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PHYSICS OF LOW-LYING HADRONS IN QUARK MODEL
AND EFFECTIVE HADRONIC APPROACHES

FINAL REPORT

September 1, 1996 → March 31, 2000

T. Mizutani

*Virginia Polytechnic Institute
and State University*

Blacksburg, Virginia 24061

June, 2000

**We have no objection from a patent
standpoint to the publication or
dissemination of this material.**

Mark P. Dvorsak *7/21/00*

Office of Intellectual Date
Property Counsel

DOE Field Office, Chicago

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FINAL REPORT for grant DE-FG02-96ER40994

This DOE grant has practically been the continuation of the PI's earlier one: DE-FG05-84ER40143, but aimed at going more in the direction of the interface between conventional hadronic approaches and more microscopic approaches based upon modelling the low energy QCD.

There were basically three theoretical projects supported by this grant. Each of them will be explained below.

(i) : [Use of confined quark models to study low energy hadronic processes]

This was done primarily in collaboration with Dr. M. Misha Ivanov from JINR, Dubna, Russia. A prototype of this activity had started during PI's previous DOE grant period. Processes studied were mainly those with electromagnetic probes as well as electroweak decays of certain mesons (from light mesons like the pion/ K-mesons to heavy ones such as B 's: pion electromagnetic polarisabilities, non-leptonic central K-meson decays, radiative decays of the η and η' mesons, and the pionic decay of the B meson). Following the visits of the PI to Dubna supported by the previous grant, Dr. Ivanov visited here [Virginia Tech] each summer supported, in part, by this grant. Overall, the approaches adopted have been successful in reproducing the available experimental data, and the predictions made will be tested at the Jefferson Lab.(TJNAF) once the secondary beam will become operative as well as elsewhere: Grenoble, Tsukuba, Uppsala, Frascati, etc.

(ii) : [Production of strangeness by Electromagnetic Probes]

This project was carried out in collaboration with Profs. C. Fayard, G. Lamot of Univ. of Lyon, and Dr. B. Saghai of CEA, Saclay, France. The principal interest has been on the processes by the real and virtual photon on the nucleon producing strange baryon and K-mesons. The approach taken was the conventional hadronic models, but for the virtual photon process some microscopic quark models were introduced to take into account the electromagnetic form factors of the baryons involved. Apart from publications in physics journals, the result was presented upon invitation to TJNAF/ECT Workshop on Excited Baryons held at Trento, Italy, in May, 1998. In view of the increasing experimental data from Mainz, TJNAF, etc.

the effort has been put forth in formulating theoretical models which is consistent with the basic gauge invariance of the electromagnetic interaction for extended (or composite) particles. Along the similar line of conventional hadronic approaches, the low energy interaction of the negative K-meson with nucleons has been investigated the understanding of which had been very controversial over the past two decades. Following the very important experiment at KEK (Japan), the controversy appeared to have gone, and it is now possible to exploit the interaction of this set of particles to understand the basic low energy dynamics of mesons and baryons. The effort taken by the present PI and his French colleagues has been to look at the negative Kaon and the proton-neutron bound system at very low energies to extract the low energy hadronic interaction parameters which are very important in understanding the microscopic structure of what is called non-perturbative domain of Quantum Chromodynamics. This theoretical effort has been progressing in parallel with the corresponding experimental endeavor at Frascati (Italy).

(iii) : [Diffractive Dissociative Production of vector mesons by virtual photons on Nucleons]

This is a Ph.D. dissertation project of a recent student (A. Pronyaev) of the PI at Virginia Tech. Here a modern picture of what was once called the Pomeron plays an essential role. Pronyaev was successful in combining the techniques from low energy constituent quark models of the nucleon and the pomerons as correlated states of gluons to account for and predict the processes. While the experiments appropriate for this theoretical work have been at higher energy and momentum transfer than what has been attained at the Jefferson Lab. the future experiments will certainly benefit from Pronyaev's work. In fact, there have been experiments at Jefferson Lab. on the electroroduction of the ϕ mesons, whose theoretical analysis depends on a very crude old models to date. The Pronyaev approach is very promising in this regard.

The PI and A. Pronyaev would like to thank DOE for finalcial support during the course of the graduate work of the latter.

Recent Publications

1. The Box Anomaly and Radiative decays of the $\eta(\eta')$ mesons (with M. I. Ivanov), hep-ph/9710514 (this need a more extensive re-writing).
2. Off-Shell Effects in Electromagnetic Production of Strangeness (with C. Fayard, G.-H. Lamot and B. Saghai), Phys. Rev. C58 75-90, (1998).
3. Twist-4 effects and Q^2 dependence of diffractive DIS (A. V. Pronyaev, et al.), Phys.Lett. B422, (1998) 238-246.
4. Heavy-to-Light Form Factors in the Quark Model with Infrared Heavy-Quark Propagators (With M. A. Ivanov and Yu. M. Valit), Few-Body Systems (Springer), 24, 201-212 (1998).
5. Predictions for the forward cone in diffractive DIS, (A. V. Pronyaev et al.), JETP Lett. 68 (1998) 634-640.
6. Effective Lagrangian Study of the $\gamma p \rightarrow K^+ \Lambda$ (Spin 3/2 Resonances and their Off-Shell Effects), Few-Body Systems (Springer), Suppl. 11, 241-245 (1999).
7. Diffraction driven steep rise of spin structure function $g_{LT} = g_1 + g_2$ at small x and DIS sum rules, (A.V. Pronyaev, et al.), Phys.Lett. B457, (1999) 218-226.
8. $K \rightarrow \pi\pi$ and a Light Scalar Meson (with J.C.R. Bloch, M.A. Ivanov, C.D. Roberts, and S.M. Schmidt), lanl nucl-th/9910029 (to be published in Phys. Rev. C).

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