

PREFACE

This volume contains contributions presented during the Workshop “Theory of Hadrons and Light-Front QCD”. One objective of the workshop was to review a new computational strategy for solving light-front QCD, a strategy which starts with a constituent quark model that can be solved using the weak-coupling methods of QED. The main objective of the workshop was to facilitate discussions on the entire spectrum of computational strategies being developed to solve QCD and to review recent work on light-front dynamics of particles and fields, providing an opportunity for experts and young researchers from the West and East to join in the discussion.

The program evolved flexibly during the Workshop according to the wishes of participants and the resulting schedule is included in this volume. We have started from overviews of major topics such as confinement, vacuum structure and chiral symmetry breaking and then moved on to the constituent quark picture of hadrons and the parton model. Light-front dynamics provides an opportunity to link these elements in a unified treatment of QCD thanks to its kinematical boost invariance. The constituent quark picture of a hadron at rest and the parton model picture of the hadron that moves near the speed of light, are connected by a kinematical transformation in light-front QCD. However, divergences and the corresponding cutoffs spoil the symmetry. The key to understanding the small longitudinal momentum cutoff is renormalization theory for the light-front Hamiltonian of QCD. So, we have discussed new renormalization techniques for Hamiltonians and first results from their applications. One exciting result is that a confining $q\bar{q}$ potential can be found in the light-front QCD effective Hamiltonian already in second order perturbation theory. Higher order analysis is required and wee-parton dynamics must be better understood. We discussed the Regge limit in QCD and deep inelastic scattering, with much attention paid to low- x physics. The wee-parton dynamics is related to the vacuum problem and spontaneous symmetry breaking. The vacuum problem appears in light-front dynamics in a different way than in the standard dynamics evolving in time. A whole day was spent on discussing the light-cone zero-mode problems that are related to the vacuum problem. Apart from basic theoretical issues, we spent considerable time discussing the phenomenology of hadrons and its theoretical implications. A number of contributions describe recent results. For example, we discussed nucleon form factors. We had discussions on the theory and phenomenology of hadronic matrix elements that require deeper understanding and need to be known with better accuracy. We also devoted time to light-front applications in relativistic nuclear physics. Theoretically, relativistic nuclear physics is an effective QCD for hadrons at small momentum transfers and it is essential to discover the connection. About half of the available time was used for discussions that aimed at making bridges among the different aspects of hadronic physics. Theoretical issues of QCD, and light-front QCD in particular, were discussed most extensively.

The contributions are ordered as closely as possible to the order in which they appeared during the Workshop, with exceptions following from the fact that some contributions summarize

a whole sequence of talks and discussions that extended over a number of days and sessions.

Some long articles by distinguished speakers are written in collaboration with junior participants who had to put a lot of work into producing them, using their own notes and tape recordings. These articles were specially prepared for the purpose of making this volume useful to graduate and post-graduate students, in addition to experts in the field. I would like to express my great appreciation of the effort the authors have put into those articles. They produced an exciting and powerful introduction to the Workshop subject covering many difficult points in the theory. Dr. Matthias Burkardt from the Institute for Nuclear Theory at the University of Washington has helped me extensively in inviting people to work on these articles and coordinating their production. The authors' positive response to our initiative suggests that there is a need among senior and junior physicists for workshops that create an atmosphere of live fundamental science in progress, that are not cut and dry formal presentations with little time for open plenary discussions of basic theoretical issues such as confinement, vacuum structure, spontaneous symmetry breaking, renormalization and gauge invariance. However, the major factor in keeping the discussions under control was the outstanding leadership of speakers who facilitated them. It is my great pleasure to thank Professor Kenneth G. Wilson for his outstanding effort of leading 7 hours of discussions on major issues in the theory of hadrons and light-front QCD. I also thank Professor L. Susskind who helped in creating the inspiring workshop by his many insightful contributions. Professor V.N. Gribov asked many questions concerning the deepest aspects of strong interactions to which the audience responded vigorously. It is my great pleasure to thank all participants for coming and creating many valuable discussions.

Contributed papers that were presented during the workshop are included in the volume and report on recent results. Unfortunately, their length had to be limited to 5 pages each because we had a limited number of pages at our disposal. A few exceptions resulted from situations where some other contribution of the same author was shorter than planned, or the time and content of the presentation was extended at the audience request. Almost no exceptions were required, and I must thank the authors for being so patient with the strict editorial constraints.

Organization of the Workshop by the Institute of Theoretical Physics of Warsaw University was invited by the International Advisory Committee of a series of meetings and workshops devoted to light-front quantization and related issues of nonperturbative dynamics that already continues for four years. Each year, there is a short meeting in late spring and a long workshop in late summer. The first meeting in that series was held at Max Planck Institut in Heidelberg, Germany, in May 1991; the first workshop was at the Aspen Institute of Physics in Aspen, Colorado, in August 1991; the second meeting was at the Southern Methodist University in Dallas, Texas, in May 1992; the second workshop was held at the Telluride Academy in Telluride, Colorado, in August 1992; the third meeting was organized by the University of Zürich and Paul Scherrer Institut at PSI, Switzerland, in June 1993; and the next workshop was held at Is-

tituto Nazionale di Fisica Nucleare at Gran Sasso Laboratory, Italy, in August 1993. The fourth meeting was hosted by the Institute for Nuclear Theory in Seattle, University of Washington, in June 1994. I thank members of the Committee for their active support for organizing the fourth workshop in Poland. Next meetings and workshops are already being organized and planned on the basis of rapid progress in the field.

As a chairman of the Workshop I gladly take this opportunity to thank people who have helped the most in organizing this conference. I thank Professor Kenneth G. Wilson for his firm commitment to come, his unconditional support, help in inviting people and guidance when it was necessary. I thank Professor Robert J. Perry for his help in the organization and contributing his expertise and experience whenever it was needed. I thank Professors Lev N. Lipatov and Daniel Wyler for their help in inviting people. I thank Professor Stefan Pokorski, who was the Director of the Institute of Theoretical Physics at that time, for providing support from the Institute and Professor Stanisław G. Rohoziński, the next Director, for the continuation of this support. I thank Dr. Lech Szymanowski for his excellent and unsolicited help with organization of sessions on Regge limit and low- x physics and many technical issues. I would like to thank all other members of the organizing committee for all their efforts. Two students, Mrs. Ewa Czuchry and Mr. Marek Wieckowski, helped in recording the sessions and many other matters. Finally, I would like to thank Mrs. Wanda Doborzyńska-Głazek, who was delegated by the Polish Physical Society to be the secretary and treasurer of the Workshop.

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Workshop Chairman