

THEORETICAL STUDIES
IN FEW - BODY INTERMEDIATE ENERGY PHYSICS

Progress Report
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T. Mizutani

Virginia Polytechnic Institute
and State University
Blacksburg, VA 24061

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PROGRESS REPORT FOR SEP.1, 1990 \Rightarrow AUG. 31 1991

During this period, (1) the present investigator invited a Soviet theorist, Mikhail A. Ivanov from Dubna, to start a collaboration from October 1990 for several months, then (2) he took a research leave from Virginia Tech. to accept a visiting scientist's position at Centro de Fisica Nuclear, Univ. of Lisbon, Portugal, from January through June, 1991. There, he had a valuable occasion to meet few-body and high energy theorists to enrich his scope of physics. He eventually started a collaboration with one of the members at that center. Collaborations with Claude Fayard, Georges Lamot (both at Lyon), and Bijan Saghai (at Saclay) on the πNN system has been continuing. The present investigator paid a visit to both places, and C. Fayard came to Virginia Tech. during Aug. 1991.

1. The πNN System with two-term interactions in P_{33} and P_{11} Channels

As theoretical models in medium energy few-body physics is now required to give a more quantitative account of the data, it has become necessary to upgrade principal inputs. Following the original work of Tanabe and Ohta ¹, we made an extensive investigation of the πNN system based upon two-term πN interactions in the P_{33} and P_{11} partial waves which are most important ingredients, and are more in line with the underlying quark picture than the one-term isobar model with an *ad-hoc* off-shell modification, adopted previously ². The overall quality of the predictions adopting this two-term interaction has turned out to be comparable to that from Ref.2, but with a significant improvement in the $pp \rightarrow \pi^+ d$ asymmetry A_{Y0} . So we have concluded that two-term interactions should be studied more in detail and be used for future medium energy problems including those induced by electromagnetic probes. This result is being sent for publication.

2. $pp \rightarrow \pi^+ np$ reactions at $T_{lab}^p = 800$ MeV

The process has been investigated by adopting two-term πN interactions discussed above. We have investigated the multifold differential cross sections and the beam asymmetry in this reaction. Improvements are seen in this result as compared with previous model results with one-term isobar interactions for the P_{33} channel. The work has been written up and sent for publication.

3. $NN \rightarrow N\Delta$ reactions

This is an extension of what we reported in the last progress report. At that time we were about to publish this work. We then decided that the whole version must be done with the two-term πN interactions. We have thus redone the whole study with the new interactions, and further investigated observables other than the differential cross sections and the beam asymmetry. We found that physics up to the Δ resonance energy can be nicely described by this model, but above the resonance, the same *spin triplet problem*: the lack of NN spin triplet inelasticity, persists. We are in the process of writing it up for publication.

4. $\pi N\Delta$ vertex

We believe that the key to solve the *spin triplet problem* is either the off-shell structure of the $\pi N\Delta$ vertex, or some mechanism involving the direct (s-channel) $N\Delta$ interaction. We have looked at a small portion of the first possibility by adopting the vertex from the Dubna Quark Confinement Model ³. This vertex was used as a building block of the resonant part of a two-term P_{33} interaction, and was tested in the NN inelasticity. Some improvement in the spin singlet channel has been observed, but no significant change has been found in the triplet partial waves. We are in the process of studying a detailed systematics of what has caused this lack of triplet strength within this first possibility.

5. Pion production from the isospin zero NN channel

The process $\vec{p} + n \rightarrow \pi^- + (np)_{1S_0}$ at low energies is now understood not to be dominated by the intermediate production of the Δ (thus I=1 NN channel) ^{4,5}. Within a relativistic three-body model we are investigating this reaction. So far we have found that the beam asymmetry is rather insensitive to the details of the model, whereas the forward-backward asymmetry in the c.m. differential cross section, which is affected by the balance of the I=1 and I=0 NN channel pion production, is not easy to reproduce.

6. Pion and kaon electromagnetic polarizability

As a test for applying the Dubna Quark Confinement Model to photo(electro) production of the pion and kaon, we have investigated the polarizability of these mesons. The model has resulted in a relatively small charged pion polarisability consistent with the prediction of Chiral Perturbation Theory (CHPT), but for the kaon our prediction has turned out to be quite large as compared with CHPT. The role of quark confinement is found to be important within our approach. This has been sent for publication.

During this project period the present investigator attended for an invited lecture at the *Workshop on the πNN System* at Saclay, France (March, 1991). Invitations to colloquium/seminar include those at Saclay, Lisbon, Coimbra, etc.

PLANS FOR THE NEXT PROJECT PERIOD

We are planning to gradually getting into the domain of the few-body system with electromagnetic probes. As a first step, the basic two-body channels: $\gamma N \rightarrow \pi N$ and $\gamma N \rightarrow KN$ will be investigated in terms of phenomenological models and a more microscopic model (what we have in mind is the Quark Confinement Model of Dubna). For this purpose several weeks' invitation of M. A. Ivanov (and

possibly his collaborator) will be planned in the fall of 1991. The study of the πNN system will be continued. A collaboration with a Lisbon colleague on the $I=0$ NN channel production of the pion will continue to a deeper level. A trip to Lisbon, Portugal is scheduled for Dec.- Jan. 1992, and another trip to Dubna, Soviet Union will be planned in May (or June), 1992.

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