

MASTER

FOUR-YEAR SUMMARY OF THE RESEARCH EFFORT
OF THE HIGH ENERGY PHYSICS GROUP AT
THE OHIO STATE UNIVERSITY FOR THE
PERIOD OF 1973 - 1977

ERDA REPORT NO. COO-1545-253

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(A) EXPERIMENTAL

Appendix I Selection of Published Experimental Papers

(B) THEORETICAL

Appendix II Selection of Published Theoretical Papers

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SUMMARY OF THE ACTIVITIES OF THE EXPERIMENTAL HIGH ENERGY PHYSICS GROUP
AT THE OHIO STATE UNIVERSITY FOR THE PERIOD OF 1973 - 1977

Introduction

The aim of this summary is to outline the main efforts which have been undertaken during the past four years by our group and to highlight results obtained.

Our manpower during that period consisted typically of five faculty members, two research associates and two or three Ph.D. and MS graduate students. The technical support group contains a programmer, an instrument designer, three technicians, and, as the need arises, a number of part-time students. Services of the electronics shop staffed with an engineer and four technicians as well as that of a modern machine shop with eight machinists and a shop foreman are readily available for our efforts. The Physics Department supported our research by granting research leaves and by substantial allocation of funds for equipment, materials and services.

Our experiments have been conducted at Fermilab, Argonne, and CERN in collaboration with groups from: Michigan State University, University of Chicago, Argonne National Laboratory, Harvard, MIT, University of Toronto, McGill University, Carleton University of Canada, Frascati, Naples, Pisa, and the Nagoya, Osaka-Kobe groups from Japan.

A list of personnel who comprised the Experimental High Energy Physics Group for the past four-year period is given below:

Faculty

T. Y. Ling	1977-present
N. W. Reay	1973-present
K. Reibel	1973-present
T. A. Romanowski	1973-present
D. Schwartz	1973-1974
N. Stanton	1973-present

Research Associates

H. R. Barton	1973-1975
R. C. Kammerud	1973
A. Lesnik	1973-1977
R. Sidwell	1976-present

Graduate Students

S. Errede	1977-present
M. Gutzwiller	1977-present
J. Horowitz	Ph.D. 1973
P. Keller	1977-present
N. Lockyer	1977-present
E. Lulofs	MS 1976
H. Povolny	MS 1975
M. Shaevitz	Ph.D. 1975

Technical Staff

J. Fitch	1973-present
J. Heimaster	1973-present
C. J. Rush	1973-present
A. Danford (secretary)	1973-present

1973-1974

This period was marked by intensive activities in running, mounting and preparing of several experiments.

The Effective Mass Spectrometer for E-337 (ZGS), a high statistics study of ω production, was assembled, debugged and some data had been taken and analyzed. Construction of the equipment for the Fermilab np charge exchange experiment E-12 had been completed and partially tested there in the neutral beam. Data taking for two ZGS experiments with the polarized 6 GeV/c beam, one on Λ production, E-336, and the other on the polarization of protons in elastic pp scattering, E-364, using the ANL Effective Mass Spectrometer, had been completed. Preliminary results on the Λ polarization were reported to the XVII International Conference on High Energy Physics in London. Partial data analysis on the polarization of the elastically scattered protons was completed.

The design of the magnetostrictive spectrometer for E-347, the $\Sigma\beta$ experiment, was finalized and hardware development began. Design of the low momentum enriched K^- beam had been finished.

A new determination of the Λ lifetime from the data obtained in experiments E-38 and E-240 had been made.

1974-1975

Data taking for the Fermilab n-p charge exchange experiment E-12 had been completed and preliminary results reported.

Shortly after the discovery of Ψ/J particles the apparatus used in the np charge exchange had been modified for a search for narrow high mass resonances which could be produced with the neutron beam. A proposal for such a search was submitted, and accepted by Fermilab (E-336). The experiment had taken some data and preliminary results were reported.

ZGS experiment E-337 on ω production, completed data taking and preliminary results were obtained.

Another experiment to measure ρ - ω interference, with high statistics using the same spectrometer was proposed and accepted (E-380). A short preliminary run had been analyzed.

A search for high mass states which decay into a charged and neutral particles was attempted and a preliminary analysis of the data sample indicated that such a search is feasible for masses up to 1.5 GeV.

Final analysis was completed on the experiments on Λ production with polarized 6 GeV/c protons and on the measurement of the polarization of elastically scattered protons.

The construction of the magnetic spectrometer for E-347, the $\Sigma\beta$ experiment, continued. A typical cell for novel large threshold Cherenkov counters to detect electrons was tested in a particle beam.

1975-1976

The Fermilab experiment E-366, a search for narrow resonances, completed data taking in Phase I. A narrow enhancement of five standard deviations was observed in the $K^-\pi^+$ mass spectrum at 2.3 GeV. Because of this effect the experiment received an additional 600 hours of beam time. The detection sensitivity of this spectrometer was improved and a Phase II of the search was completed. Data for this experiment was analyzed and published.

The experiment on ρ - ω interference, E-380 at the ZGS, completed data-taking and analysis began. Another experiment to search for A_1^0 , H, D, S, ... mesons, E-397, ZGS, had been proposed and approved. The data-taking for this experiment had been completed and some results were submitted to the forthcoming XVIII International Conference on High Energy Physics. Analysis of the Fermilab np charge exchange experiment was completed and results published.

The spectrometer for the experiment on the polarized $\Sigma\beta$ decays had been partially assembled, and the beam survey run took place in October. Tests of the detector assembly, the so-called "engineering" run in April, demonstrated the feasibility of this experiment.

N. W. Reay spent the Autumn and Winter Quarters working at Fermilab on the Energy Doubler/Saver project. K. Reibel spent his assigned research leave June 1975-December 1976, at CERN working on ISR experiment R209 "Measurement of High Mass Muon Pairs and Associated Hadrons."

1976-1977

During this period most of our efforts were concentrated at the ZGS. Two experiments with the Charged and Neutral Spectrometer were proposed to the ZGS Program Committee and approved: "Study of Neutral Mesons Decaying into $\pi^+\pi^-3\gamma$ and $\pi^+\pi^-4\gamma$ (E-420 ZGS) and "Study of Mesons in $\omega\pi$, $\omega\pi^+\pi^-$ and $(4\pi)^-$ Channels (E-428 ZGS).

Data analysis from experiments performed in the past with the Charged and Neutral Spectrometer continued.

Assembly of the $\Sigma\beta$ (E-347 ZGS) experiment was finished in December 1976, and the data taking run began in January 1977.

At the end of July, the ZGS 12 GeV/c unpolarized conventional operation was terminated. Both of our spectrometers were running during the last phases of the conventional ZGS operation, and an all out effort was made to utilize maximum available time for data taking.

A new proposal at Fermilab was generated and approved (E-531). This experiment will study the lifetimes of charmed particles produced by neutrino using emulsions tagged by a magnetic spectrometer. This effort is an international collaboration of physicists from Canadian universities (McGill, Universities of Toronto and Ottawa) and Japanese universities (Nagoya, Yokohama, Kobe, Aichi,

Osaka and the Institute of Osaka Prefecture). North American collaborators are providing an emulsion developing laboratory and the particle tagging spectrometer; the Japanese are contributing the emulsion and the bulk of the emulsion expertise.

In the fall, T. Y. Ling from the University of Pennsylvania joined our group as an Assistant Professor. He participated in the Fermilab-Harvard-Pennsylvania-Rutgers-Wisconsin neutrino experiments and continued with that effort. This collaboration submitted for action to the Fermilab program committee: "A Proposal to Assemble a High Resolution-Electron Sensitive-Energy Flow Calorimeter in the Neuland Spectrometer."

R. Sidwell from Michigan State University came to OSU as a Senior Research Associate to work on the tagged emulsion experiment (E-531 Fermilab).

Recently three graduate students who are Ph.D. candidates joined our group: M. Gutzwiller, S. Errede and N. Lockyer.

K. Reibel spent the summer at CERN continuing his collaboration with ISR experiment R209 studying production of high mass muon pairs and associated hadrons.

PUBLICATIONS AND REPORTS, EXPERIMENTAL

1973-1977

Publications

Application of the ALICE Flying Spot Digitizing System to Oscilloscope and Spark Chamber Data, D. Hodges, J. Lindquist, B. Nelson, E. C. Swallow, and D. M. Schwartz, Nucl. Inst. and Meth. 108, 551 (1973).

Search for Structure in $\pi^-p \rightarrow \Lambda K^0$ at EK Threshold, B. Nelson, T. M. Knasel, J. Lindquist, R. L. Sumner, E. C. Swallow, R. Winston, D. M. Wolfe, P. R. Phillips, K. Reibel, D. M. Schwartz, A. J. Stevens, T. A. Romanowski, and J. M. Watson, PRL 31, 901 (1973).

What Can We Measure in $\rho \omega$ Interference Experiments? , A Rabl and N. W. Reay, Phys. Lett. 47B, 29 (1973).

Experimental Study of the Reactions $\pi^-p \rightarrow \Lambda K^0$ at Beam Momenta Between 930 and 1130 MeV/c, T. M. Knasel, J. Lindquist, B. Nelson, R. L. Sumner, E. C. Swallow, R. Winston, D. M. Wolfe, P. R. Phillips, K. Reibel, D. M. Schwartz, A. J. Stevens, T. A. Romanowski, and J. M. Watson, Phys. Rev. D, 11, 1 (1975).

Measurement of the Polarization Parameter in Small Angle Proton-Proton Elastic Scattering at 6 GeV/c, D. R. Rust, R. R. Crittenden, R. M. Heinz, H. A. Neal, I. Ambats, D. S. Ayres, R. Diebold, R. J. Jost, S. L. Kramer, W. T. Meyer, A. J. Pawlicki, C. E. W. Ward, A. B. Wicklund, A. Lesnik, D. M. Schwartz, and E. C. Swallow, Phys. Lett. 58B, 114 (1975).

Observation of a Difference Between Polarization and Analyzing Power in Λ^0 Production with 6 GeV/c Polarized Protons, A. Lesnik, D. M. Schwartz, I. Ambats, E. Hayes, W. T. Meyer, C. E. W. Ward, T. M. Knasel, E. C. Swallow, R. Winston, and T. A. Romanowski, PRL 35, 770 (1975).

Differential Cross Section for $\pi^-p \rightarrow \eta^0 n$ at 6.0 GeV/c, M. H. Shaevitz, M. A. Abolins, J. A. Dankowych, K. W. Edwards, G. J. Luste, G. Luxton, J. F. Martin, J. D. Prentice, N. W. Reay, K. Reibel, R. D. Sidwell, and N. R. Stanton, PRL 36, 1 (1976).

High Statistics Study of ω^0 Production, M. H. Shaevitz, M. A. Abolins, J. A. Dankowych, K. W. Edwards, G. J. Luste, G. Luxton, J. F. Martin, J. D. Prentice, N. W. Reay, K. Reibel, R. D. Sidwell, and N. R. Stanton, PRL 36, 8 (1976).

Search for Narrow Two-Body Enhancements at Fermilab, M. A. Abolins, D. Cardimona, J. A. J. Matthews, R. A. Sidwell, H. R. Barton, Jr., N. W. Reay, K. Reibel, N. Stanton, K. W. Edwards, G. Luxton. PRL 37, 417 (1976).

Measurement of the Angular Correlation Parameters in the β Decay of Polarized Λ Hyperons, J. Lindquist, E. C. Swallow, R. L. Sumner, J. M. Watson, R. Winston, D. M. Wolfe, P. R. Phillips, K. Reibel, D. M. Schwartz, A. J. Stevens and T. A. Romanowski, - J. of Phys. G: Nucl. Phys., 2, L211, (1976).

n-p Charge Exchange Scattering from 60 to 300 GeV/c, H. R. Barton, Jr., N. W. Reay, K. Reibel, M. Shaevitz, N. R. Stanton, M. A. Abolins, P. Brindza, J. A. J. Matthews, R. Sidwell, K. W. Edwards, G. Luxton, and P. Kitching, PRL 37, 1656, (1976).

Some Features of n-p Charge-Exchange Scattering between 60 and 300 GeV/c, H. R. Barton, Jr., N. W. Reay, K. Reibel, M. Schwartz, N. R. Stanton, M. A. Abolins, P. Brindza, J. A. J. Matthews, R. Sidwell, K. W. Edwards, G. Luxton, and P. Kitching, PRL 37, 1659, (1976).

A Novel Large-Acceptance Threshold Gas Cerenkov Counter - I. Ambats, E. R. Hayes, C. W. Ward, W. E. Keig, D. A. Park, E. C. Swallow, R. Winston, and T. A. Romanowski. Nuclear Instruments and Methods, 138, 61-65, (1976).

Measurement of the angular correlation parameters in the β decay of polarized Λ hyperons - J. Lindquist, E. C. Swallow, R. L. Sumner, J. M. Watson, R. Winston, D. M. Wolfe, K. Reibel, D. M. Schwartz, A. J. Stevens, and T. A. Romanowski - Phys. Rev. D16, 2104 (1977).

Observation of Asymmetry in Inclusive Proton Production by 6-GeV/c Polarized Protons, D. S. Ayres, I. Ambats, R. Diebold, R. J. Jost, S. L. Kramer, W. T. Meyer, A. J. Pawlicki, C. E. W. Ward, A. B. Wicklund, R. R. Crittenden, H. A. Neal, and D. R. Rust, A. Lesnik and D. M. Schwartz, E. C. Swallow - Phys. Rev. D15, 1826, (1977).

Reports and Proposals for Experiments

Inclusive Production of Λ^0 's Using a Polarized Proton Beam, I. Ambats, E. Hayes, W. T. Meyer, C. E. W. Ward, Argonne National Laboratory; T. M. Knasel, E. C. Swallow, R. Winston, University of Chicago; A. Lesnik, D. M. Schwartz, Argonne National Laboratory; T. A. Romanowski, Argonne National Laboratory and The Ohio State University, submitted to the XVIIth International Conference on High Energy Physics, July, 1974, Imperial College, London.

A High Statistics Measurement of ρ - ω Interference in $\pi N \rightarrow \pi^+ \pi^- \pi^0$, H. R. Barton, Jr., N. W. Reay, K. Reibel, M. Shaevitz, N. R. Stanton, The Ohio State University; M. A. Abolins, J. A. J. Matthews, Michigan State University; G. Luxton, Carleton University; Proposal to ZGS. (1974).

Study of Heavy, Narrow Mesons Using a Mass-Focusing Spectrometer, H. T. Barton, Jr., N. W. Reay, K. Reibel, M. Shaevitz, N. R. Stanton, The Ohio State University; M. A. Abolins, P. Brindza, J. A. J. Matthews, R. A. Sidwell, Michigan State University; K. W. Edwards, G. Luxton, Carleton University; I. Ambats, C. E. W. Ward, Argonne National Laboratory, Fermilab Experimental Proposal (1974).

Measurement of Spin Rotation Parameters in Λ^0 Production at 12 GeV/c Using the Polarized Proton Beam and the Effective Mass Spectrometer, I. Ambats, E. Hayes, C. E. W. Ward, Argonne National Laboratory; W. Keig, D. Park, E. C. Swallow, R. Winston, University of Chicago; A. Lesnik, The Ohio State University; T. A. Romanowski, Argonne National Laboratory and The Ohio State University, Proposal to ZGS (1974).

A Novel Large-Acceptance Threshold Gas Cherenkov Counter, I. Ambats, E. R. Hayes, C. E. W. Ward, Argonne National Laboratory; W. E. Keig, D. A. Park, E. C. Swallow, R. Winston, University of Chicago; and T. A. Romanowski, Argonne National Laboratory and The Ohio State University (1977).

Measurement of the Angular Correlation Parameters in the β Decay of Polarized Λ Hyperons, K. Reibel, D. M. Schwartz and A. J. Stevens, The Ohio State University, and T. A. Romanowski, Argonne National Laboratory and The Ohio State University; J. Lindquist, E. C. Swallow, R. L. Sumner, J. M. Watson, R. Winston, and D. M. Wolfe, Enrico Fermi Institute, University of Chicago, P. R. Phillips, Washington University, St. Louis. Submitted to Topical Conference on Weak Interactions, University of Sussex, 29 June - 1 July 1976. (COO-1545-167).

Request for an Extension of E-366 - M. A. Abolins, J. A. J. Matthews, R. A. Sidwell, Michigan State University; H. R. Barton, Jr., N. W. Reay, N. Stanton, The Ohio State University; K. W. Edwards, Carleton University. (1975)

- Neutron-Proton Charge Exchange Scattering at Fermilab - H. R. Barton, Jr., N. W. Reay, K. Reibel, M. Shaevitz, N. Stanton, Ohio State University; M. A. Abolins, P. Brindza, J. A. J. Matthews, R. Sidwell, Michigan State University; K. W. Edwards, G. Luxton, Carleton University - Submitted to the XVIIIth International Conference on High Energy Physics, Tbilisi, 15-21 July 1976. (COO-1545-189).
- Search for Narrow Two-Body Enhancements at Fermilab - M. A. Abolins, D. Cardimona, J. A. J. Matthews, R. A. Sidwell, Michigan State University; H. R. Barton, Jr., N. W. Reay, K. Reibel, N. Stanton, Ohio State University; K. W. Edwards, G. Luxton, Carleton University - Submitted to the XVIIIth International Conference on High Energy Physics, Tbilisi, 15-21 July 1976. (COO-1545-190).
- A Search for Narrow, High Mass, Two-Body Resonances at Fermilab Energies - M. A. Abolins, D. Cardimona, J. A. J. Matthews, R. A. Sidwell, Michigan State University; H. R. Barton, Jr., N. W. Reay, K. Reibel, N. Stanton, Ohio State University; K. W. Edwards, G. Luxton, Carleton University - Published in the Proceedings of the 1975 Divisional Meeting of Particles and Fields at Seattle in August, p. 162.
- Neutron-Proton Charge-Exchange Scatterings, 60 - 300 GeV/c - H. R. Barton, Jr., N. W. Reay, K. Reibel, M. H. Shaevitz, N. R. Stanton, Ohio State University; M. A. Abolins, P. Brindza, B. Dodge, J. A. J. Matthews, R. A. Sidwell, Michigan State University; K. W. Edwards, G. Luxton, Carleton University; P. Kitching, University of Alberta - Published in the Proceedings of the 1975 Divisional Meeting of Particles and Fields at Seattle in August, p. 424.
- A High-Statistics Search for A^0 and H^0 in $\pi^- p \rightarrow \pi^+ \pi^- \pi^0$ at 8.4 GeV/c - K. W. Edwards, D. Legacey, Carleton University; P. Brockman, J. Gandsman, P. M. Patel, C. Zanfino, McGill University; N. R. Stanton, Ohio State University; J. A. Dankowych, J. F. Martin, J. D. Prentice, University of Toronto - Submitted to the XVIIIth International Conference on High Energy Physics, Tbilisi, 15-21 July 1976, (COO-1545-191).
- Production of η' , D and E Mesons in $\pi^- p \rightarrow \pi^+ \pi^- n$ at 8.4 GeV/c - K. W. Edwards, D. Legacey, Carleton University; P. Brockman, J. Gandsman, P. M. Patel, C. Zanfino, McGill University; N. R. Stanton, Ohio State University; J. A. Dankowych, J. F. Martin, J. D. Prentice, University of Toronto - Submitted to the XVIIIth International Conference on High Energy Physics, Tbilisi, 15-21 July 1976, (COO-1545-192).
- Comparison of the Differential Cross Sections for $\pi^- p \rightarrow \eta' n$ and $\pi^- p \rightarrow \eta n$ at 8.4 GeV/c - K. W. Edwards, D. Legacey, Carleton University; P. Brockman, J. Gandsman, P. M. Patel, C. Zanfino, McGill University; N. R. Stanton, Ohio State University; J. A. Dankowych, J. F. Martin, J. D. Prentice, University of Toronto - Submitted to the XVIIIth International Conference on High Energy Physics, Tbilisi, 15-21 July, 1976 (COO-1545-193).

- Search for Neutral Mesons Decaying into $\pi^+\pi^-3\gamma$ and $\pi^+\pi^-4\gamma$ - K. W. Edwards, D. Legacey, Carleton University; P. Brockman, J. Gandsman, P. M. Patel, C. Zanfino, McGill University; N. R. Stanton, Ohio State University; J. A. Danowych, J. F. Martin, J. D. Prentice, University of Toronto - Submitted to the XVIIIth International Conference on High Energy Physics, Tbilisi, 15-21 July, 1976, (COO-1545-194).
- Observation of Asymmetry in Inclusive Proton Production by 6-GeV/c Polarized Protons. - D. S. Ayres, I. Ambats, R. Diebold, R. J. Jost, S. L. Kramer, W. T. Meyer, A. J. Pawlicki, C. E. W. Ward, R. R. Crittenden, H. A. Neal, D. R. Rust, A. Lesnik, D. M. Schwartz and E. C. Swallow - Submitted for publication. (COO-1545-204). (1976)
- Study of Neutral Mesons Decaying Into $\pi^+\pi^-3\gamma$ and $\pi^+\pi^-4\gamma$, K. W. Edwards, D. Legacey, P. Brockman, J. Gandsman, P. M. Patel, N. R. Stanton, J. A. Dankowych, A. J. Pawlicki, J. D. Prentice, T. S. Yoon, W. R. Frisken - Proposal to ZGS. (COO-1545-186).
- A Proposal to Fermilab to Study Neutrino-Induced Di-Lepton Events Using a Hybrid Emulsion Electronic Detector - Cornell-Fermilab-Kobe-Krakow-Lund-Nagoya-Ohio State-Osaka City-Ottawa-Toronto-Washington-York Collaboration. (1976)

SUMMARY OF THE ACTIVITIES OF THE THEORETICAL HIGH ENERGY PHYSICS GROUP
AT THE OHIO STATE UNIVERSITY FOR THE PERIOD OF 1973 - 1977

Introduction

During the past four years and since its inception, the program has enjoyed continued moral and financial support of the AEC, ERDA, and now DOE, and enthusiastic support and encouragement by the Department of Physics.

Since 1973, the personnel of the contract have consisted of four faculty members of the Department of Physics, all on 50% time during the nine months and full time during the summer, and two research associates, both on full time. Recently a research associateship position has been upgraded into a senior research associate position. In addition the group has enjoyed collaboration with colleagues on The Ohio State University Regional Campus. A list of personnel engaged in our research in the past four years is given below:

Faculty

K. Tanaka	1973 - present
W. W. Wada	1973 - present
W. F. Palmer	1973 - present
S. S. Pinsky	1973 - present

Research Associates

A. Rabl	1972 - 1974
M. Vaughn	1972 - 1973
J. Katz	1973
M. Arik	1974
K. Geer	1974 - 1975

G. B. Mainland	1974 - 1975
J. Hietarinata	1975 - 1977
E. Takasugi	1975 - 1977
T. Hagiwara	1976 - 1977
S. Nandi	1978 - present

Senior Research Associate

P. H. Frampton	1977 - present
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Regional Campus Staff

G. Aubrecht	1975 - present
B. Mainland	1975 - present
D. Scott	1973 - present

Advanced Degrees Achieved

J. Mackey	Ph.D. 1971
E. Adelson	Ph.D. 1974
V. Rabl	Ph.D. 1974
E. Powell	M.S. 1974
W. Armbrust	Ph.D. 1975
J. Bolzan	Ph.D. 1976

In the following each faculty member of the theory group of the contract briefly describes the nature and the scope of his investigations. Research Associates and graduate students who were in residence during the past five years have collaborated with the faculty and made many invaluable contributions and added enthusiasm to our research.

William F. Palmer

Upon the emergence of unified weak and electromagnetic theories, questions of interest connected with my previous work on chiral symmetries were studied including the incorporation of PCAC¹ in models of unified weak and EM symmetry, and the origin of the Cabibbo rotation^{2,3,4} through spontaneous breaking mechanisms.⁵ This work related the Cabibbo angle to chiral and SU(3) breaking parameters, in the context of several specific models.

An effort in the area of unified gauge symmetries was the study of theories in which chiral and gauge symmetry are realized (in local dense domains of nuclear matter) manifestly,⁷ that is with weak and electromagnetic interactions of the same (local) strength. Implications for parity violations in heavy ion scattering, as well as possible astrophysical consequences were speculated.

The Melosh transform was exhaustively studied in the equal time canonical formulation with respect to Fock space properties.⁶ Explicit distributions of "Current" quarks in terms of "constituent" quarks were calculated, and the difficulty of interpreting these as physical parton distributions was established, in the simple free quark model framework.

Additionally, deep inelastic data⁸ were studied with W. Wada (see subsequent section) and work was done on Zweig Rule and the new particles, and then on Instantons and QCD⁹.

Publications

1. "Model for Lepton, Pion, and Nucleon Interaction," Phys. Rev. D 6, 1190 (1972).
2. "Lepton Hadron Symmetry Breaking and the Cabibbo Rotation," Phys. Rev. D 6, 2898 (1972).
3. "Cabibbo Angle and Rotation Projection," Phys. Rev. D 8, 1156 (1973).

4. "Symmetry Breaking in O(3) Gauge Theories with Three Triplet Models of Hadrons," Phys. Rev. D 8, 504 (1973).
5. "Chiral Symmetry Limit in the SU(3) σ -Model with Bilinear Breaking," Phys. Rev. D 8, 2532 (1973) (with D. McKay and R. Sarraga).
6. "Canonical Transforms between "Current" and "Constituent" Quarks," Phys. Rev. D 10, 2554 (1974) (with V. Rabl).
7. "Recovery from Spontaneous Breakdown of Chiral and Gauge Symmetry in Dense Domains of Hadronic Matter," Phys. Rev. D 11, 2932 (1975) (with J. Bolzan).
8. "Deep Inelastic Data as a Test of Hadron Symmetries," Phys. Rev. D 12, (1974) (with W. Wada).
9. See joint section with S. Pinsky.

William F. Palmer and Stephen S. Pinsky

I. New High Mass Narrow Resonances

The electromagnetic production and decay of the $\Psi(3095)$ meson was shown to be consistent with the vector-meson-dominance model and the assignment of the Ψ to a SU(4) $J^P=1^-$ multiplet with the width of ρ ω ϕ and ψ in the ratio 9:2:1:8.¹

Continuing with the study of the Ψ , it was found that both the production and decay of the Ψ could be accounted for within the context of the breaking of Zweig's Rule. The breaking of Zweig's Rule was mediated by an "0" meson which was taken to be a particle on the $J^P = 1^-$ daughter of the Pomeron.² The model was extended to the t-channel to account for the breaking of exchange degeneracy, and discussed within the context of the topological expansion of Veneziano.³ The model was shown to be similar to that of Chew and Rosenzweig except that it had a distinct Pomeron. The study of the Ψ decay was extended to the $\Psi' \rightarrow \Psi \pi \pi$ channel,⁴ as well as many others including studies of double Zweig forbidden decay of the Ψ , and photonic decay.⁵ A detailed study of the $J^P = 0^+$ multiplet was made in order to understand the 0^+ classification.⁵

A variety of possible modifications of the 0-meson schemes were considered including the replacement of the pole by a cut as well as changing the group theoretical structure.⁶ The $J^P = 0^-$ multiplet was studied in detail and the large $\Psi' \rightarrow \Psi \eta$ rate was explained, as well as several related photonic rates.⁷ Additionally, the general question of mixing models⁸ was investigated, especially with regard to level shifts, asymptotic planarity notions, and charm mass.⁹

Publications

1. "Electromagnetic Production and Decay of $\Psi(3105)$," Phys. Rev. D 11, 2480 (1975) (with K. Geer, G. B. Mainland).
2. "Duality Violation and the Production and Decay of New and Old Mesons," Phys. Rev. Lett. 35, 419 (1975) (with J. Bolzan and K. Geer).
3. "A Dynamical Realization of Breaking of Exchange Degeneracy and Violation of Zweig's Rule," Phys. Rev. D 13, 1470 (1976) (with D. R. Snider).
4. "Zweig's Rule Violation, SU(3) Character of the Decay of the New Particles and Pole Dominance Picture," Phys. Lett. 59B, 351 (1975) (with J. Bolzan and K. Geer).
5. " $\Gamma(\Psi \rightarrow \phi \pi^+ \pi^-) / \Gamma(\Psi \rightarrow \omega \pi^+ \pi^-)$ and the OZI Rule," Phys. Rev. D 14, 1916 (1976).
6. "Forbidden Coupling and Inhibited Decay: A Study of Disconnection," Phys. Rev. D 14, 3202 (1976).
7. "Pseudoscalar Mixing Effects on Hadronic and Photonic Decays of the New Mesons," Phys. Rev. D 14, 1920 (1976).
8. "Three Simple Classes of Mixing Models," Phys. Rev. D 15, 3460 (1977) (with J. F. Bolzan).
9. "Level Shift and Charm Mass: A Test of Asymptotic Planarity," Phys. Rev. D 15, 889 (1977) (with C.-C. Shi).

II. Instantons and QCD

The effect of instantons in QCD was studied in connection with mass generation, chiral symmetry breaking, and dilute gas approximations.

Quark and gluon correlation functions were calculated in a single instanton and multi-instanton background,^{1,2,3,4} obtaining the momentum dependence and explicit tensorial form of the U(1) breakdown found by 't Hooft. Green's functions were consistently interpreted as expansions in powers μ/p when μ_0 is the invariant renormalization mass and p the external momenta. In this U(1) broken but chiral SU(N) symmetric phase, valid at large p , mass is generated only when there is a single flavor.

It was then questioned whether and how these results, perturbative about single instantons, are modified when more general configurations are taken into account.^{5,6,7} Failure of mass generation from gauge configurations with net integer >0 topological charge was demonstrated⁵ independent of perturbation theory. How this is reflected in the dilute gas approximation was then studied⁶ and it was concluded that if mass is generated it comes from the topologically neutral sector of equal numbers of instantons and anti-instantons.⁶ The number of zero-fermion modes was found to be consistent with the results in previous work⁵ after a number of zero-modes were lifted by taking into account instanton-anti-instanton interactions.⁶

Finally, these instanton-anti-instanton interactions of an improved dilute gas approximation were used⁷ to calculate power law corrections to the current-current correlation function of e^+e^- annihilation. Mass, however, is not generated by these interactions; the power law corrections survive in the massless theory.

Publications

1. "Quantum Effects of Pseudoparticle Size," Phys. Rev. Lett. 38, 103 (1977) (with J. Hietarinta).
2. "Chiral Properties of the Fermionic Determinant in QCD," Phys. Rev. D 16, 3008 (1977) (with J. Hietarinta).

3. "Virtual Quark-Quark Scattering in the Pseudo Particle Background," Phys. Lett. 71B, 415 (1977) (with J. Hietarinta).
4. "Perturbation Theory about Instantons," Nucl. Phys. B135, 486 (1978) (with P. Carruthers and F. Zachariasen).
5. "Do Fermion-Pseudoparticle Interactions Generate Quark Masses?," Phys. Rev. Lett. 40, 421 (1978) (with J. Hietarinta).
6. "Mass Generation and Chiral Symmetry Breaking by Pseudo Particles," submitted for publication.
7. "The Effect of Instanton-Anti-Instanton Interactions on Current Correlation Functions in Massless QCD," submitted for publication.

Stephen S. Pinsky

My achievements in the past five years at The Ohio State University naturally divide and can be summarized in two sections, the first on inclusive reaction and the multiperipheral models, and on Reggion calculus, and the second on the new narrow high mass resonance, and Instanton and QCD which was done primarily in collaboration with W. F. Palmer (see joint sections with W. F. Palmer).

Inclusive Reaction and the Multiperipheral Model--It was proven that a large class of pionization Mueller Regge Models (MRM) are equivalent to the multiperipheral model (MPM). An orthogonal similarity transformation was found which allows one to transform either direction between equivalent MPM and MRM.^{1,4} A simple generalization of the MPM and the MRM was studied which had improved phenomenological capabilities by explicitly incorporating resonances, or clusters.³ Finally, a complete phenomenological analysis of all inclusive pion data in the central region was made.² Particular attention was paid to the constraints of charge conjugation and the approach to scaling. One consequence was the prediction that $\pi\pi$ correlations scale from above.

The constraints of charge conservation were derived and in particular a relation between the Pomeron-Pomeron coupling and the Pomeron-Rho coupling was derived and the phenomenological fits showed it to be well satisfied.

Reggion Field Theory - The implications were investigated of a Reggeon field with two exchange degenerate meson-like trajectories as input. A Pomeron and a lower-lying Reggeon were generated by spontaneous symmetry breaking, and the implications for s-channel unitarity were discussed.⁵ Continuing with the study of Reggeon field, the structure of a theory with higher order interaction was investigated using renormalization-group methods. The infrared fixed point where only the ϕ^3 interaction was shown to be stable with respect to all higher order interactions within the context of perturbation theory both in two dimensions and in the ϵ expansion.⁶ The domain structure of the theory was studied in detail, numerically, and the implications for the transition from the fixed point behavior to the perturbation behavior were considered.⁷ Finally, some of the possible phenomenological implications of a fundamental four-Reggeon coupling to two partial correlations were considered.⁸

Publications

1. "Equivalence between the Nueller-Regge Model and the Multiperipheral Model," Phys. Lett. 47B, 505 (1973) (with D. R. Snider and G. H. Thomas).
2. "Can Mueller-Regge Models Describe Inclusive Data Consistently?," Phys. Rev. D 9, 1350 (1974) (with G. H. Thomas).
3. "Inclusion of Resonances in the Multiperipheral Model," Phys. Rev. D 10, 261 (1974) (with D. R. Snider and G. H. Thomas).
4. "Equivalent Exclusive and Inclusive Multiperipheral Descriptions," Phys. Rev. D 10, 2237 (1974) (with G. H. Thomas).
5. "Is the Pomeron an Goldstone Boson?," Phys. Rev. D 10, 4177 (1974) (with V. Rabl).

6. "Infrared Behavior of the Reggeon Field Theory for the Pomeron," Phys. Rev. D 12, 1820 (1975) (with W. A. Bardeen, J. Dash, and V. Rabi).
7. "Domain Structure of a Reggeon Field Theory, Phys. Rev. D 12, 3996 (1975) (with K. Geer).
8. "Four-Reggeon Coupling in Two-Particle Inclusive Data, COO-1545-151 (unpublished).

Katsumi Tanaka

An analogy between a triplet of quarks and a triplet of leptons was discussed in the framework of a model of weak and electromagnetic interactions possessing local $SU(2)_L \times U(1)$ symmetry. After the symmetry was broken spontaneously by use of the Higgs-Kibble mechanism, two of the quark masses are non-zero. The relations of the quark masses to the chiral $SU(3) \times SU(3)$ model of strong interactions as well as the Cabibbo angle was discussed.¹ The neutrino charge radius was calculated in a modified $SO(3)$ model.²

Topological cross sections and correlation functions in high energy pp and πp collisions above 10 GeV/c was fitted with a two component model in which the dominant component possesses Koba, Nielsen, and Olesen scaling and the other component is diffractive.³ The multiplicity data on pp collisions above 100 GeV/c was interpreted in terms of a language familiar in statistical mechanics.⁴

A nonlinear Born-Infeld type of Lagrangian which yields the Maxwell and Higgs Lagrangian in a weak limit and the dual string model in a strong limit,⁵ and a spontaneously broken Abelian-gauge invariant supersymmetry model were studied.⁶ The interplay between symmetry breaking, Goldstone particles, and mass breaking⁶ as well as fermion number conservation was investigated in supersymmetric models.⁷ The model of

Ref.6 was generalized to a supersymmetric SU(2) X U(1) gauge model for the electromagnetic weak and neutral weak interaction of the electron. It conserves lepton number without requiring the bosons to carry lepton number and is sufficiently simple so that low-energy theorems could be checked readily.⁸

Bounds were obtained on the ratio of ν and $\bar{\nu}$ charged current cross sections and the ratio of ν and $\bar{\nu}$ neutral current cross sections in the standard 4 quark parton model.⁹ These calculations were performed using the conventional V-A theory and also in a model which included a V+A term. Our results rule out the model with a V+A term. Inclusive neutrino interactions were then studied in a six quark model.¹⁰

Work on exact classical non-linear solutions was continued; common features of solvable models were identified.¹¹ Solutions of euclidean theories with both instantons and anti-instantons were found.¹²

Publications

1. "Weak and Electromagnetic Interaction Symmetry," K. Tanaka and R. Torgerson, Nucl. Phys. B45, 637 (1972).
2. "Neutrino Charge Radius in a Model of Weak and Electromagnetic Interactions," G. J. Aubrecht and K. Tanaka, Phys. Rev. D 10, 3522 (1974).
3. "Topological Cross Sections and Correlation Functions in High Energy pp and π p Collisions," D. M. Scott, K. Tanaka and R. Torgerson, Phys. Rev. D 8, 2240 (1973).
4. "Fluid Analog in High Energy pp Collisions," K. Tanaka and Y. Ueda, Nucl. Phys. B66, 505 (1973).
5. "Higgs Type Lagrangian and Dual Strings," M. Arik and K. Tanaka, Phys. Rev. D 11, 2803 (1975).
6. "Spontaneously Broken Abelian Gauge Invariant Supersymmetric Model," G. B. Mainland and K. Tanaka, Phys. Rev. D 12, 2394 (1975).
7. "Fermion Number Conservation in Supersymmetric Lagrangians," G. B. Mainland and K. Tanaka, Proceedings Fifth International Conference on Neutrino Science, Balaton, P.346, Hungary (1975).

8. "A Supersymmetric Gauge Model of the Electron and Its Neutrino," G. B. Mainland and K. Tanaka, Phys. Rev. D 13, 2318 (1976).
9. "Phenomenological Bounds in Inclusive Neutrino Interactions, G. J. Aubrecht, E. Takasugi and K. Tanaka, Phys. Rev. D 13, 1877 (1976).
10. "Inclusive Neutrino Interaction in a Six Quark Model," G. J. Aubrecht, E. Takasugi, and K. Tanaka, Phys. Rev. D 15, 1246 (1977).
11. "Common Feature of Non-Linear Solvable Models," G. B. Mainland, E. Takasugi, and K. Tanaka, Phys. Rev. D 15, 3007 (1977).
12. "Classical Solutions with Both Instantons and Anti-Instantons," G. B. Mainland, E. Takasugi, and K. Tanaka, Lettere al Nuovo Cimento 19 556 (1977).

Walter W. Wada

During the past five years, the direction of my research has shifted from the duality-based hadron physics in low-energy phenomenology¹⁻³ to lepton-hadron physics based on quark-parton model in high-energy e^+e^- annihilation⁴⁻⁹ and proton-proton collisions.¹⁰⁻¹¹ Special emphasis has been placed on theoretical analyses and predictions that are closely related to experimental observations.

In order to gain experience in Regge phenomenology, an attempt was made to deduce from meson-nucleon elastic polarization data the real part of the nonflip amplitude. The high-energy Compton scattering from the point of view of Pomeron and Regge exchange and the question of the saturation of the Cabibbo-Radicati sum rule deduced from current algebra were studied and compared with experimental observations.²

The question of the saturation of the Adler neutrino sum rule was investigated by relating, via the $p-A_2$ exchange degeneracy, the $C = -1, I = 1$ structure functions for the neutrino interactions to the $C = +1, I = 1$ structure function for the virtual Compton scattering.³ Introducing the SLAC result for the latter, the Adler sum rule is seen to be approximately satisfied.

Turning to the $C = 1, I = 0$ structure function for the neutrino interaction, it is shown to be related to $C = 1, I = 0$ Compton scattering structure function via vector-dominance model. A possible deviation in the region of small $x = Q^2/2Mv$ appears when $SU(4)$ symmetry rather than $SU(3)$ symmetry is considered for hadrons.⁴

In the more recent time, the inclusive pion spectra in e^+e^- annihilation has been studied in the parton fragmentation model with nonvanishing transverse momenta for the pions and with additional heavy partons beyond the conventional three light quarks. The well-known nonscaling phenomenon in the small x region of has been explained satisfactorily.⁵

A detailed calculation for $e^+e^- \rightarrow L^+L^-$, followed by $L^+ \rightarrow \mu^+ \ell_0 \nu_\mu$ and $L^- \rightarrow \mu^- \ell_0 \bar{\nu}_\mu$ where L^\pm are the heavy leptons (1.8 GeV) discovered at SPEAR, has been carried out. When compared with the preliminary experimental data, coupling that is predominantly vector in nature and nonvanishing ℓ_0 ($\bar{\ell}_0$) (heavy neutrino) mass appear to be preferred.⁶

Using a quark model of a broken $SU(8)$ symmetry, the production cross sections for $D\bar{D}$, $D\bar{D}^* + \bar{D}D^*$, and D^*D^* near thresholds were examined. The production is found to be dominated by $(0^-, 1^-)$ pairs, and D^*D^* production is seen to be much too small to reproduce the higher peak in the recoil-mass spectrum against $D^0(D^0)$ through reflection. In order to be reconciled with the experimental situation, assignment of 1^+ for $D^*(D^*)$ was speculated.⁷

After the discovery of $\gamma(9.5)$ in proton-nucleus collisions at Fermi lab, predictions on the leptonic decay width and integrated hadronic production cross sections in e^+e^- annihilation were made, assuming $\gamma(9.5)$ to be a bound state of heavy quark-antiquark pair ($b\bar{b}$). In this

calculation, the electric charge of b was left unspecified ($|e_Q| = \frac{1}{3}$ or $\frac{2}{3}$). These predictions have been confirmed at DESY (Ch. Berger et al. Phys. Lett. 76B, 243 (1978)), if $|e_Q| = \frac{1}{3}$ is assigned for the b quark. Also predicted was the photoproduction cross section for $\gamma(9.5)$, which appears within the possibility of experimental observation.⁸

The coherent production of η_c (Primakoff effect) has been studied by several authors. The difficulty is the observation of its decay $\eta_c \rightarrow \gamma\gamma$. Using the scheme in which $\eta_c \rightarrow B\bar{B}$ proceeds via broken symmetry (Bolzan, Palmer, and Pinsky), production cross section was calculated. The values of the cross section are such that experimental observation appears feasible.⁹

A very promising mechanism for the production of Higgs scalar in e^+e^- annihilation has been proposed by F. Wilczek (Phys. Rev. Lett. 39, 1304 (1977)). Specific predictions have been made as to the magnitudes of the cross section for $e^+e^- \rightarrow \text{vector meson} \rightarrow \text{Higgs} + \text{photon}$ when the vector state is $\gamma(9.5 \text{ GeV})$ and $T(\sim 20 - 30 \text{ GeV})$. Assuming that the Higgs mass is smaller than these vector meson masses, remarkable large rates have been obtained. This is expected to have a considerable experimental implication at the e^+e^- colliding beam facilities.¹⁰

Higgs boson production in energetic proton-protons collision has been studied by H. Georgi et al. (Phys. Rev. Lett. 40, 692 (1978)). A related calculation in which Higgs boson with large transverse momentum is produced off heavy quark-antiquark pair as bremsstrahlung has been carried out.¹¹

Publications

1. "The Meson-Baryon Elastic Polarization and the Real Part of the Non-flip Amplitude," Nuovo Cimento 17A, 355 (1973) (with C. B. Chiu).

2. "Asymptotic Behavior and Cabibbo-Radicati Sum Rule," Ann. of Phys. 78, 2, (1973) (with G. J. Aubrecht).
3. " -A Exchange Degeneracy and the Adler Sum Rule," Phys. Rev. D 8, 4217² (1973).
4. "Deep-Inelastic Data as a Test of Hadron Symmetries," Phys. Rev. D 12, 4217 (1975) (with W. F. Palmer).
5. "Parton Fragmentation Model for Inclusive Pion Spectra in Electron-Positron Annihilation," Phys. Rev. D 14, 1299 (1976) (with M. Suzuki).
6. " μ^{\pm} Production in e^+e^- Annihilation," Phys. Rev. D 14, 2955 (1976) (with G. J. Aubrecht and M. G. Ziegler).
7. "Production of Charmed Meson Pairs in Electron-Positron Annihilation," Phys. Rev. D 15, 759 (1977) (with M. Suzuki).
8. "Production of $\gamma(9.5)$ in e^+e^- Annihilations and Photoproduction," Phys. Rev. Lett. 39, 978 (1977) (with G. J. Aubrecht).
9. "Baryon-Antibaryon Pair Decay of η_c in Coherent Production," Phys. Lett. 72B, 377 (1978) (with G. J. Aubrecht, and M. G. Ziegler).
10. "Higgs Scalar in Heavy Vector-Meson Decays," Phys. Rev. D in press (with P. H. Frampton).
11. "Higgs Boson Production at Large Transverse Momentum in QCD, SLAC-PUB-2197, submitted to Phys. Rev. D (with Risto Raitio).

Paul Frampton

For the last four years, the results fall into two categories (1) Dual models (roughly items 1 through 20) and (2) Gauge theories (roughly items 21 through 31). Note that nearly all this work was done at Syracuse University (1973-75) and U.C.L.A. (1975-77). Only four items (27, 28, 30, 31) have been published during 1978 since arrival at The Ohio State University (Dec. 1977 through Oct. 1978).

(1) Dual Models

Application of dual diagrams to rapid scaling in inclusive reactions involving baryons were made.¹ A new type (symmetric group) of dual resonance model was proposed and its properties studied in detail.^{2,5,6,7,8,12,13,15,18} Reviews of dual models were given.^{4,10,19,20}

Expansion of dual models in the Regge slope was investigated.³

Spontaneous symmetry breaking and the Higgs mechanism in dual models were discussed.⁹ A dual model having two different Regge intercepts in the same channel was constructed.¹⁷

(2) Gauge Theories

Solitons were studied with respect to uniqueness²¹ and stability.²⁹ Instantons and vacuum decay were related.^{23,24,26} The Gribov gauge ambiguity was investigated.^{27,30,31}

Phenomenological Work

The symmetric-group dual model was applied to $\bar{N}N$ annihilation.¹¹ A critical remark concerning the Ψ/J particle was made.¹⁴ Mass corrections to the scaling variable of deep inelastic scattering were derived.²² A model for scaling violation was invented.²⁵ A model for Higgs scalar/photon decay of heavy vector mesons was made.²⁸

Publications

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2. "Symmetric Group and Meson Born Amplitudes," *Phys. Rev. D* 7, 3077 (1973).
3. "Regge Slope Expansion of Meson Born Amplitudes," *Phys. Rev. D* 8, 1879 (1973) (with K. C. Wali).
4. Recent Developments in Dual Models, In Laws of Hadronic Matter, edited by A. Zichichi (Academic Press, 1975), p.112.
5. "Possible Born Amplitude for Pions," *Nuovo Cimento Lett.* 8, 525 (1973).
6. "Symmetric Group Construction of a New Multiparticle Amplitude for Physical Pions," *Phys. Rev. D* 9, 487 (1974).
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8. "An Investigation of Four-Meson Symmetric-Group Dual Models," *Phys. Rev. D* 10, 1234 (1974) (with K. A. Geer).

9. "Spontaneous Symmetry Breaking and Regge Intercepts," Phys. Lett. 50B, 475 (1974) (with R. F. Cahalan).
10. Dual Resonance Models (W. A. Benjamin, 1974).
11. " $N\bar{N} \rightarrow 3\pi$ Amplitudes and the Symmetric-Group Dual Resonance Model," Phys. Rev. D 11, 1040 (1975) (with A. Nandi and T. Kalogeropoulos).
12. "Evidence for Critical Space-Time Dimensionality Equals Four in Symmetric Group Model," Phys. Rev. D 11, 953 (1975).
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14. "Consequences of Direct Ψ -Lepton Coupling," Nuovo Cimento Lett. 13, 293 (1975) (with V. Rabi).
15. "Meson Mass Formula from Duality," Phys. Rev. D 7, 2164 (1975).
16. "String Approaches to Hadron Structure," Phys. Rev. D 7, 538 (1975).
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21. "Uniqueness of S-Wave Non-Abelian Magnetic Monopole," Phys. Rev. D 14, 528 (1976).
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23. "Vacuum Instability and Higgs Scalar Mass," Phys. Rev. Lett. 37, 1378 (1976).
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25. "Model for Scaling Violation," Phys. Rev. D 16, 572 (1977) (with J. J. Sakurai).

26. Vacuum Bubble Instantons. In The Significance of Nonlinearity in the Natural Sciences, edited by B. Kursunoglu, A Perlmutter and L. F. Scott (Plenum Publishing Corporation, 1977), p.57.
27. "Yang-Mills Vacua in Landau Gauge," Phys. Lett. 76B, 455 (1978) (with T. Hagiwara, W. F. Palmer and S. S. Pinsky).
28. "Higgs Scalar in Heavy Vector Meson Decays," to appear in Phys. Rev. D (with W. W. Wada).
29. "Scale Invariance and Solitons," submitted to Nuovo Cimento Lett. (with L. Tyburski).
30. "Concerning Gribov Vacuum Copies in Non-Abelian Gauge Theory," submitted to Nucl. Phys. B. (with W. F. Palmer and S. S. Pinsky).
31. "Gauge Ambiguities, Zero Modes, and Classification of Field Size," submitted to Phys. Rev. Lett. (with T. Hagiwara).

S. Nandi

Following is a brief summary of Nandi's research activity during the last four years.

As a graduate student in the University of Chicago, he worked on $\pi^0 \rightarrow 2\gamma$ problem¹; and also on high P_T hadronic scattering.² His Ph.D. thesis has been on supersymmetric quantum field theories.^{3,4} As a research project he worked on neutrino phenomenology.⁵ In the University of Bonn (1976-78), his main activity has been on the phenomenology of electroproduction and neutrino scattering^{6,7,8} and on the inclusive hadron production at low P_T .^{9,10} Recently he has also been engaged in the study of coupling constant relations in renormalizable field theories.¹¹

Publications

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2. "Scaling and Regge Behavior in Hadron Scattering," Nuovo Cimento 25A, 395 (1975) (with P. G. O. Freund).

3. "Dynamical Approach to Supersymmetry," Nucl. Phys. B97, 178 (1975).
4. "SU(6) and Supersymmetry," Il Nuovo Cimento A31, 159 (1976).
5. "Neutrino Data, Right-Handed Currents and Number of Quark Flavours," Phys. Lett. 64B, 81 (1976).
6. "Multimuon Production in Deep Inelastic μ -Nucleous Scattering," Phys. Rev. D 15, 3247 (1977) (with H. R. Schneider).
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8. "Dileptons, Trileptons and the V-A Structure of the Charged Weak Currents," Univ. of Bonn Preprint BN-HE-77/9; April 1977 (with G. C. Branco, H. P. Niles and V. Rittenberg) (unpublished).
9. "Quark-Antiquark Annihilation and Small P_T Inclusive Spectra," Phys. Rev. D 17, 1336 (1978) (with H. R. Schneider and V. Rittenberg).
10. "Hadronic Production of J/ψ : Determining Gluon Distributions," Phys. Rev. D 18, 756 (1978) (with H. R. Schneider).
11. "Can Coupling Constants Be Related?," Univ. of Bonn preprint, BN-HE-78/11; submitted to Phys. Rev. D. (with W. C. Ng).

Regional Campus Collaborators

Gordon Aubrecht

Aubrecht's work in the last four years has been broadly focused on symmetry and its effects in nature. He has worked on current-algebra sum rules, ^{1,2} KNO scaling, ^{3,4} unified theories of the weak and electromagnetic interaction, ^{5,6,8,9,10,13} higher symmetries and the effects of the new particles, ^{7,11,14,16,17,18} and new particles in e^+e^- colliding beams. ^{12,15}

In Ref. 1 it was shown that the inclusion of higher resonances in the Cabibbo-Radicoti sum rule better satisfied the sum rule. In Ref. 2, a technique involving the slope of the $\bar{N}N$ amplitude in t , allowed a novel theoretical prediction of $\langle r_{\pi}^2 \rangle^{\frac{1}{2}} = 0.8F$. In Refs. 3 and 4 we investigated universal properties of the n -particle cross sections.

In Ref. 5, the ν charge radius was calculated in an $SO(3)$ model of weak and electromagnetic interactions with a regulator procedure, assuming the existence of heavy leptons. Within the context of unified models, most analyses assume charge symmetry of the νN structure functions. In Refs. 6 and 10, the experimental data was tested within the framework of different models using light cone algebra. The data rules out the Achiman model, which uses Han-Nambu quarks. Refs. 8, 9 and 13, and some more recent work deal with various analyses of the neutrino data. In Ref. 8, we attempted to use the data to determine the integrated sea contributions; while in Ref. 9 we tried to relate the $\mu^- \mu^+ / \mu^+ \mu^-$ ratio to the rates of baryon and meson decay into particles containing charmed quarks. In Ref. 13 we saw that nondiagonal $(\bar{c}b)$ neutral currents could be mixed with more conventional currents in $SU(2) \times U(1)$ models. More recent work has again focused on the sea contributions.

Another interest has manifested itself in the papers on symmetries and their applications. In Refs. 7, 17, and 18, the masses and decay rates of particles in $SU(N)$, $N = 4, 5$, and 6, were studied. Predictions of various decay rates as well as masses were given. In Ref. 11, the multiplicity of heavy particles (especially the D) were calculated as a function of energy while in Ref. 14, an Amati-Fubini-Stanghellini picture was used to obtain a closed system of equations for $SU(4)$ -meson-proton cross section ratios. We estimated the Ψ_p total cross section on the basis of the known ρp , $K^* p$, cross sections and obtained the approximately correct value of 1mb . In Ref. 16, the OZI-forbidden decays of η_c into $\gamma\gamma$ and baryon-antibaryon were examined for Primakoff

production of η_c from a heavy (lead) nucleus, and cross sections and momentum spectra were calculated.

In Ref. 12, we found that analytical calculations rather than numerical ones could be done in τ -production. This greatly simplifies the labor involved in the various calculations; we also showed that only the heavy lepton hypothesis was consistent with the data. In Ref. 15 we calculated the QCD predictions for $\Gamma(\gamma \rightarrow e^+e^-)$ and for photoproduction cross sections. QCD gave the number correctly, as subsequent experiment showed.

In more current work; SU(2) X U(1) models in di and trimuon production and the determination of sea contributions are being investigated. Other topics in e^+e^- colliding beams are being actively pursued. Also, higher-order contributions to Higgs boson production are being investigated.

Publications

1. "Asymptotic Behavior and the Cabibbo-Radicati Sum Rule," G. J. Aubrecht and W. W. Wada, Ann. Phys. 78, 376 (1973).
2. "Pion Charge Radius from Current Algebra Sum Rule and Short Range Correlation Model," G. J. Aubrecht and R. C. Hwa, Phys. Lett. 44B, 515 (1973).
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4. "Compendium of Data on $\pi^\pm p$ and $pp \rightarrow n$ Charged Particles $P_{LAB} > 4$ GeV/c," G. J. Aubrecht, preprint (review and not for publication), September, 1973.
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15. "Production of $\gamma(9.5)$ in e^+e^- Annihilation and Photoproduction," G. J. Aubrecht, and W. W. Wada, Phys. Rev. Lett. 39, 978 (1977).
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18. "SU(6) as an Internal Symmetry: Meson Mass Spectra and Decay Widths," G. J. Aubrecht and D. M. Scott, COO-1545-240.

Bruce Mainland

Since coming to Ohio State in October, 1974, I have worked in four major areas: (1) electromagnetic properties of the J/Ψ particle, (2) the application of supersymmetry to high-energy physics, (3) a search for classical solutions (both solitons and instantons), and (4) a study of

the relationship between the Cabibbo angle and CP violation within the framework of gauge models.

Shortly after the J/ψ particle was discovered, Geer, Palmer, Pinsky, and I pointed out that if the J/ψ particle was a $\bar{c}c$ bound state, its electromagnetic production and decay properties are consistent with the vector-meson-dominance model. Our viewpoint is now widely accepted.

Tanaka and I made a major effort to construct a realistic spontaneously broken supersymmetric gauge model of leptonic interactions for which the observed neutrinos were Goldstone neutrinos. We succeeded in constructing the simplest supersymmetric gauge model which incorporated the usual weak and electromagnetic interactions of the electron. Electron number was conserved in a natural way. Later it was shown that low energy data was inconsistent with the observed neutrinos being Goldstone neutrinos. We generalized the arguments and applied them to our supersymmetric model.

Tanaka, Takasugi and I showed that previously known exact solutions to models with vertex lines, magnetic monopoles, or instantons could be obtained naturally from the equations of motion if they were supplemented by the ansatz that the trace of the energy-momentum tensor over relevant co-ordinates was zero. We then generalized a known $SU(2)$ Yang-Mills instanton solution to $SO(4)$ which is the simplest generalization that includes both instantons and anti-instantons.

Most recently Tanaka, Hagiwara, Kitazoe and I have studied the relationship of the Cabibbo angle and CP violation within the framework of the gauge group $SU(2)_L \times SU(2)_R \times U(1)$ with six quarks. If the Lagrangian is invariant under specific discrete symmetries, the Cabibbo angle is

determined primarily in terms of quark masses but is fine-tuned by the phases of the vacuum expectation values of the Higgs scalars which are also responsible for spontaneous CP violation.

Publications

1. "Electromagnetic Production and Decay of $\Psi(3105)$," Phys. Rev. D 9, 2480 (1975) (with Kevin Geer, William F. Palmer, and Stephen S. Pinsky).
2. "Fermion Number Conservation in Supersymmetric Lagrangians," Proceedings of the Fifth International Conference on Neutrino Science, Balaton, Hungary (1975) (with K. Tanaka).
3. "Spontaneously Broken Abelian Gauge Invariant Supersymmetric Model," Phys. Rev. D 12, 2318 (1975) (with K. Tanaka).
4. "A Supersymmetric Gauge Model for the Electron and Its Neutrino," Phys. Rev. D 13, 2318 (1976) (with K. Tanaka).
5. "Low Energy Theorems in Supersymmetry," Phys. Rev. D 14, 1065 (1976) (with E. Takasugi, and K. Tanaka).
6. "Common Feature of Non-Linear Solvable Models," Phys. Rev. D 15, 3007 (1977) (with E. Takasugi, and K. Tanaka).
7. "Classical Solutions with Both Instantons," Nuovo Cimento Lett. 19, 556 (1977) (with E. Takasugi, and K. Tanaka).
8. "Cabibbo Current and CP Violation in a Six Quark Gauge Model," Phys. Lett. 76B, 602 (1978) (with T. Hagiwara, T. Kitazoe, and K. Tanaka).
9. "Vacuum Expectation Values of Higgs Scalars in a $SU(2)_L \times SU(2)_R \times U(1)$ Gauge Model," submitted for publication (with T. Kitazoe, and K. Tanaka).

David M. Scott

Cluster models of hadron production were studied from several points of view. Topological cross sections and correlation functions in high energy pp and π p collisions were fitted with a two component model in which the dominant component shows Koba, Nielsen, and Olesen scaling and the other component is diffractive. Statistical models of cluster production were also developed. The first ² involved only neutral clusters

while the second³ had both charged and neutral clusters. The latter also contained a constraint on the magnitude of the charge transferred between clusters--the concept of limited charge exchange.

The extension of unitary symmetry to higher dimensions has been investigated. Using a full internal SU(6) symmetry, the spectroscopy of mesons⁴ and their two-body hadronic and photonic decays have been predicted.

Publications and Reports

1. "Topological Cross Sections and Correlation Functions in High Energy pp and πp Collisions," D. M. Scott, K. Tanaka, and R. Torgerson, Phys. Rev. D8, 2240 (1973).
2. "Multiparticle Production through Isoscalar Clusters," W. T. Arbrust, and D. M. Scott, Unpublished, (Report No. COO-1545-154).
3. "Cluster Model Satisfying Limited Charge Exchange," W. T. Arbrust and D. M. Scott, Phys. Rev. D14, 140 (1976).
4. "Vector Meson Mass Spectrum from Broken SU(6)," G. J. Aubrecht II and D. M. Scott, Unpublished (Report No. COO-1545-225).
5. "SU(6) As An Internal Symmetry," G. J. Aubrecht II and D. M. Scott, in preparation, (Report No. COO-1545-240).