Symmetries of empty space

Preface

The elementary modes of nuclear excitation are vibration and rotations, are rotations of spatially deformed systems and vibration of both spherically and deformed systems, single-particle motion, and pairing vibrations and rotations.

11/05/13.

Preface

The elementary modes of nuclear excitation are vibrations and rotations, single-particle motion, and pairing vibrations and rotations. The specific reactions probing these modes are inelastic and Coulomb excitation, and single- and two-particle transfer processes respectively.

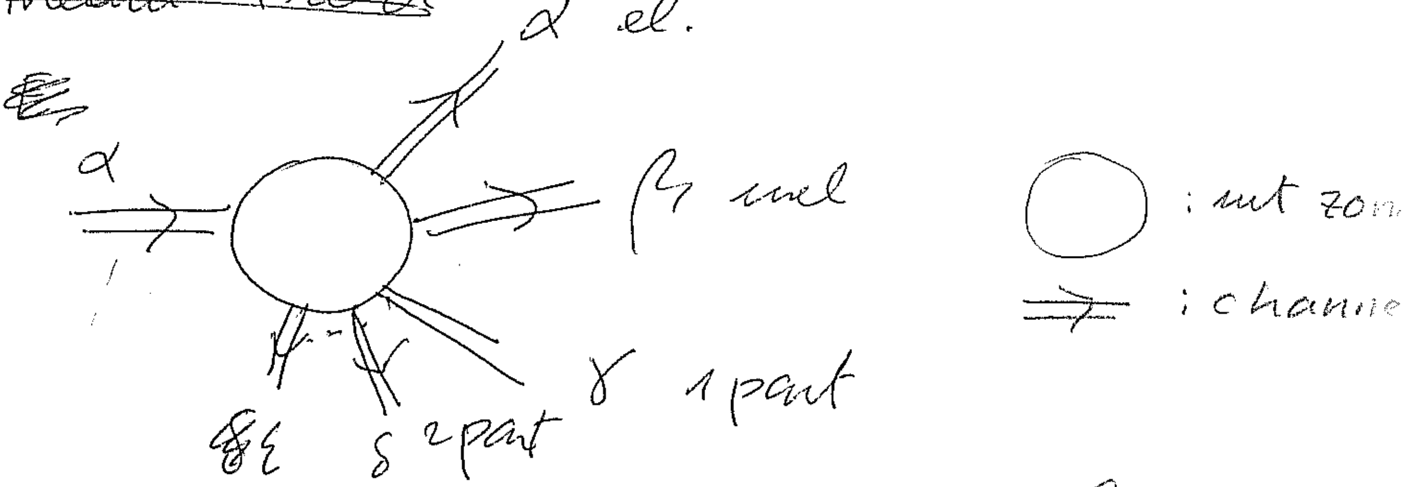
Pairing vibration and rotations, closely connected with nuclear superfluidity are, arguably, a paradigm of quantal nuclear phenomena. They thus play a central role within the field of nuclear structure. It is only natural that two-nucleon, Cooper pair, transfer plays a similar role concerning direct nuclear reactions.

Book Gregory   9/04/2013

~~General~~ Background QM

General intr.

~~Mean Field~~



R: react
S: str.

α: Elastic ~~coul~~ R
(meanfield (HF) S

β: inel R
Coll. vibrs (TDHF) S

γ: 1-part. R
~~Dressed s.p. sta~~
beyond meanfiel β N S

δ: 2-part. R
Pairing correls. S

α': elastic revisited
absorptive potentiae

Lectures Reactions

Light and Heavy Ions
succ. sim
etc.

book ~~[illegible]~~ con gregory

15 p. book

1) Notes (small blue book)
- ~~[illegible]~~ Pairing in Nuclei and neutron stars

2) Phys. Rep. version 1

3) " " " 2

4) Paper PRC Sn
~~with and [illegible]~~
without corrects referee

5) Paper PRC Sn
with corrs. referee

6) Pape ^{12}Be, ^{11}Li Belyaev

7) PRL ^{11}Li

8) PRL Sn

~~10~~

9) Review paper Heenen

~~[illegible]~~ 10) } blurbs on
11) } ~~paired~~ pairing vibr.
12) } halo
13)
:
:

^{132}Sn

anti pairing effects is ok   ~~B~~ H + Mott

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but "L (gs) exists

Thus

dynamical

Preface

The origin of these lectures, attended by RAB and, can be traced back to October 1965, date of the first lecture of the course on Nuclear Reactions held, during the fall semester by Ben Mottelson at the [illegible] Universitets Institut for Teoretisk ~~Physik~~ (now The Niels Bohr Institute of the University of Copenhagen), in the unique setup of Aud. A, rich of tradition ~~but also of~~ as well as a beautiful look to Fælledparken. It was the fortune of RAB to ~~work~~ start a collaboration ~~about~~ with Claus that time, ~~to collaborate on~~ Riedel on ~~the subject of~~ two-nucleon transfer reactions, ~~to shed light~~ with which to probe the newly postulated pairing vibrations (and rotations), in particular in connection with the (t,p) measurements ~~carried out~~ made at Harwell (UK) by the group of Ole Hansen and Ove Nathan with the collaboration of Stan Hinds. The Monday morning experimental groups meetings carried out at Aud. A (and moderated by Aage Bohr), in which the essentially raw data was confronted with ~~theoretical~~ speculations and numerical results, with ~~interventions~~ central contributions by Daniel Bes were instrumental ~~to shape~~ to shed important light ~~on nuclear~~ on pairing correlations in nuclei, as well as to make ~~it clear~~ operative that ~~direct~~ structure and reactions are but two aspects of the same physics, one referring mainly to bound

and to continuum states respectively.
The fact that this is not only a technical question, but at the basis of the observed nuclear properties, is solidly anchored [redacted] on quantum mechanics, and the associated central role that quantal fluctuations [redacted] and associated virtual states play [redacted] in atomic nuclei, a fact that is [redacted] at the basis of medium renormalization processes dressing the nuclear mode of elementary excitation, i.e. single-particle and collective vibrations and rotations, and [redacted] leading to the actual value of the observables, i.e. effective mass, charge, energies, lifetimes, absolute cross sections, etc. [redacted]
This view led, under the guidance of Daniel Bes to the Nuclear Field Theory (NFT) of Aage Winther, to a corresponding formulation of Heavy Ion Reactions, [redacted] The development of the consequences of this project [redacted] has taken many years to be [redacted] implemented. Regarding the structure aspects Francesco Barranco, George Bertsch, Pier Francesco Bortignon and Enrico Vigezzi have played an important role, [redacted] the contribution of [redacted] have been central [redacted] concerning also the structure [redacted]

and to continuum RPA (projectors).
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11/05/13

During the last few years new impetus [redacted] towards a quantitative description of the probing of pairing in nuclei have been pursued at Milan, in particular in connection with the probing of new mechanisms of cooper pair binding. The results of these efforts constitutes an important part of the present monograph, [redacted] and also the basis for a [redacted] series of lectures delivered by the authors within the framework of the PhD program of the Department of Physics of the University of Milan.

Gregory Potel

Ricardo A. Broglia

Preface

The pairing interaction arizing from the exchange of mesons and empirically parametrized in terms of a nucleon-nucleon potential, like e.g. the Argonne potential, can be viewed as a contact interaction. A multipole expansion reveals that none of the multipole terms is more important than the other, and that one has to consider rather high multipoles to obtain convergence. These effects were already discussed in detail in the seminal papers of Beliaev [1], Mottelson [2] and Bayman [3]. In fact, one of the main subjects studied in these papers was that of the competition between pairing and deformation effects, the conclusion arrived was: single, low-multipoles control mean field (deformation), while many, high multipoles, glue pairs of nucleons together (Cooper pairs) giving rise to pairing correlations [4-6].

While this result is quite sound, it leaves out about half of the effects which control the nuclear structure. This is because it is based on a static view of the mean field (shell model), where nucleons move independently of each other feeling the pullings and pushings of all other nucleons when bouncing elastically off the surface. Single-particle levels are the solutions of a nucleon of mass equal to the bare mass moving in a static Saxon-Woods potential. This picture is, however, not quite correct, as the motion of the nucleons and their interactions are strongly renormalized by vibrations of the mean field (dynamical shell model [7-9]). This is not only the case for nuclei lying along the stability valley but it is especially true in the case of exotic nuclei in general and halo nuclei in particular [10,11].

In what follows (the first part of monography), the case for the dynamical shell model will be contructed one step at a time, starting from the study of the effective mass and of the lifetime of single-particle motion, resulting from the interweaving of nucleons with low-lying collective vibrations of the nuclear surface and arriving, in the second part of the monography, to the pairing induced interaction arizing from the exchange of these vibrations between pairs of nucleons. It will be concluded that such a description of the nuclear structure

in which the self-consistency existing in nature between density and potential and their fluctuations is correctly treated, provides a unified picture of single-particle and collective motion, its natural mathematical framework being the nuclear field theory (NFT) [12-16]. The study of the structure of atomic nuclei, paradigm of finite-many body systems provides, largely for free, the physical insight and the mathematical tools needed to understand other finite or compact systems like neutron stars, metal clusters [17], fullerenes [18], Bose Einstein condensates, etc. In particular, their behaviour at very low temperatures (superfluidity and superconductivity). This constitutes the last part of the present monography and, in a very real sense, is a gift that the practice of the discipline of nuclear structure provides to its practitioners.

6/05/13