ph/9412211, *J. Math. Phys.* 38, 571-581 (1997).

SPIN-STATISTICS, SPIN-LOCALITY, AND TCP: THREE DISTINCT THEOREMS, hep-th/9707220, *Phys. Lett. B* 416, 144-149 (1998).

VARIATIONAL PRINCIPLE IN THE ALGEBRA OF ASYMPTOTIC FIELDS, hep-th/9803190, *Phys. Rev. D* 58, 065004, 1-7 (1998).

THE RELATION OF CONSTRAINTS ON PARTICLE STATISTICS FOR DIFFERENT SPECIES OF PARTICLES, with R.C. Hilborn, hep-th/9808106, *Foundations of Physics* 29, 397-407 (1999), (special issue in honor of D.M. Greenberger).

QUON STATISTICS FOR COMPOSITE SYSTEMS AND A LIMIT ON THE VIOLATION OF THE PAULI PRINCIPLE FOR NUCLEONS, with R.C. Hilborn, hep-th/9903020, *Phys. Rev. Lett.* 83, 4460-4463 (1999).

STUDY OF A MODEL OF QUANTUM ELECTRODYNAMICS, hep-th/0002201, *Foundations of Physics* 30, 383-391 (2000), (special issue in honor of K. Haller).

QUONS IN RELATIVISTIC THEORIES MUST BE BOSONS OR FERMIONS, with Chi-Keung Chow, hep-th/0011150, *Phys. Lett. A* 283, 20-24 (2001).

CONSTRUCTION OF BOSONS AND FERMIONS OUT OF QUONS, hep-th/0107058, with J.D. Delgado, *Phys. Lett. A* 288, 139-144 (2001).

CPT VIOLATION IMPLIES VIOLATION OF LORENTZ INVARIANCE, hep-ph/0201258, *Phys. Rev. Lett.* 89, 231602-1 to 231602-4 (2002).

HYBRID DIRAC FIELDS, hep-ph/0305276, *Phys. Lett. B* 567, 179-183 (2003).

PATH INTEGRALS FOR PARASTATISTICS, with A.K. Mishra, math-ph/0406011, *Phys. Rev. D* 70, 125013-1 to 125013-7 (2004).

FAILURE OF MICROCAUSALITY IN QUANTUM FIELD THEORY ON NONCOMMUTATIVE SPACETIME, hep-th/0508057, Phys. Rev. D 73, 045014-1 to 045014-5 (2006).

COVARIANCE OF TIME-ORDERED PRODUCTS IMPLIES LOCAL COMMUTATIVITY OF FIELDS, hep-th/0405211, Phys. Rev. D 73, 087731-1 to 087701-3 (2006).

WHY IS CPT FUNDAMENTAL?, hep-ph/0309309, Found. Phys. 36, 1535-1553 (2006).

2. Instrumentation or techniques – none

3. Review papers

COLOR MODELS OF HADRONS, with C. A. Nelson, Physics Reports 32C, 69-121 (1977).

QUARKS, Ann. Rev. Nucl. Part. Sci. 28, 327-386 (1978).

RESOURCE LETTER $Q - 1$: QUARKS, Am. J. Phys. 50, 1074-1089 (1982).

A NEW LEVEL OF STRUCTURE? COMPOSITENESS OF PARTICLES IN THE STANDARD MODEL, Physics Today 38, No. 9, 22-30 (1985); reprinted in Japanese translation in Parity 1, No. 3, 18-29 (1986); and to be reprinted in Russian translation in Fizika za Rubezhom '87, A Series.

QUARKS (theory) in 7th edition of the McGraw-Hill Encyclopedia of Science and Technology, 623-626.

ELECTROWEAK INTERACTION to appear in 7th edition of the McGraw-Hill Encyclopedia of Science and Technology

STANDARD MODEL to appear in 7th edition of the McGraw-Hill Encyclopedia of Science and Technology

revision of QUARKS (theory) to appear in 8th edition of the McGraw-Hill Encyclopedia of Science and Technology.

FROM WIGNER'S SUPERMULTIPLY THEORY TO QUANTUM CHROMODYNAMICS. MDDP-PP-03-028, Dec 2002. 16pp., hep-ph/0212174. To appear in the proceedings of Wigner Centennial Conference in Commemoration of the 100th year of Wigner's Birth, Hungary, Pecs, Hungary, 7-12 Jul 2002. In Acta Physica Hungarica A, Heavy Ion Phys. A Vol. 19 (2004) pp. 353-364.

4. Teaching and miscellaneous

GROUP THEORETICAL METHODS IN ELEMENTARY PARTICLE PHYSICS (with E. P. Wigner), Physics Today 16, 62-64 (1963).

THE QUEST FOR THE ELEMENTARY PARTICLES OF MATTER, American Scientist 76, 361-363 (1988).

A TESTING TIME FOR BOSONS, Physics World 9, No. 7, 27 (1996).

Book reviews

- TECHNIQUES AND APPLICATIONS OF PATH INTEGRATION, by Lawrence S. Schulman, in J. of Stat. Phys. 27, 827 (1982).
- POINTLIKE STRUCTURES INSIDE AND OUTSIDE HADRONS, ed. A. Zichichi, in Amer. Sci. 70, 638 (1982).
- LEPTONS, HADRONS AND NUCLEI, by Florian Scheck, Foundations of Physics, 16, 1227-1228 (1986).
- THE QUANTUM UNIVERSE, by T. Hey and P. Walters, Science 238, 558 (1987).
- GROUP THEORY IN PHYSICS, AN INTRODUCTION TO SYMMETRY PRINCIPLES, GROUP REPRESENTATIONS, AND SPECIAL FUNCTIONS IN CLASSICAL AND QUANTUM PHYSICS, by W.-K. Tung, Foundations of Physics 18, 489-490 (1988).
- QUANTUM FIELD THEORY AND PARASTATISTICS, by Y. Ohnuki and S. Kamefuchi, Foundations of Physics 19, 229-230 (1989).
- INWARD BOUND by A. Pais, Foundations of Physics Letters 1, 97-100 (1988).
- SYMMETRIES IN PHYSICS, by W. Ludwig and C. Falter, in American Scientist, July 1989.
- ASPECTS OF SYMMETRY, by S. Coleman, Foundations of Physics 19, 787-788 (1989).
- AN OLD MAN'S TOY, by A. Zee and TURBULENT MIRROR, by J. Briggs and F.D. Peat, Washington Post Book World, **XIX**, No. 30, p6; Sunday, July 23, 1989. (Reprinted in the International Herald Tribune, August 1989.)
- PRINCIPLES OF STRING THEORY, by Lars Brink and Marc Henneaux; INTRODUCTION TO SUPERSTRINGS, by Michio Kaku; GAUGE FIELDS AND STRINGS, by A.M. Polyakov; INTRODUCTION TO STRING FIELD THEORY, By Warren Siegel. (to appear in Foundations of Physics)
- QUANTUM FIELD THEORY by Lowell S. Brown and QUANTUM FIELD THEORY A MODERN INTRODUCTION by Michio Kaku, Physics Today **47**, No. 2, 104-106 (1994).
- THE QUANTUM THEORY OF FIELDS, VOLUME I FOUNDATIONS by Steven Weinberg, Physics Today **48**, No. 11, 78 (1995).
- THE QUANTUM THEORY OF FIELDS, VOLUME II MODERN APPLICATIONS by Steven Weinberg, Physics Today **50**, No. 1, 67-68 (1997).
- THE QUANTUM THEORY OF FIELDS, VOLUME III SUPERSYMMETRY by Steven Weinberg, Foundations of Physics **30**, 1131-1133 (2000).
- A TALE OF TWO CONTINENTS by Abraham Pais, Foundations of Physics **31**, 869-870 (2001).

SPIN IN PARTICLE PHYSICS by Elliot Leader, *Physics Today* **55**, No. 9, 63-64 (2002).

QUANTUM FIELD THEORY IN A NUTSHELL by Anthony Zee, *Foundations of Physics*, **34**, 187-188 (2004).

B. Papers presented at scientific meetings

1. Invited papers

TOPICS IN HIGH ENERGY SCATTERING THEORY, 1962 Istanbul NATO Advanced Study Institute. (See article in C)

PARASTATISTICS: AXIOMATIC FORMULATION, CONNECTION WITH SPIN AND TCP THEOREM FOR A GENERAL FIELD THEORY, with G. F. Dell'Antonio and E.C.G. Sudarshan, 1962 Istanbul NATO Advanced Study Institute. (See article in C)

PARAFIELD THEORY, Conference on Mathematical Theory of Elementary Particles, at Endicott House, MIT, 1965. (See article in C)

SATURATION IN TRIPLET MODELS OF HADRONS, Colloques Internationaux du Centre National de la Recherche Scientifique, Gif-sur-Yvette, 1966. (See article in A.1)

QUARK MODELS OF BARYON RESONANCES, American Physical Society meeting in Washington, D.C., April, 1967. (See article in E)

SU(3) EXCITATION IN BARYON RESONANCES, with C. A. Nelson, Fifth Coral Gables Conference, January, 1968. (See article in C)

RESONANCE MODELS, Rapporteur's review, Lund International Conference on Elementary Particles, 1969. (See article in C)

e^+e^- REACTIONS-THEORY, Division of Particles and Fields Meeting, College of William and Mary, September 1974. (See article in C)

DIFFRACTIVE LEPTON SCATTERING AND CONSTANT $\sigma(e^+e^- \rightarrow \text{HADRONS})$, Seminar on Quark-Parton Model, Soviet Academy of Sciences, Moscow, 1974. (See article in A.1)

ELECTRON-POSITRON ANNIHILATION TO HADRONS AND COLOR SYMMETRIES OF ELEMENTARY PARTICLES, OR THE OUTLOOK FOR COLOR: GRAY OR ROSY?, Second Orbis Scientiae at the University of Miami, Coral Gables, Florida, 1975. (See article in C)

UNBOUND COLOR, PREFACED BY REMARKS ON BARYON SPECTROSCOPY, XI-Ith Rencontre de Moriond, 1977. (See article in C)

COLOR VAN DER WAALS FORCES?, Orbis Scientiae 1980 at the University of Miami, Coral Gables, Florida, 1980. (See article in C)

QUARK CONFINEMENT AND HADRON SEPARATION, with J. Hietarinta, XVII Winter School of Theoretical Physics in Karpacz, University of Wroclaw, 1980. (See article in C)

THE COLOR DEGREE OF FREEDOM IN ELEMENTARY PARTICLE PHYSICS, XVII Winter School of Theoretical Physics in Karpacz, University of Wroclaw, 1980.

A QUANTUM STRUCTUREDYNAMIC MODEL OF QUARKS, LEPTONS, WEAK VECTOR BOSONS, AND HIGGS MESONS, XX International Conference on High Energy Physics, University of Wisconsin at Madison, 1980. (See article in C)

COMPOSITE MODELS OF QUARKS AND LEPTONS WITH WEAK AND STRONG INTERACTIONS ON A PARALLEL FOOTING, with J. Sucher, Conference on Weak Interactions as Probes of Unification, Virginia Polytechnique Institute and University, 1980. (See article in C)

THE NEXT LAYER ON THE ONION?: COMPOSITE MODELS OF QUARKS AND LEPTONS, Symposium on Grand Unified Theories and Cosmology at meeting of the AAAS, Washington, D.C., January, 1982.

THE NEXT LAYER OF THE ONION?: COMPOSITE MODELS OF QUARKS AND LEPTONS, at Session on Composite Models of Quarks and Leptons, Orbis Scientiae 1982, University of Miami, January, 1982. (See article in C)

THE N -QUANTUM APPROXIMATION, CONCRETE COMPOSITE MODELS OF QUARKS AND LEPTONS, AND PROBLEMS WITH THE NORMALIZATION OF ZERO-MASS BOUND STATES, at Session on Composite Models of Quarks and 1982, University of Miami, January, 1982. (See article in C)

COMPOSITE MODELS OF QUARKS AND LEPTONS, 21st Eastern Theoretical Physics Conference, University of Delaware, October, 1982.

LOCALLY GAUGE-INVARIANT FORMULATION OF PARASTATISTICS, with K. Macrae, Workshop on Non-Perturbative Quantum Chromodynamics, Oklahoma State University, March, 1983. (See article in C)

NAMBU-GOLDSTONE FERMIONS AND COMPOSITE MODELS OF QUARKS AND LEPTONS, Workshop on Composite Models of Quarks and Leptons, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, September, 1983.

PATTERNS OF NAMBU-GOLDSTONE FERMIONS, Workshop on Composite Models of Quarks and Leptons, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, September, 1983.

NAMBU-GOLDSTONE FERMIONS AND COMPOSITE MODELS OF QUARKS AND LEPTONS, WORKSHOP ON COMPOSITE MODELS OF QUARKS AND LEPTONS, Erice, April, 1984.

A NEW LEVEL OF STRUCTURE. COMPOSITENESS OF PARTICLES IN THE STANDARD MODEL, Workshop on Composite Models of Quarks and Leptons, University of California at Irvine, November, 1984.

N-QUANTUM APPROACH TO DYNAMICAL SYMMETRY BREAKING AND COMMENTS ABOUT THE ORIGIN OF FAMILIES, Nambu Symposium, University of Chicago, January, 1986. (See article in 1.)

ON THE SURPRISING RIGIDITY OF THE PAULI EXCLUSION PRINCIPLE, International Symposium on Spacetime Symmetries, University of Maryland, May, 1988. (See article in 1.)

Q-MUTATORS AND VIOLATIONS OF STATISTICS, Spring Workshop on Quantum Groups, Argonne National Laboratory, May 1990. (See article in C.)

QUONS, A NEW INTERPOLATION BETWEEN BOSONS AND FERMIONS, Nordita Workshop on Anyons, University of Stockholm, May 1991.

SMALL VIOLATIONS OF PARTICLE STATISTICS, First International Andrei D. Sakharov Conference on Physics, Lebedev Institute, Moscow, May 1991. (See article in C.)

COLOR: FROM BARYON SPECTROSCOPY TO QCD, Baryons '92, International Conference on the Structure of Baryons and Related Mesons, Yale University, New Haven, June 1992. (See article in C.)

QUONS, AN INTERPOLATION BETWEEN BOSE AND FERMI OSCILLATORS, Workshop on Harmonic Oscillators, University of Maryland, March, 1992. (See article in C)

(PARA)BOSONS, (PARA)FERMIONS, ANYONS, QUONS AND OTHER BEASTS IN THE MENAGERIE OF PARTICLE STATISTICS, Symposium on Fundamental Aspects of Quantum Theory in Honor of Yakir Aharonov, University of South Carolina, December 1992, (See article in C).

QUON ALGEBRA, Symposium on The Beauty of Physics in Honor of Ralph Amado, University of Pennsylvania, January, 1993.

VIRTUES OF THE HAAG EXPANSION IN QUANTUM FIELD THEORY, Fourth Meeting on Light Cone Quantization and Non-Perturbative Dynamics, Workshop on Light Front Physics, University of Washington, June 17, 1994.

VIRTUES OF THE HAAG EXPANSION IN QUANTUM FIELD THEORY, University of Maryland Preprint 95-99, pp1-28, First Arctic Workshop on Future Physics and Accelerators, Saariselka, Finland, August, 1994, (See article in C).

RELATIVISTIC BOUND STATES, Fourth Meeting on Light Cone Quantization and Non-Perturbative Dynamics, Workshop on Light Front Physics, Telluride, August 22, 1995. (See article in C).

A NEW VARIATIONAL PRINCIPLE FOR QUANTUM FIELD THEORY, Eighth International Workshop on Light Cone QCD and Non-Perturbative Hadronic Physics, Lutsen, August 22, 1997. (See article in C).

THE RELATION OF SPIN, STATISTICS, LOCALITY AND TCP, *Orbis Scientiae* 1997 II:Physics of Mass, Miami, December, 1997. (See article in C).

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THEORIES OF VIOLATION OF STATISTICS, International Conference on the Spin-Statistics Connection and Commutation Relations: Experimental Tests and Theoretical Implications, Capri, Italy, May 31, 2000. (See article in C).

FROM WIGNER'S SUPERMULTIPLY THEORY TO QUANTUM CHROMODYNAMICS, Wigner Centennial Conference, Pecs, Hungary, July 9, 2002. (See article in C).

CPT, LORENTZ INVARIANCE, LOCALITY AND RELATED ISSUES, 8th International Wigner Symposium, New York, May 29, 2003. (Article in preparation.)

WHY IS CPT FUNDAMENTAL?, Third International Symposium on Quantum Theory and Symmetries, Cincinnati, September 11, 2003. (See article in C.)

THE COLOR DEGREE OF FREEDOM IN ELEMENTARY PARTICLE PHYSICS, Symposium in Honor of Silvan S. Schweber, Dabner Institute, Massachusetts Institute of Technology, Cambridge, October 8, 2003.

LORENTZ COVARIANCE, T-PRODUCTS AND CPT INVARIANCE, Conference on Fundamental Symmetries and Fundamental Constants, Abdus Salam, International Centre for Theoretical Physics, Trieste, September 16, 2004.

QUANTUM STATISTICS IN THREE SPACE DIMENSIONS, Symposium in Honor of the 60th Birthday of Jon Magne Leinaas, University of Oslo, October 14, 2006.

HOW QUARKS GOT COLOR; A PARTICIPANT VIEW, Winter Symposium, Dublin Institute for Advanced Studies, December 14, 2006.

2. Contributed papers

RE-EXAMINATION OF NEUTRINO THEORY OF LIGHT, with A. S. Wightman, Abstract, *Phys. Rev.* 99, 675 A (1955).

THE ASYMPTOTIC CONDITION IN QUANTUM FIELD THEORY, Abstract, *Bull. Am. Phys. Soc.* 2, 190 (1957). (See thesis in E)

CLOTHED PARTICLE OPERATORS IN SIMPLE MODELS OF QUANTUM FIELD THEORY, with S.S. Schweber, Abstract, *Bull. Am. Phys. Soc.* 3, 10 (1958). (See article in A.1)

- DIFFUSION EFFECTS ON SHOCK STRUCTURE IN A PLASMA, with H.K. Sen and Y.M. Treve, Third Annual Shock Tube Symposium, Fort Monroe, Va., (1959). (See article in C)
- PROOF OF HAAG'S THEOREM, Abstract, Bull. Am. Phys. Soc. 4, 280 (1959). (See article in A.1)
- CHARGE SEPARATION EFFECTS ON SHOCK STRUCTURE IN PLASMA, with H.K. Sen and Y.M. Treve, Fourth International Conference on Ionization Phenomena in Gases, Uppsala, (1959). (See article in C)
- GENERALIZED FREE FIELDS AND MODELS OF LOCAL FIELD THEORY, Abstract, Bull. Am. Phys. Soc. 6, 306 (1961). (See article in A.1)
- N -QUANTUM APPROXIMATION IN THE A^4 THEORY, Abstract, with D. G. Currie, Bull. Am. Phys. Soc. 9, 449 (1964).
- INTRODUCTION TO THE N -QUANTUM APPROXIMATION IN QUANTUM FIELD THEORY, Abstract, Bull. Am. Phys. Soc. 9, 448 (1964). (See article in A.1)
- N -QUANTUM DESCRIPTION OF BOUND STATES IN QUANTUM FIELD THEORY, Abstract, Bull. Am. Phys. Soc. 10, 484 (1965). (See article in A.1)
- STRING-BREAKING DESCRIPTION OF THE BARYON-MESON INTERACTION, Abstract, with R.J. Perry and R. D. Smith. Bull. Am. Phys. Soc. Amherst Meeting Oct. 14-16 (1982).
- Q-MUTATORS ALLOW SMALL VIOLATION OF THE EXCLUSION PRINCIPLE, Abstract, Bull. Am. Phys. Soc. 35, 981 (1990).

C. Books or contributions to edited books

- HAAG'S THEOREM AND CLOTHED OPERATORS, (See article in A.1),
- DIFFUSION EFFECTS ON SHOCK STRUCTURE IN A PLASMA, with H. K. Sen and Y.M. Treve, Proc. Fourth AFBMD/STL Symposium: Advances in Ballistic Missile Technology, Vol. 2, pp. 358-373, ed. C. T. Morrow, D. P. LeGalley, and L.D. Ely (Pergamon Press, Oxford, 1961).
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- SPIN AND UNITARY-SPIN INDEPENDENCE IN A PARAQUARK MODEL OF BARYONS AND MESONS, (See article in A.1), reprinted in The Quark Model, pp. 122-126, ed. J. J. J. Kokkedee (Benjamin, New York, 1969); in Selected Papers in Physics, Vol. 25; Elementary Particle Models, pp. 154-158, ed. S. Tanaka and S. Ishida (Physical Society of Japan, Tokyo, 1975); in Developments in the Quark Theory of Hadrons, pp.

102-106, ed. D.B. Lichtenberg and S.P. Rosen (Hadronic Press, Nonantum, 1980); in Selected Papers on Gauge Theories of Fundamental Interactions, pp.311-315, ed. R.N. Mohapatra and C.H. Lai (World Scientific, Singapore, 1981). and in Quarks, Selected Reprints, pp. 1-156, ed O. W. Greenberg (American Association of Physics Teachers, McGregor and Warner, Washington, D.C., 1986).

TOPICS IN HIGH ENERGY SCATTERING THEORY, in Group Theoretical Concepts and Methods in Elementary Particle Physics, pp. 107-134, ed. F. Gürsey (Gordon and Breach, New York, 1964).

PARASTATISTICS: AXIOMATIC FORMULATION, CONNECTION WITH SPIN AND STATISTICS AND TCP THEOREM FOR A GENERAL FIELD THEORY (with G.F. Dell'Antonio and E.C.G. Sudarshan), in Group Theoretical Concepts and Methods in Elementary Particle Physics, pp. 403-408, ed. F. Gürsey, (Gordon and Breach, New York, 1964).

COUPLING OF INTERNAL AND SPACE-TIME SYMMETRIES, (See article in A.1), reprinted in Symmetry Groups in Nuclear and Particle Physics, pp. 246-249, ed. F. J. Dyson (W. A. Benjamin, Inc., New York, 1966).

PARAFIELD THEORY, in Mathematical Theory of Elementary Particles, pp. 26-44, ed. R. Goodman and I. Segal (Massachusetts Institute of Technology Press, Cambridge, 1966).

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- ROSY, in *Theories and Experiments in High-Energy Physics, Studies in the Natural Sciences, Volume 9*, pp. 71-114, ed. A. Perlmutter and S. M. Widmayer (Plenum Press, New York, 1975).
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gary, Pecs, Hungary, 7-12 Jul 2002; *Acta Physica Hungarica A, Heavy Ion Phys. A*
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CPT AND LORENTZ COVARIANCE, PP-04-011, Dec. 2003, 10pp., in *Quantum Theory
and Symmetries, Proceedings of the Third International Symposium*, ed. P.C. Argyres,
et al, (World Scientific, Singapore, 2004), University of Cincinnati, Cincinnati, Septem-
ber 11, 2003.

D. Articles in preparation or submitted for publication

THE N-QUANTUM APPROACH TO THE HYDROGEN ATOM, (pedogogical paper),
draft of 9 pages exists.

VARIATIONAL CALCULATION OF THE FIELD ATTACHED TO A CHARGE, draft of
13 pages exists.

VACUUM MATRIX ELEMENT OF AN ARBITRARY PRODUCT OF PARAFIELDS with
A.K. Mishra, draft of 5 pages exists.

E. Technical Reports (not published elsewhere)

Thesis: THE ASYMPTOTIC CONDITION IN QUANTUM FIELD THEORY, Princeton
(1956), pp. 1-198, supervising professor, A.S. Wightman (unpublished).

INTRODUCTORY LECTURES IN SCATTERING THEORY, pp. 1-75, U. of Md., Phys.
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of Md., Phys. Dept. (1963).

QUARK MODELS OF BARYON RESONANCES, U. of Md. Tech. Report No. 680, pp. 1-23 (1967).

A SCHEMATIC MODEL OF LEPTONS AND ITS POSSIBLE RELATION TO HADRONS, pp. 1-9, with C.A. Nelson, Univ. of Md. Tech. Report No. 74-006 (1973).

SINGLE-PARTICLE INCLUSIVE DISTRIBUTIONS IN ELECTRON-POSITRON ANNIHILATION NOT DUE TO THE ONE-PHOTON GRAPH, pp. 1-17, with G. B. Yodh, Univ. of Md. Tech. Report No. 74-109 (1974).

ABSENCE OF COLOR VAN DER WAALS FORCES, NON-ASSOCIATIVITY, AND THE LARGE- N LIMIT OF $SU(N)$ THEORIES, University of Maryland Technical Report No. 80-027 (1979), pp. 1-10.

SCHEMATIC MODEL OF GENERATIONS OF QUARKS AND LEPTONS, University of Maryland Preprint PP-06-010, e-Print Archive: hep-ph/0605089.

G. Contracts, grants, and proposals: Descriptions, dates, amounts, and other principal investigators.

NSF grant with S. Oneda, May 1, 1970-April 30, 1974, \$338,500

NSF grant with J. C. Pati, May 1, 1974-April 30, 1976, \$119,500

NSF grant with J. C. Pati, May 1, 1976-April 30, 1978, \$126,300

NSF grant with J. C. Pati, May 1, 1978-April 30, 1980, \$145,900

NSF grant with J. C. Pati, May 1, 1980-April 30, 1983, \$259,100

NSF grant with J. C. Pati, May 1, 1983-April 30, 1986, \$144,000 for first year.

NSF grant with J. C. Pati, May 1, 1983-April 30, 1986, \$155,000 for second year.

NSF grant with J. C. Pati, May 1, 1983-April 30, 1986, \$167,000 for third year.

NSF grant with J. C. Pati, June 15, 1986-May 1, 1987, \$167,000. for first year.

NSF grant with J. C. Pati, May 1, 1987-April 30, 1988, \$167,000 for second year.

NSF grant with J. C. Pati, May 1, 1988-Oct. 30, 1988, \$100,000 for last half year.

NSF grant with J.C. Pati, Feb. 1, 1989-Dec. 31, 1989, \$164,000 for first year.

NSF grant with J.C. Pati, Jan. 1, 1990-Dec. 31, 1990, \$145,000 for second year.

NSF grant with J.C. Pati, Jan. 1, 1991-Dec. 31, 1991, \$145,000 for third year.

NSF grant with J.C. Pati, Jan. 1, 1992-Dec. 31, 1992, \$160,000 for first year.

NSF grant with J.C. Pati, Jan. 1, 1993-Dec. 31, 1993, \$160,000 for second year.

NSF grant with J.C. Pati, Jan. 1, 1994-Dec. 31, 1994, \$160,000 for third year.

NSF grant with J.C. Pati, Jan. 1, 1995-Dec. 31, 1995, \$130,000 for first year.

NSF grant with J.C. Pati, Jan. 1, 1996-Dec. 31, 1996, \$123,000 for second year.

NSF grant with J.C. Pati, Jan. 1, 1997-Dec. 31, 1997, \$130,000 for third year.

NSF grant, Nov. 15, 2002-Oct. 31, 2003, \$48,108 for first year.

NSF grant, US-India Cooperative Research Program grant, June 1, 2002-July 31, 2005, three years \$14,300; extended at no additional cost to July 31, 2007.

NSF grant, Nov. 15, 2003-Oct. 31, 2004,\$50,038 for second year.

NSF grant, Nov. 15, 2004-Oct. 31, 2005,\$52,036 for third year.

Courses Taught Since 1969

Fall 1969	Phys. 255	Advanced Quantum Mechanics (3)
Spr. 1970	Phys. 254	Advanced Quantum Mechanics (3)
	Phys. 230	Seminar Elementary Particles (1)
Fall 1970	Phys. 254	Advanced Quantum Mechanics (3)
	Phys. 230	Seminar Elementary Particles (1)
Spr. 1971	Phys. 255	Advanced Quantum Mechanics (3)
	Phys. 230	Seminar Elementary Particles (1)
Fall 1971	Phys. 624	Advanced Quantum Mechanics (3)
Spr. 1972	Phys. 851	Advanced Quantum Mechanics (3)
Fall 1972	Phys. 624A	Advanced Quantum Mechanics (3)
	Phys. 759	Seminar Elementary Particles (1)
Spr. 1973	Phys. 759	Seminar Elementary Particles (1)
	Phys. 851	Advanced Quantum Mechanics (3)
Fall 1973	Phys. 101A	Contemporary Physics (3)
Spr. 1974	Phys. 451	Introduction to Elementary Particles (3)
Fall 1974	Phys. 191	Introductory Physics Mechanics (3)
	Phys. 759	Seminar Elementary Particles QFT (1)
Spr. 1975	Phys. 499	Intro. to Nuclear and Elementary Part. Phys. (4)
	Phys. 758	Seminar Elementary Particles and QFT (1)
Fall 1975	Phys. 624	Advanced Quantum Mechanics (3)
Spr. 1976	Phys. 859	Spec.Top. in Elementary Part. and Quan.F.Th. (3)
Fall 1976	Phys. 759	Seminar Elementary Particles (1)
	Phys. 624	Advanced Quantum Mechanics (3)
Spr. 1977	Phys. 759	Seminar Elementary Particles (1)
	Phys. 752	Elementary Particles (3)
Fall 1977		Sabbatical leave
Spr. 1978		Sabbatical leave
Fall 1978	Phys. 262	General Physics, Heat, Electricity, and Magnetism (4)
	Phys. 759	Seminar Elementary Particles and QFT (1)
Spr. 1979	Phys. 263	General Physics, Waves, Relativity, and Quantum (4)
	Phys. 759	Seminar Elementary Particles and QFT (1)
Fall 1979	Phys. 262	General Physics, Heat, Electricity, and Magnetism (4)
	Phys. 759	Seminar Elementary Particles and QFT (1)

Spr. 1980	Phys. 263	General Physics, Waves, Relativity, and Quantum (4)
	Phys. 759	Seminar Elementary Particles and QFT (1)
Fall 1980	Phys. 262	General Physics, Heat, Electricity, and Magnetism (4)
Spr. 1981	Phys. 263	General Physics, Waves, Relativity, and Quantum (4)
	Phys. 759	Seminar Elementary Particles and QFT (1)
Fall 1981	Phys. 859	Special Topics in Elementary Particle Physics and Field Theory: Quarks, Quantum Chromodynamics, and Composite Models of Quarks and Leptons (3)
	Phys. 759	Seminar Elementary Particles and QFT (1)
Spring 1982		Faculty Research Grant
Fall 1982	Phys. 624	Advanced Quantum Mechanics
	Phys. 759	Seminar Elementary Particles and QFT
	Phys. 798	Special Topics Advanced Physics
Spr. 1983	Phys. 752	Elementary Particle Physics
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1983	Phys. 751	Elementary Particle Physics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 1984	Phys. 752	Elementary Particle Physics
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1984		Sabbatical leave
Spr. 1985		Sabbatical leave
Fall 1985	Phys. 263	General Physics, Electrodynamics, Light, Relativity and Modern Physics
	Phys. 759	Seminar Elementary Particles and QFT
	Phys. 299	Physics 263 as a special topics course
Spr. 1986	Phys. 262	General Physics, Vibrations, Waves, Heat, Electricity and Magnetism
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1986	Phys. 262	General Physics, Vibrations, Waves, Heat, Electricity and Magnetism
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 1987	Phys. 263	General Physics, Electrodynamics, Light, Relativity and Modern Physics
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1987		Semester Research Grant
Spr. 1988	Phys. 262	General Physics, Vibrations, Waves, Heat, Electricity and Magnetism
	Phys. 759	Seminar Elementary Particles and QFT

Fall 1988	Phys. 602	Statistical Physics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 1989	Phys. 851	Advanced Quantum Field Theory
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1989	Phys. 602	Statistical Physics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 1990	Phys. 851	Advanced Quantum Field Theory
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1990	Phys. 602	Statistical Physics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 1991	Phys. 851	Advanced Quantum Field Theory
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1991	Phys. 602	Statistical Physics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 1992		Sabbatical leave
Fall 1992		Semester Research Grant from GRB
Spr. 1993	Phys. 851	Advanced Quantum Field Theory
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1993	Phys. 301	Intermediate Theoretical Physics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 1994	Phys. 851	Advanced Quantum Field Theory
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1994	Phys. 301	Intermediate Theoretical Physics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 1995	Phys. 603	Methods of Statistical Physics
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1995	Phys. 301	Intermediate Theoretical Physics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 1996	Phys. 851	Advanced Quantum Field Theory
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1996		Semester Research Grant from GRB
Spr. 1997	Phys. 851	Advanced Quantum Field Theory
	Phys. 759	Seminar Elementary Particles and QFT
Fall 1997	Phys. 410	Classical Mechanics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 1998	Phys. 263	General Physics, Electrodynamics, Light, Relativity and Modern Physics
	Phys. 410	Classical Mechanics (reading course)
	Phys. 759	Seminar Elementary Particles and QFT

Fall 1998	Phys. 410	Classical Mechanics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 1999		Sabbatical leave
Fall 1999	Phys. 410	Classical Mechanics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 2000	Phys. 262	General Physics, Vibrations, Waves, Heat Electricity and Mag
	Phys. 759	Seminar Elementary Particles and QFT
Fall 2000	Phys. 410	Classical Mechanics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 2001	Phys. 263	General Physics, Electrodynamics, Light, Relativity and Mod
	Phys. 759	Seminar Elementary Particles and QFT
Fall 2001	Phys. 262	General Physics, Vibrations, Waves, Heat Electricity and Mag
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 2002	Phys. 263	General Physics, Electrodynamics, Light, Relativity and Mod
	Phys. 759	Seminar Elementary Particles and QFT
	Phys. 499B	Individual Study
Fall 2002	Phys. 711	Symmetry Problems in Physics
	Phys. 759	Seminar Elementary Particles and QFT
	Phys. 499B	Individual Study
Spr. 2003	Phys. 603	Methods of Statistical Physics
	Phys. 759	Seminar Elementary Particles and QFT
Fall 2003	Phys. 170	Professional Physics Seminar
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 2004	Phys. 270	General Physics, Electrodynamics, Light, Relativity and Mod
	Phys. 759	Seminar Elementary Particles and QFT
Fall 2004	Phys. 122 Lab	Laboratory for Fundamentals of Physics II
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 2005	HONR239Y	Inward Bound, the Quest for the Ultimate Particles of Matter
	Phys. 759	Seminar Elementary Particles and QFT
Fall 2005	Phys. 711	Symmetry Problems in Physics
	Phys. 759	Seminar Elementary Particles and QFT
Spr. 2006	HONR239Y	Elementary Particles for Poets
	Phys. 759	Seminar Elementary Particles and QFT
Fall 2006		On leave as Fulbright Scholar, Dublin Institute for Advanced
Spr. 2007	Phys. 752	Elementary Particle Physics II: Theory
	Phys. 759	Seminar Elementary Particles and QFT