

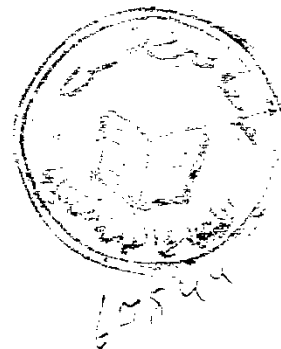
THREE-BODY FORCES IN HIGH-ENERGY COLLISION

A THESIS SUBMITTED
TO
Department of Mathematics
Faculty of Science
Ain Shams University

For The Degree of Ph.D.
in
(Applied Mathematics)

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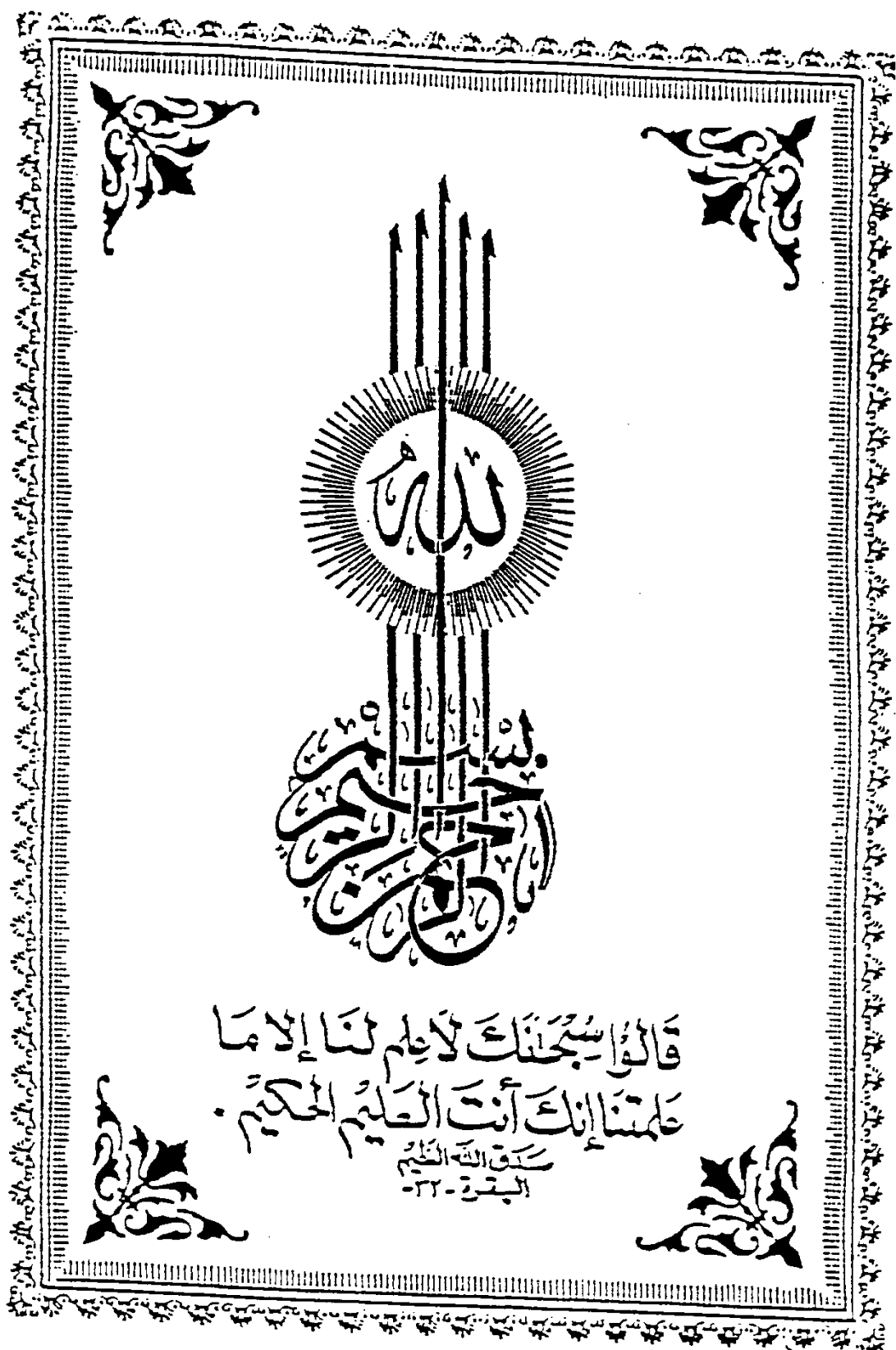
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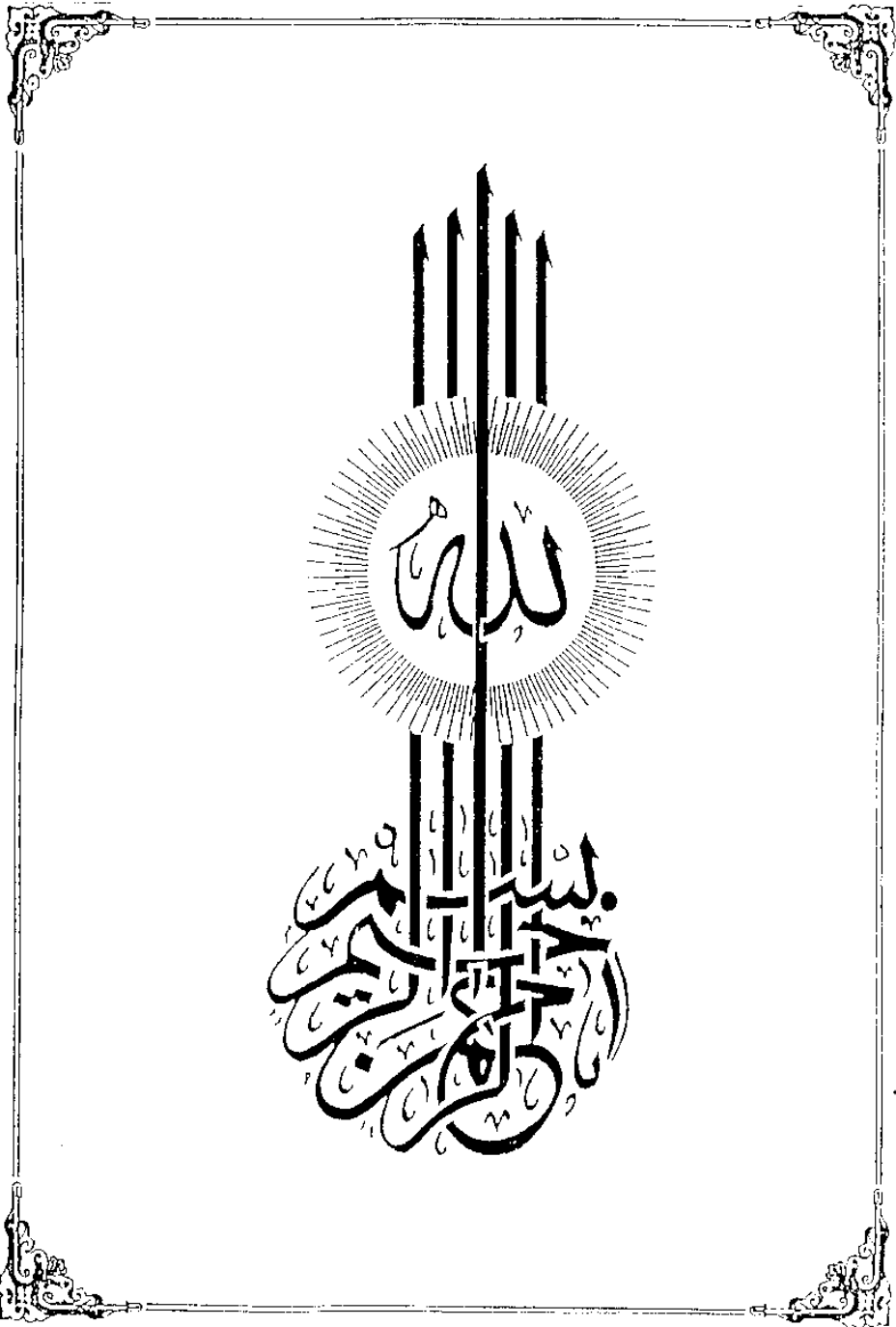
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CAIRO
1995



قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا
عَلَّمْنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ
سُبْحَانَ اللَّهِ الْعَلِيِّ
الْبَاقِي - ٢٢ -



ACKNOWLEDGMENT

First of all, gratitude and thanks to ~~ALLAH~~ who always helps and guides me.

The author is deeply grateful to Prof. Dr. Ahmed G. El-Sakka, head of Department of Mathematics, Faculty of Science, Ain Shams University, for his kind supervision, valuable advices and paternal encouragement.

I would like to express my thanks to Prof. Dr. Farouk A. Ayoub, head of Department of Mathematics, University College for Women, Ain Shams University, for his great help and discussions he offered during the preparation of this thesis and for his valuable encouragement and follow-up through this work.

The author is greatly indebted to Dr. Mohammed A. Hassan, Department of Mathematics, Faculty of Science, Ain Shams University, for suggesting this line of research, kind supervision and systematic guidance. With his generous and fruitful discussions this work has been completed.

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Abstract

ABSTRACT

This thesis is concerned with the study of three-body force effect on the hadron-deuteron collision at intermediate and high energies. The traditional nuclear method is used to introduce this effect to the hadron-deuteron scattering amplitude, where the three-body force effect is represented by a correction to the scattering phase-shift function. By a suggestion of a definite form for the three-body force profile function, the different cross sections of collision are calculated.

The thesis consists of five chapters as follows:

In Chapter I: A general definition of the three-body force and its general properties with a brief presentation of the three-body force effect on the calculations of the three-nucleon system, specially, of the hadron-nucleus collision are given. A simple formulation of the high energy approximation of Glauber, which is used in calculations, is presented.

In Chapter II: The general formalism of introducing the three-body force in the hadron-nucleus scattering amplitude is given. The special case of hadron-deuteron scattering is considered. Some forms of three-body force profile function are discussed. A simple approach, which is used in the thesis, for the introducing of the three-body force into the hadron-deuteron scattering amplitude is suggested with a definite simple form of the three-body force profile function.

In Chapter III: Hadron-deuteron elastic scattering differential cross section is calculated, in the range 0.8-12 GeV of energy, for the hadrons p , $\bar{p}$, $\pi^\pm$ as incident particles, taking into account the three-body force effect. A good fitting with the experimental data is obtained for pure imaginary profile function with the value 13 (GeV/c)^{-2} of the three-body force parameter γ . This value of γ corresponds to 0.7 fm as a radius of the three-body force. The most contributions of the three-body force correction are coming from the single scattering terms, while the three-body force effect on the double scattering terms can be neglected. In general, the results of hadron-deuteron elastic scattering differential cross section, at intermediate and high energies, insure that, the three-body force should be taken into account in the calculations. We can consider this conclusion as an evidence on the existence of the three-body force.

In Chapter IV: The differential cross section of the sum of elastic and inelastic scattering with dissociation, and differential cross section of inelastic scattering with dissociation are calculated in the same range of energy as in Chapter III, also, for the same incident particles. The three-body force effect is clear at the small and large values of momentum transfer. Also, the most contributions of the three-body force correction are coming from the double scattering terms, which is consistent with the fact that, both of inelastic scattering and the double scattering terms are more sensitive to the nuclear structure.

In Chapter V: The total cross section, integral cross sections of elastic scattering and inelastic scattering with dissociation, the sum of these two

cross sections and the reaction cross section of p^- , $\bar{p}^-$, k^- -d collision are calculated in the wide range of energy from 1 up to 200 GeV. All results lead to that, the inelastic and reaction cross sections are more sensitive with respect to the three-body force effect than the elastic and total cross sections. In general, the three-body force effect must be taken into account in the calculations of total and integral cross sections, specially, for inelastic and reaction cases.

Thus, all results of our study insure the importance of the three-body force effect on the hadron-deuteron collision. Considering it we obtained a good fitting with the experimental data of elastic scattering differential cross section, which can be considered as an evidence on the existence of the three-body force in nuclear interaction in the three-body system.

Chapter 1

CHAPTER I

INTRODUCTION

1.1. Three-body force-definition, evidence and existence.

Traditionally, nuclear physics has attempted to describe the nucleus as a collection of non relativistic nucleons interacting via two-nucleon forces. These forces depend on the coordinates (and possibly momenta), as well as spins and isospins, of only two nucleons. This is a tremendous simplification which has no theoretical justification, other than a rough consistency between predictions of the theoretical (two-body) models and experiments (Laverne and Gignoux, (1973), [1]; Brandenburg et al, (1975), [2]; Afnan and Birrell, (1977), [3]; Brandenburg et al, (1977), [4]; Birrell and Afnan, (1978), [5]; Payne et al, (1980), [6]; Hajduk and Sauer, (1981), [7]; Friar et al, (1982), [8]; Friar et al, (1983), [9]; Friar et al, (1984), [10] and Mckeller and Glöckle, (1984), [11]). The discrepancy between the experimental data and theoretical result of two-body models, sometimes interpreted, partially at least, as a result of three-body force effect, (Friar, (1983), [12] and Mokellar, (1986), [13]).

The three-body force between nucleons has been around for a long time as a concept -at least since 1938 (Primakoff and Holstein, (1939), [14]) However, it is only in recent years that most nuclear physicists have taken the concept seriously. This

delay has been due to the great difficulties that have been in the way of deciding that the 3-nucleon force is necessary for the understanding of nuclear properties or so it has become apparent that 2-nucleon forces, used in a non-relativistic framework, do not quantitatively describe the properties of nuclei. The fault could be in many places-relativistic effects, many-nucleon interactions, renormalization of the interaction by the medium, quark effects, etc. Of course, the distinction between the various items on this list is not clear out, and we find people using different labels to describe the same basic effects (Berman, (1986), [15]).

What do we mean by a three-body force in the nucleus? Three-body forces depend on the simultaneous positions, momenta, spins, and isospins of three nucleons. the definition of a three-body force given above seems obvious, but is incomplete. We must have some way of distinguishing 2 successive two-body forces between 3 objects and a real three-body force. Therefore, the following definition is more convenient to the work with three-nucleon system: Force which depends on the simultaneous coordinates of 3 nucleons, when only nucleon degrees of freedom are taken into account (Friar, (1983), [12]). The degrees of freedom other than nucleons which are included in the nuclear wave function don't lead to explicit three-body forces; freezing them out produces such forces (Friar, (1983), [12]).

The coordinates of such a three-nucleon system are depicted in Figure 1.1; two distances, x and y , and one angle, θ , are required to completely specify the relative orientation of the three nucleons. The most important of these coordinates is θ . It is entirely reasonable, even probable, that a three-body force would depend on this coordinate. It could, for example, be repulsive when the nucleons are in a linear configuration ($\theta=0$ or π) and attractive when the configuration is isosceles ($\theta=\pi/2$). Thus, a three-body force can select particular three-body configurations, diminishing some and enhancing others (Friar, (1983), [12]).

Three nucleon forces are due to exchanges of two or more Bosones (like as π -meson and ρ -meson) (Coelho and Das, (1983), [16]); Osman, (1989), [17]) and some of the corresponding processes are shown in Figure 1.2 (Coelho and Das, (1983); [16]). The first diagram represents the pion-pion exchange three-body force, the only one to be considered in the present thesis. The other diagrams correspond to forces of shorter range and represent either the exchange of heavier mesons or the exchange of more than two pions.

Many works (Friar, (1983), [12]; Møkelar, (1986), [13]; Primakoff and Holstein, (1939), [14]; Berman, (1986), [15]; Coelho and Das, (1983), [16]; Osman, (1989), [17]; Glöckle, (1982), [18]; Fujita and Miyazawa, (1957), [19]; Torre et. al., (1981), [20]; Muslim et.al. (1982), [21]; Van Hees et. al. (1989), [22]; Nash, (1969), [23]; Goldhammer et.al., (1968), [24]; Fabre de la Ripelle,