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HEAVY IONS REACTIONS

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By

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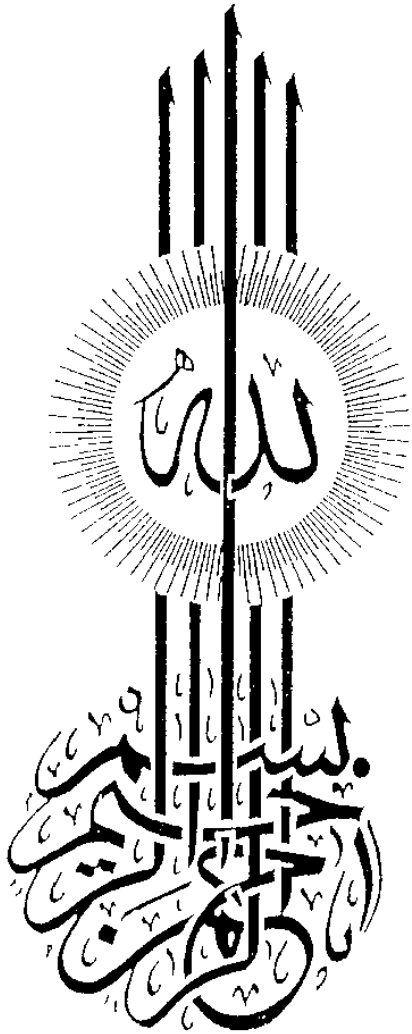
بسم الله الرحمن الرحيم

وقل اعملوا فسيرى الله عملكم ورسوله والمؤمنون

صدق الله العظيم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HEAVY IONS REACTIONS

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CONTENTS

SUMMARY

SUMMARY

The present submitted thesis mainly represents a study on the possibility of two approaching nuclei to form after contact one single nucleus. Such a study is based on the liquid drop model and is devided into three parts.

The first part deals with a deep investigation on the equilibrium form of two separate adjacent nuclei under the action of their electrostatic interaction. The two nuclei are assumed to be non-rotating. The shapes of the two adjacent nuclei are first approximated by two ellipsoids of revolutions having a common axis of symmetry,

The additional deformation energy for such a nuclear distribution is obtained. The equilibrium shape is such to make the deformation energy an absolute minimum.

The special case when the two nuclei are in contact is also studied.

A computer program is carried out and the corresponding graphical representations for some of the obtained equilibrium forms are given.

In the second part, the stability of the transfer of the nuclear matter between two touching nuclei is studied. Accordingly, it can be decided whether two nuclei touching each other will eventually separate from each other under their mutual electrostatic repulsion or on the other hand will swallow one another forming one single nucleus.

Such a study is based on the lagrangian formulation for the transfer of the nuclear liquid between the two touching nuclei across a very small hypothetical neck having a very small cross-section.

In the third part the study is extended to consider in addition that the two touching nuclei are rotating around the common axis of symmetry with constant different angular momenta.

For rotating drops the energy method can also be applied for obtaining the equilibrium forms.

The submitted thesis consists of an introduction and three chapters.

The introduction deals with some salient features of some nuclear models and nuclear reactions, beside a survey of the related literatures.

Chapter one deals with the equilibrium form of two separate nuclei under the action of their electrostatic repulsion. This study can be applied to drops in the form of an ellipsoid of revolution.

In chapter two, the stability of two nuclei in contact and having a common axis of symmetry is investigated.

In chapter three, the equilibrium form and stability of an axially symmetric rotating liquid drop is discussed. The discussion is extended to drops having deformed, ellipsoidal shapes. The thesis contains also illustrative figures, tabulated results, mathematical appendices and the main references related to the submitted subject.

INTRODUCTION

INTRODUCTION

In the present work, the drop model of the nucleus is assumed to be valid in the main investigation of the collision of two nuclei and the possibility of the their common integration to form one single nucleus.

Models are necessary in nuclear physics, since there does not yet exist one simple complete nuclear theory. In practice it is found that the range of applicability of any given model of the nucleus is generally rather restricted.

In this chapter we would like to investigate to what extent and under what conditions the drop model of the nucleus is valid.

It is well known that a classical non rotating charged drop can only have the spherical form as an equilibrium form. For a rotating uniformly charged liquid drop the equilibrium form deviates from the spherical form. Extensive numerical calculations on the total energy of a uniformly charged rotating liquid drop have shown that the equilibrium forms start as axially symmetric oblate spheroids [1] .

These shapes are called Hiskes shapes and are similar to the Maclaurian oblate spheriods for the gravitational case. When the rotating parameter y exceeds a critical value Y_I (which naturally depends on the value of the fissionality parameter x of the drop), the equilibrium form of the classical drop becomes similar to the Jacobi triaxial ellipsoids. They are called Beringer-Knox shapes [2] .

For very large angular momenta these shapes get nearly axially symmetric around an axis perpendicular to the symmetry axis.

The critical value Y_I which corresponds to the Jacobi point is at the same time a point of vanishing of the stability of the drop when the fissionality parameter $x \geqslant 0.81$ (for heavy nuclei) Otherwise for light nuclei the nucleus can pass the bifurcation point ($Y = Y_I$) from the Hiskes axially symmetric shape to the triaxial Beringer Knox shapes.

Experimentally quite different equilibrium shapes of the nucleus are present corresponding to high values of positive quadrupole moments. These shapes are thus similar to elongated prolate ellipsoids of revolution, which cannot be explained on the basis of the classical drop model of the nucleus. These shapes could first be explained on a quantum mechanical basis by Nilsson.

The idea of considering the nucleus as a liquid drop originally came from considerations about its saturation properties and from the fact that the nucleus has a very low compressibility and a well defined surface. However the nucleus differs from the ordinary liquid drop in many respects. For instance, the mean free path in a liquid is roughly given by the value at which the potential energy is minimum, while this distance for nucleus inside a ground state (or moderately excited state) nucleus is of order of the nuclear dimension. One reason of this big difference is that the nucleons are fermions (obey fermi statistics) and a nucleus is thus a quantum fluid. The pauli principle prevents the nucleons from coming too close to one another. Consequently, the scattering events are very scare inside the nucleus , whereas in an ordinary fluid they are predominant [3]. Thus, the nucleus resembles a non-interacting gas. This fact has some consequences that are absent in droplets of ordinary fluids for instance, in a vibrating nuclear drop (e.g., (dynamical) quadrupole deformations) the