Istituto Nazionale di Fisica Nucleare

Enrico Vigezzi - INFN Milano

RICARDO A. BROGLIA

In memoriam

Ricardo Americo Broglia was born in Cordoba, Argentina, in 1939.
He graduated at Instituto Balseiro of the University of Cuyo and obtained his Ph.D. in Buenos Aires under the direction of Daniel Bes in 1965.

From Ricardo's personal notes:
I went to Buenos Aires to do my doctoral thesis with Daniel Bes, who had just returned from the Niels Bohr Institute in Copenhagen after a 10-year internship.
In his luggage, in addition to porcelain from Kongelik Fabrik, he carried three or four central problems of nuclear physics of the time, problems that in less than two years a group of four very young people (Zuker, Federman, Maqueda, Broglia) have solved, in a continuous discussion, and open to all members of the group. So open that we often forgot to whom the research topic under discussion "belonged". Typical of this magical atmosphere of a high-level school is the fact that I wrote Maqueda's doctoral thesis and he wrote mine (the assignments had already been approved by the teaching staff).
In the face of competition.

1.D.2

Nuclear Physics **80** (1966) 289—313; © *North-Holland Publishing Co., Amsterdam*

PAIRING VIBRATIONS

D. R. BÈS †
NORDITA, Copenhagen
and
R. A. BROGLIA
Facultad de Ciencias Exactas y Naturales, Buenos Aires

Received 30 September 1965

Abstract: We study the properties of the collective states (pairing vibrations) which are associated with fields changing the numbers of particles. In particular, we discuss which processes may be enhanced by the coherence in the pairing-vibration state.

The pairing vibration appears as a low-energy collective mode in the case of a residual two-body interaction such that the nucleus should be sufficiently close to the transition point between the single-particle and a superconducting system, and if there exists at least two well-defined groups of single-particle levels in such a way that the spread on energy within each group should be significantly smaller than the distance between the two groups.

The operator which specifically feels the coherence of the collective state corresponds to the two-body transfer processes.

In spherical nuclei, the most promising cases are the closed-shell nuclei. The main characteristic of the resulting spectrum is the existence of a low-energy 0^+ state which is populated with the same intensity as the ground state. Such spectrum appears to exist in ^{208}Pb although residual effects must have at least quantitative importance.

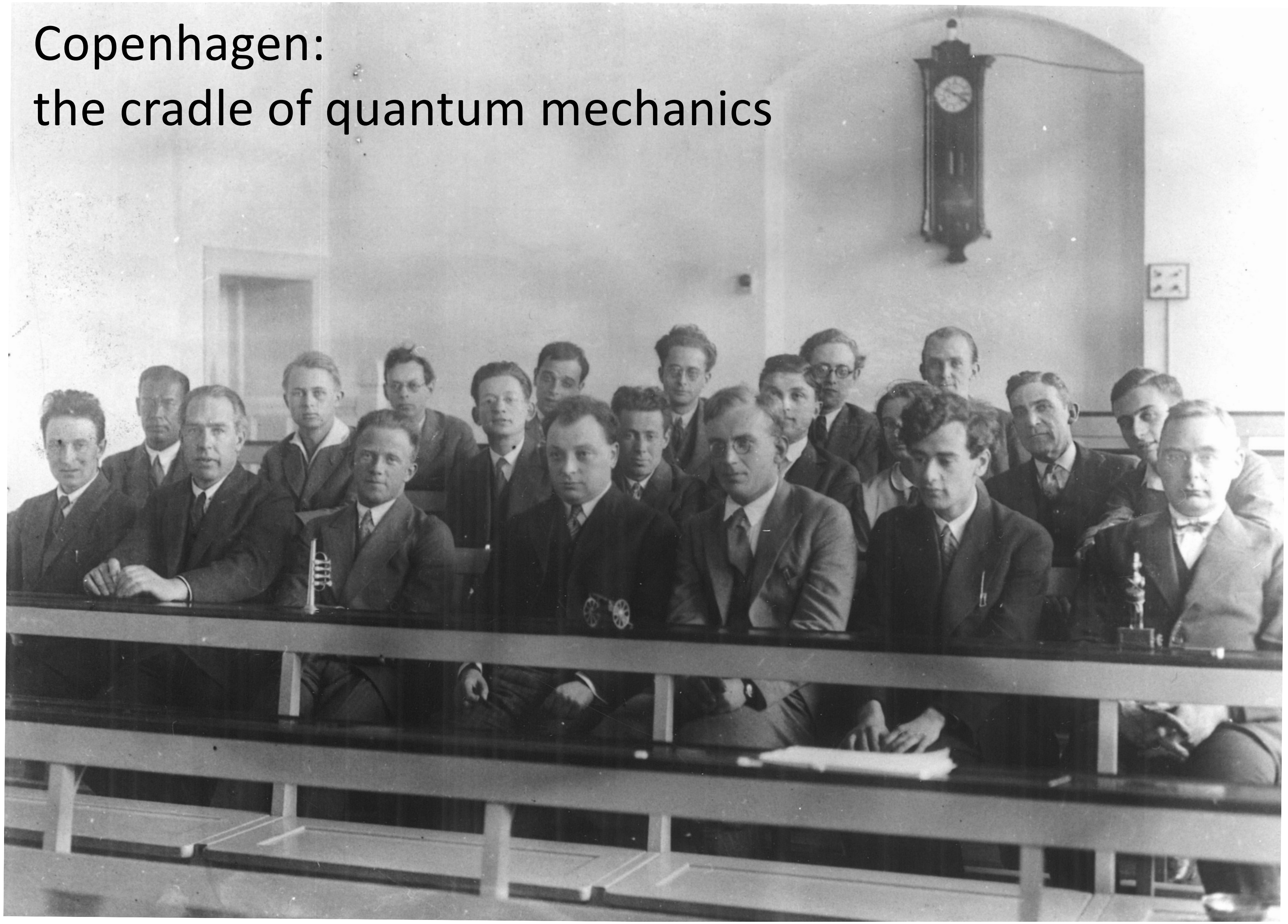
The Niels Bohr Institute, Copenhagen

Post-doc (1965-68) and then staff from 1970 after 2 years in Minnesota

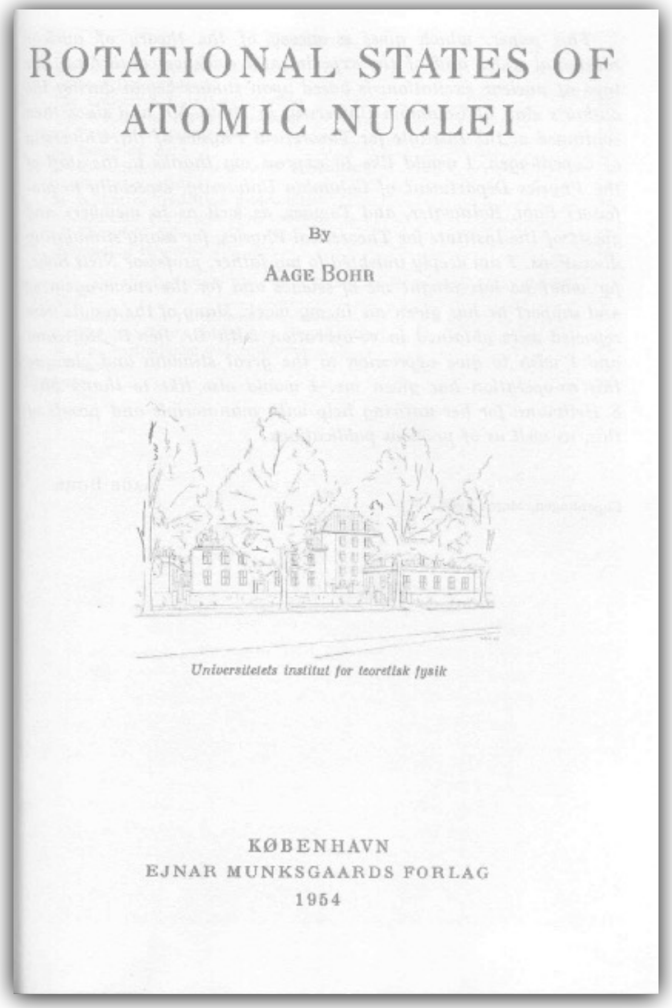
NBI 1970

Yearly photograph of institute staff and guests at The Niels Bohr Institute, on the recurrence of Niels Bohr's birthday on 7 October 1970. Courtesy of The Niels Bohr Institute, Copenhagen.

Copenhagen:
the cradle of quantum mechanics



The Bohrs: father and son



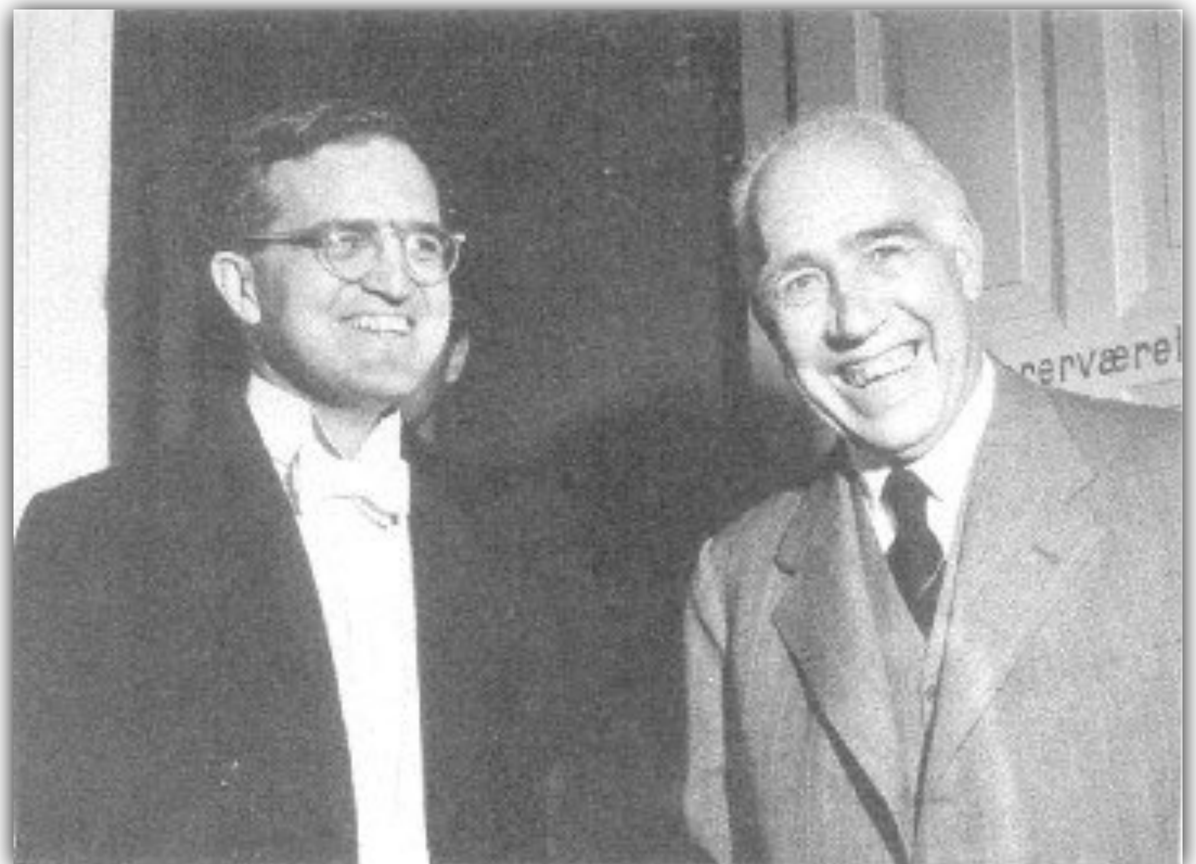
ROTATIONAL STATES OF ATOMIC NUCLEI

By

AAGE BOHR

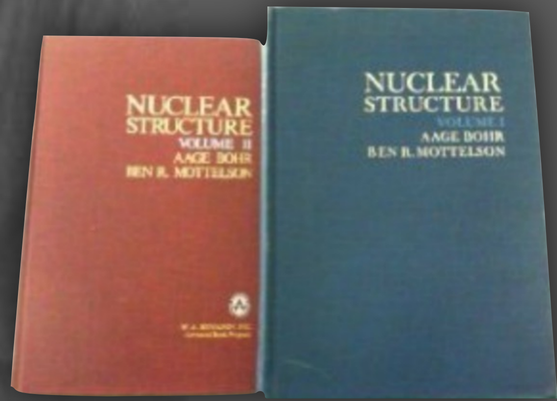
Universitetets institut for teoretisk fysik

KØBENHAVN
EJNAR MUNKSGAARDS FORLAG
1954

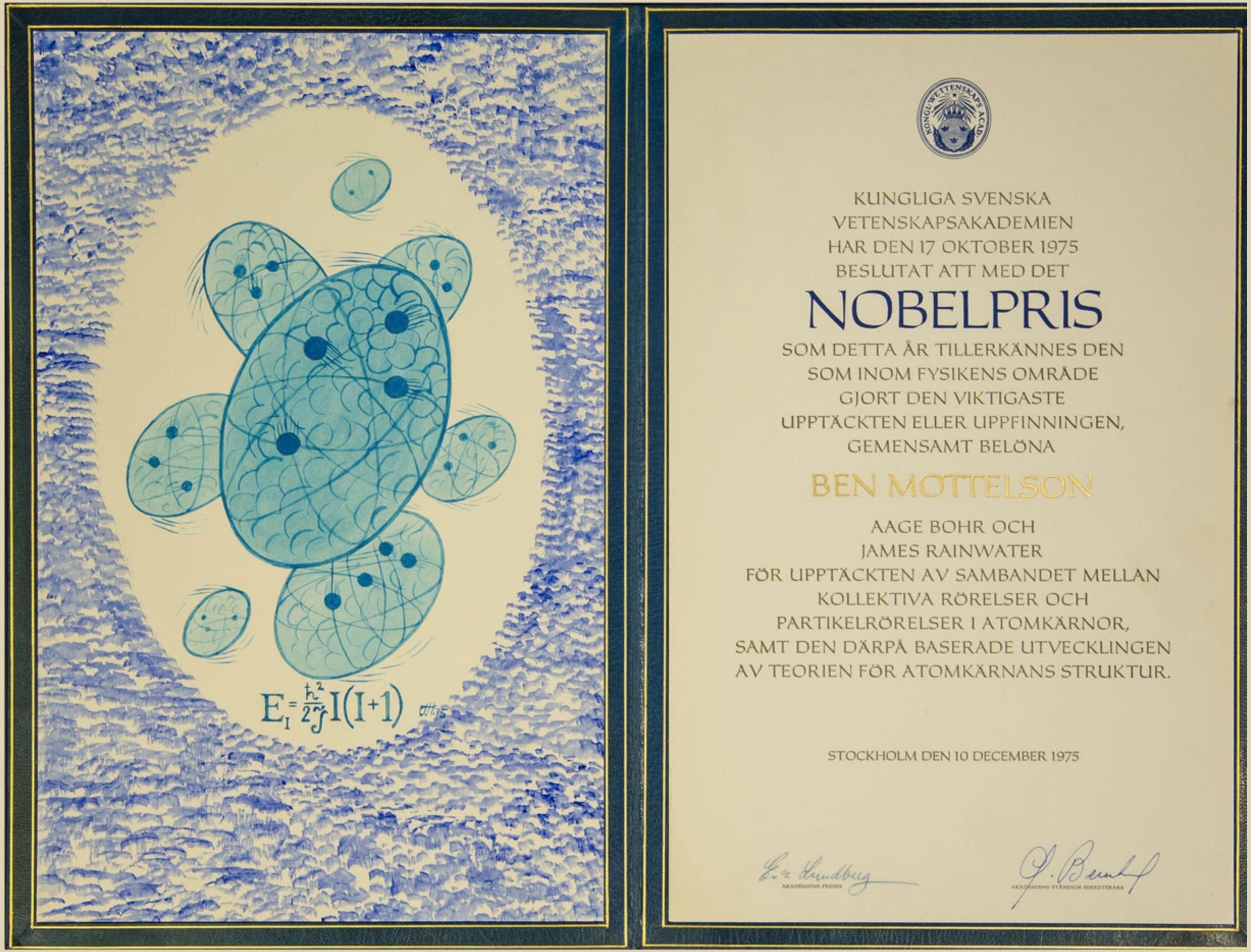


Aage and Niels Bohr in Copenhagen in 1954, after Aage's thesis defence. Courtesy of Niels Bohr Archive, Copenhagen.

1969-1975


NUCLEAR STRUCTURE
VOLUME II
AAGE BOHR
BEN R. MOTTELSON
NUCLEAR STRUCTURE
VOLUME I
AAGE BOHR
BEN R. MOTTELSON

1975


KUNGLIGA SVENSKA
VETENSKAPSAKADEMIEN
HAR DEN 17 OKTOBER 1975
BESLUTAT ATT MED DET
NOBELPRIS
SOM DETTA ÅR TILLERKÄNNES DEN
SOM INOM FYSIKENS OMRÅDE
GJORT DEN VIKTIGASTE
UPPTÄCKTEN ELLER UPPFINNINGEN,
GEMENSAMT BELÖNA
BEN MOTTELSON
AAGE BOHR OCH
JAMES RAINWATER
FÖR UPPTÄCKTEN AV SAMBANDET MELLAN
KOLLEKTIVA RÖRELSER OCH
PARTIKELRÖRELSER I ATOMKÄRNOR,
SAMT DEN DÄRPÅ BASERADE UTVECKLINGEN
AV TEORIEN FÖR ATOMKÄRNANS STRUKTUR.
STOCKHOLM DEN 10 DECEMBER 1975

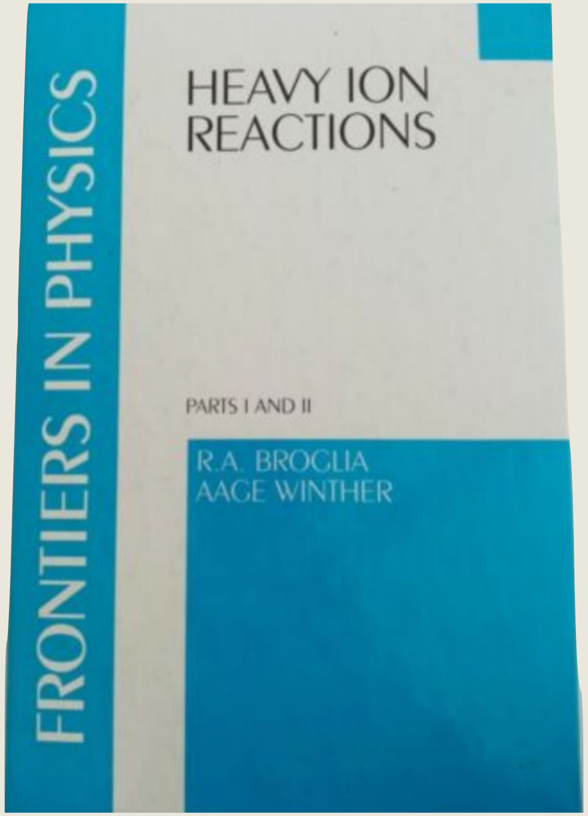
ALL ALONG HIS CAREER: STRUCTURE AND REACTIONS, THE TWO INSEPARABLE FACES OF THE SAME MEDAL

1965 (FROM LATER PERSONAL NOTES)

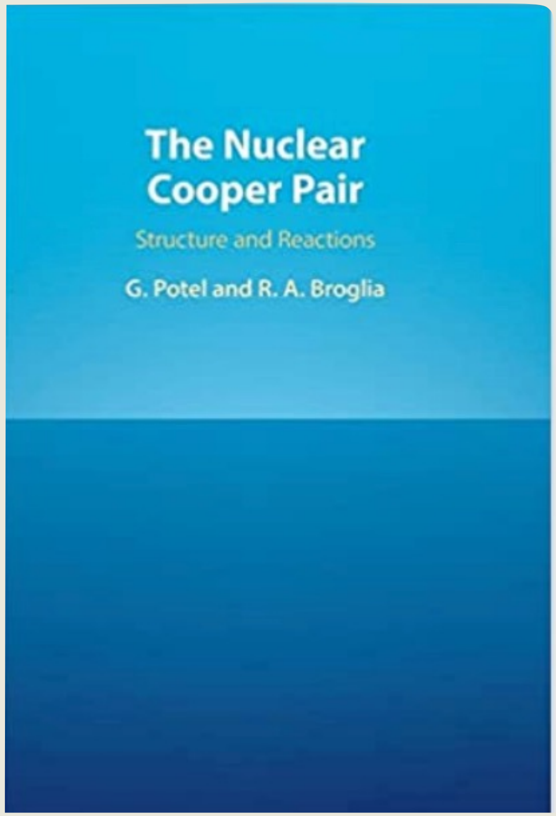
In the morning of 4th October 1965 , I (RAB) sat in a rather crowded auditorium A of the Niels Bohr Institute to attend the first of a series of lectures on nuclear reactions which were to be delivered by Ben Mottelson. In the following spring term, the Monday lectures were expected to deal with the subject of nuclear structure and the lecturer to be Aage Bohr, as it duly happened. After Ben's lecture, an experimental group meeting took place in which experimentalists, as it was the praxis, showed their spectra, likely not yet completely analyzed, while theoreticians attempted at finding confirmation of their predictions in connection with specific peaks of the spectra.

In the afternoon I would continue with the calculation of pairing vibrations I was carrying out in collaboration with Daniel Bès, as well as discuss with Claus Riedel on how to use this information to work out two-nucleon transfer differential cross sections for lead isotopes, quantities newly measured at the Aldermaston facility by Ole Hansen and co-workers. Within this context it did not seem surprising to me, nor to the rest of the attendees of Ben's lecture as far as I recall, that reactions and structure went hand in hand, to the extent that practitioners aimed at checking theory with experiment. Given this background, reinforced through the years by my association with Aage Winther and Daniel Bès, aside from that with Aage Bohr and Ben Mottelson, it is only natural that I view structure and reactions as the two inseparable faces of the same medal.

1991



2021

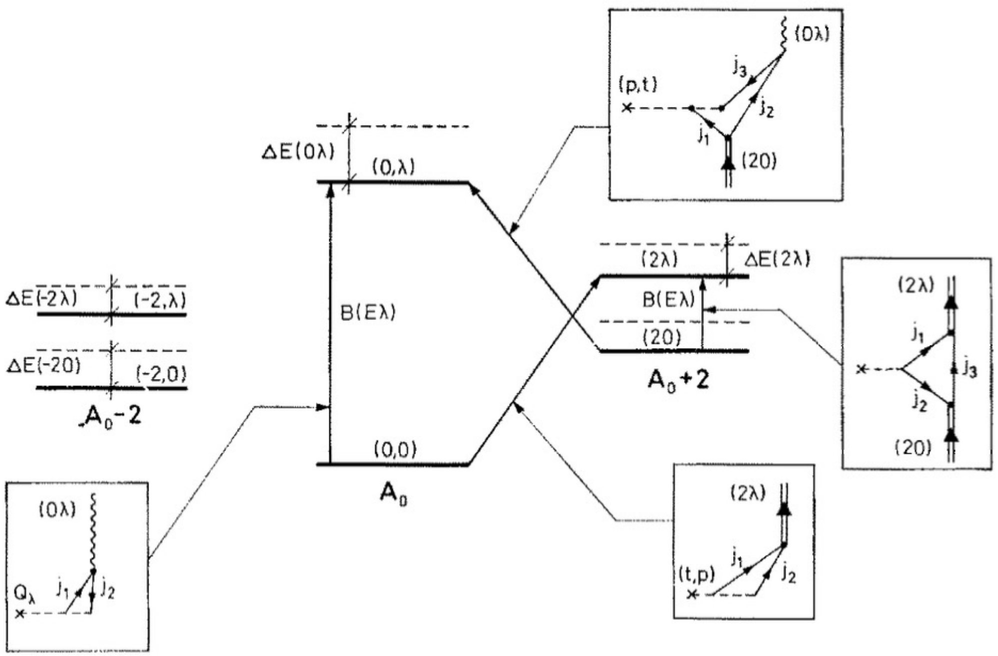


https://www0.mi.infn.it/~vigezzi/BHR/BrogliaHansenRiedel.pdf

Nuclear Physics **A169** (1971) 225—238;

COHERENCE PROPERTIES OF TWO-NEUTRON TRANSFER REACTIONS AND THEIR RELATION TO INELASTIC SCATTERING

R. A. BROGLIA
The Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark
C. RIEDEL
Zentralinstitut für Kernforschung, Rossendorf near Dresden, Germany (DDR)
T. UDAGAWA
Center for Nuclear Studies, University of Texas, Texas 78712



1973

Chapter 3

TWO-NEUTRON TRANSFER REACTIONS AND THE PAIRING MODEL

Ricardo A. Broglia
The Niels Bohr Institute
University of Copenhagen, Copenhagen
Denmark

Ole Hansen
*Los Alamos Scientific Laboratory, University of California**
Los Alamos, New Mexico 87544

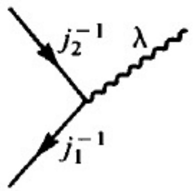
and

Claus Riedel
Zentralinstitut für Kernforschung, Rossendorf, D.D.R.
and
Physics Department, University of Karl Marx Stadt
Karl Marx Stadt, D.D.R.

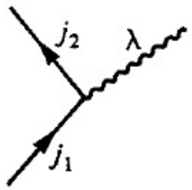
1. INTRODUCTION

The description of many-body systems at low energy in terms of "elementary modes of excitation" (see, e.g., Noz 65) is very useful in the case of nuclei (see BM 69). "Elementary modes of excitation" as used here comprise collective (rotations and vibrations) as well as quasiparticle excitations.

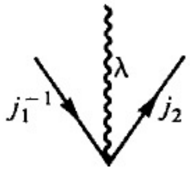
THE DEVELOPMENT OF NUCLEAR FIELD THEORY IN THE '70S



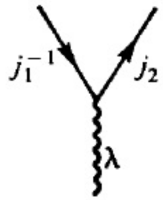
$-h(j_1 j_2 \lambda)$



$h(j_1 j_2 \lambda)$



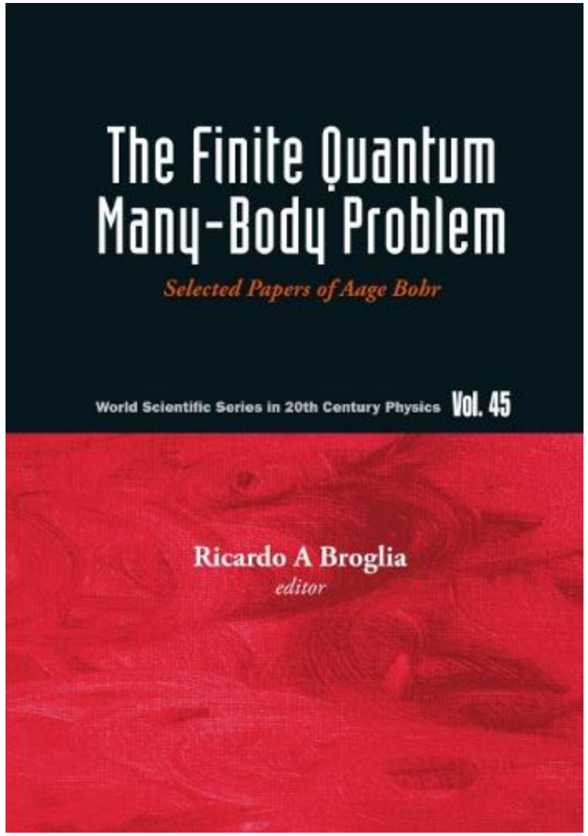
$-(2j_1+1)^{1/2} h(j_1 j_2 \lambda)$



$-\left(\frac{2j_1+1}{2\lambda+1}\right)^{1/2} h(j_1 j_2 \lambda)$

Nuclear Structure, Vol. II

In the preceding parts of Sec. 6-5, we have considered some of the consequences of the particle-vibration coupling in renormalizing the properties of the elementary modes of excitation and producing interactions between them. The systematic treatment of the particle-vibration coupling amounts to a nuclear field theory, which incorporates in a consistent manner the consequences arising from the fact that the quanta are built out of the same degrees of freedom as are the particle modes of excitation.



THE FERMION HAMILTONIAN IS MAPPED ON THE NUCLEAR FIELD THEORY HAMILTONIAN WHICH TREATS BOTH FERMIONIC (HF STATES) AND PHONONIC (RPA STATES) DEGREES OF FREEDOM

$$H = H_{sp} + H_{tb},$$

$$H_{sp} = \sum_{J} \varepsilon_J a_J^+ a_J,$$

$$H_{tb} = \tfrac{1}{4} \sum_{J_i} \langle j_1 j_2 | V | j_3 j_4 \rangle a_{j_1}^+ a_{j_2}^+ a_{j_4} a_{j_3}.$$

$$H_f = H_{sp} + H_{tb} + H_b + H_{pv},$$

$$H_{sp} = \sum_{J} \varepsilon_J a_J^+ a_J,$$

$$H_{tb} = \tfrac{1}{4} \sum_{J} \langle j_1 j_2 | V | j_3 j_4 \rangle a_{j_1}^+ a_{j_2}^+ a_{j_4} a_{j_3},$$

$$H_b = \sum_{n} \omega_n \Gamma_n^+ \Gamma_n,$$

$$H_{pv} = \sum_{n} \sum_{j_1 j_2} \{ \Lambda^*(j_1 j_2 n) \Gamma_n^+ a_{j_2}^+ a_{j_1} + \Lambda(j_1 j_2 n) \Gamma_n a_{j_1}^+ a_{j_2} \},$$

Nuclear Physics **A260** (1976) 77–94

ON THE MANY-BODY FOUNDATION OF THE NUCLEAR FIELD THEORY

D. R. BÈS †
Comisión Nacional de Energía Atómica, Buenos Aires, Argentina ††

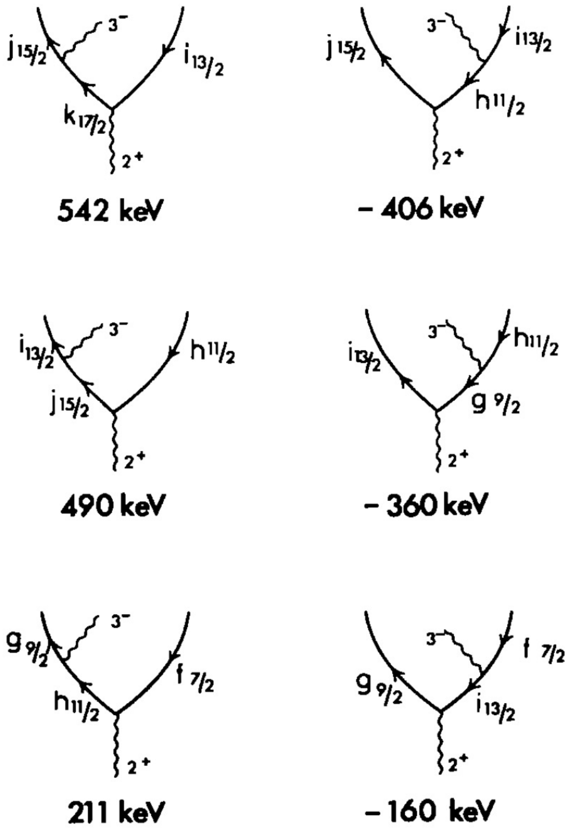
R. A. BROGLIA
Niels Bohr Institute, University of Copenhagen, Denmark

and

G. G. DUSSEL †, R. J. LIOTTA and R. P. J. PERAZZO †
Comisión Nacional de Energía Atómica, Buenos Aires, Argentina ††

A SET OF RULES IS DEFINED TO TAKE INTO ACCOUNT THE OVERCOMPLETENESS OF THE NFT BASIS AND TO RESPECT THE PAULI PRINCIPLE IN THE PERTURBATIVE EXPANSION

NFT is applied to Understand the width of collective Giant Resonances: the coupling to 2p-2h states



Nuclear Physics A371 (1981) 405–429

ROLE OF THE NUCLEAR SURFACE IN A UNIFIED DESCRIPTION OF THE DAMPING OF SINGLE-PARTICLE STATES AND GIANT RESONANCES

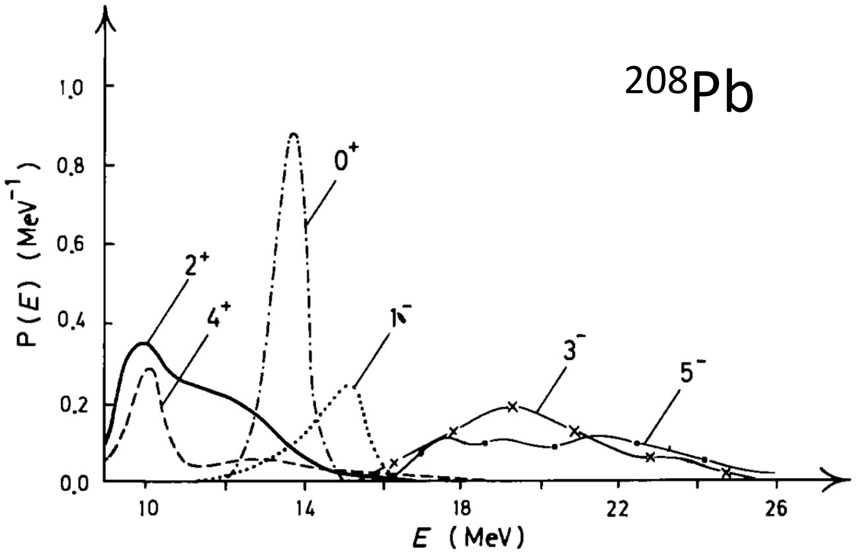
P. F. BORTIGNON

University of Padova, Istituto di Fisica Galileo Galilei, Padova, and INFN, L. N. Legnaro, Italy
and
The Niels Bohr Institute, University of Copenhagen, DK-2100 Copenhagen Ø, Denmark

and

R. A. BROGLIA

The Niels Bohr Institute, University of Copenhagen, DK-2100 Copenhagen Ø, Denmark



Reviews of Modern Physics, Vol. 55, No. 1, January 1983

Damping of nuclear excitations

G. F. Bertsch

Department of Physics and Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824

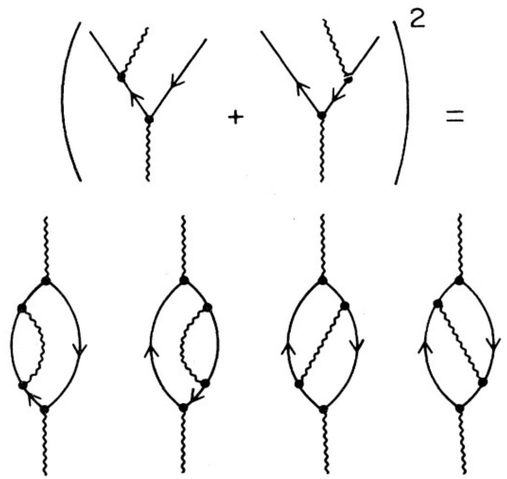
P. F. Bortignon

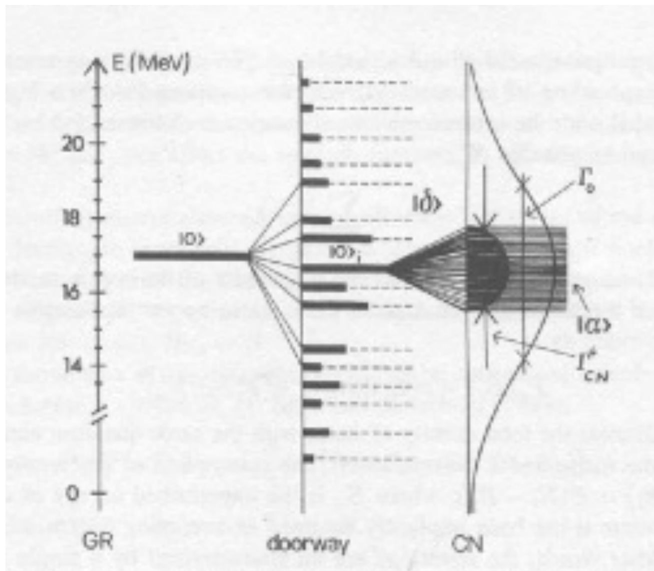
University of Padova, Istituto di Fisica Galileo Galilei, Padova and INFN, L.N. Legnaro, Italy

R. A. Broglia

The Niels Bohr Institute, University of Copenhagen, DK-2100 Copenhagen Ø, Denmark

On a numerical level, the calculated widths are generally within a factor of 2 of the empirical values. However, there is a systematic tendency for the empirical damping to be underestimated by theory, showing that our understanding is not yet complete. The theoretical strength function often has much more structure than that observed experimentally. The doorways themselves must be strongly mixed with states of even higher complexity. A complete description of damping would require an understanding of the mixing at each level of complexity, but this remains for the future.





EXTENSIVE ANALYSIS OF THE EFFECTS OF THE COUPLING OF SINGLE-PARTICLE LEVELS TO OTHER MODES OF EXCITATION IN ^{3}HE, ELECTRON GAS, NUCLEAR MATTER AND NUCLEI

PHYSICS REPORTS 120, Nos. 1–4 (1985) 1–274.

DYNAMICS OF THE SHELL MODEL

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P.F. BORTIGNON

Istituto di Fisica Galileo Galilei, I-35100 Padova, Italy

R.A. BROGLIA

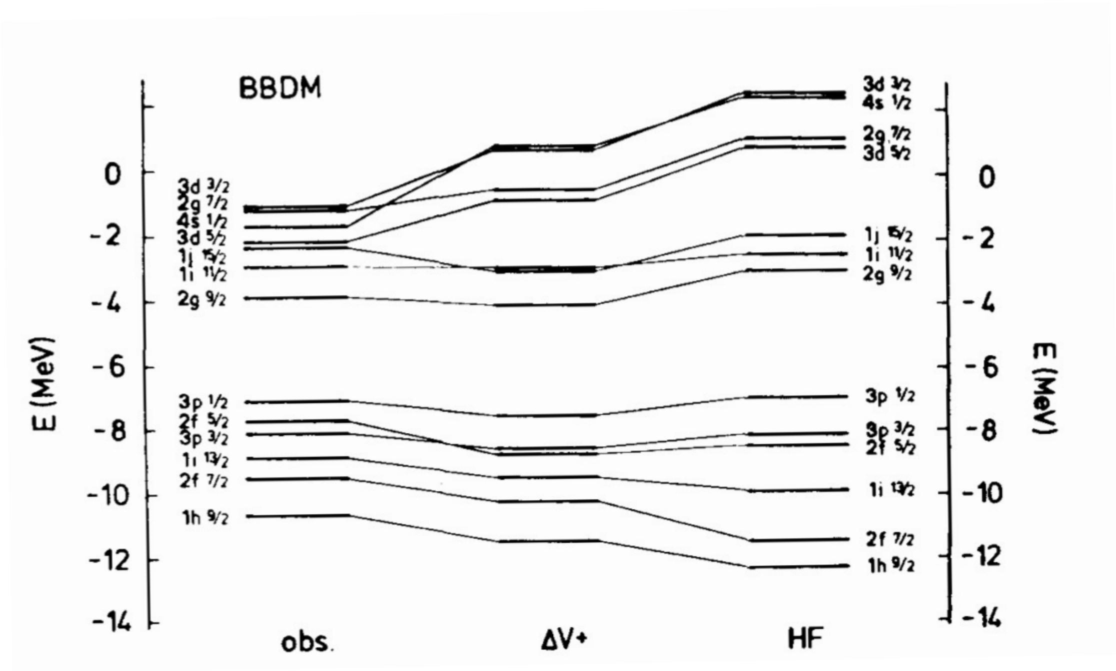
Niels Bohr Institutet, University of Copenhagen, DK-2100 Copenhagen Ø, Denmark

and

C.H. DASSO

NORDITA, Blegdamsvej 17, DK-2100 Copenhagen Ø, Denmark

^{208}Pb



Eur. Phys. J. A (2019) **55**: 222
DOI 10.1140/epja/i2019-12742-2

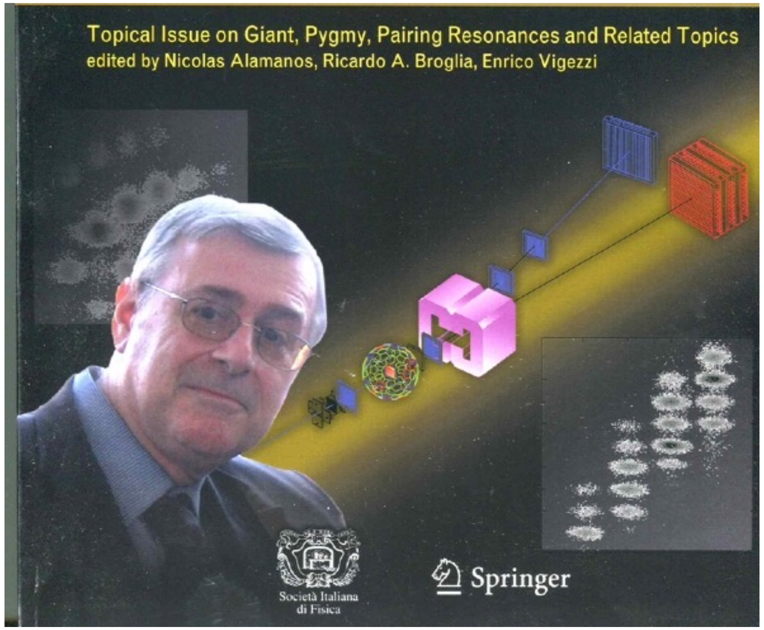
THE EUROPEAN PHYSICAL JOURNAL A

Regular Article – Theoretical Physics

Pier Francesco Bortignon as a scientist[★]

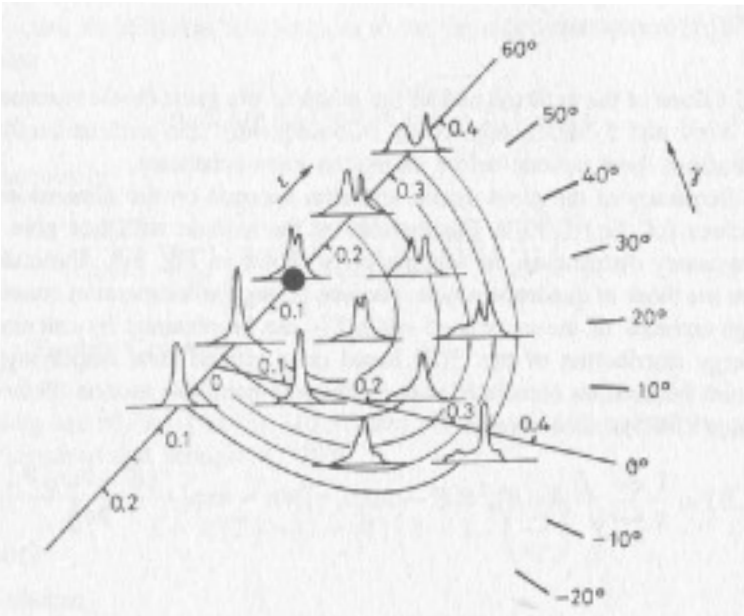
R.A. Broglia[1,2,a]

[1] Department of Physics, University of Milan, via Celoria 16, 20133 Milan, Italy
[2] The Niels Bohr Institute, Blegdamsvej 17, DK-2100 University of Copenhagen, Copenhagen, Denmark

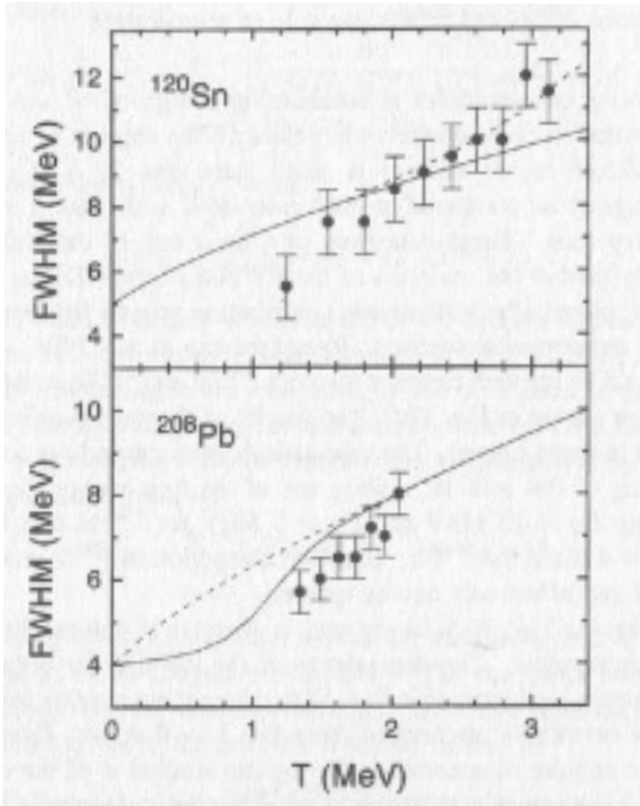


I vividly remember the summer of 1981 at Santa Barbara when we (Pier Francesco and myself) together with George Bertsch wrote the Review of Modern Physics paper on the damping of nuclear excitations. The initial remark of George regarding the project was something like "now there is something to review". He was referring to the recently published Nuclear Physics paper concerning the role of the nuclear surface on the damping of nuclear motion, a paper in which Pier Francesco had demonstrated his mastery in the subtleties of finite many-body techniques by identifying the doorway states to the compound nucleus, for both single-particle motion and giant resonances.

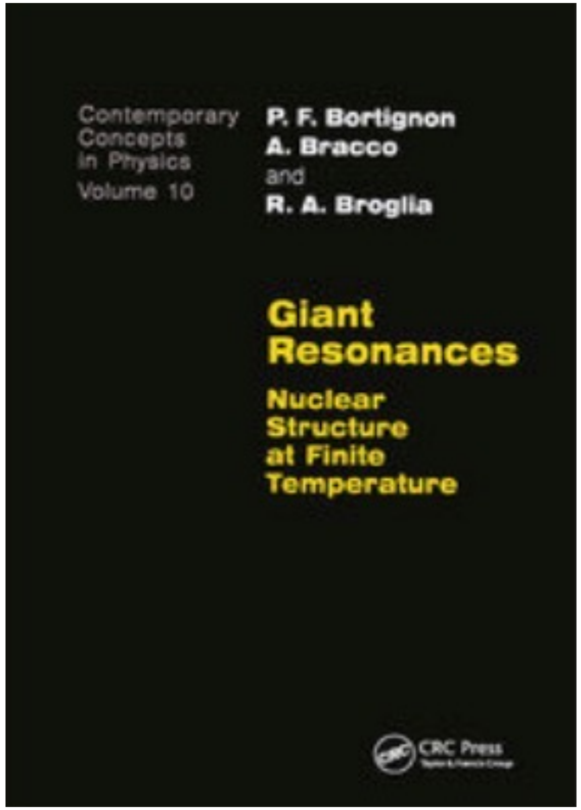
THE GIANT DIPOLE RESONANCE IN HOT NUCLEI



I. Gallardo, M. Diebel, T. Døssing, R.A. Broglia, Nucl. Phys. A443 (1985) 415



W.E. Ormand, P.F. Bortignon, R.A. Broglia, A. Bracco, Nucl. Phys. A614 (1997) 217



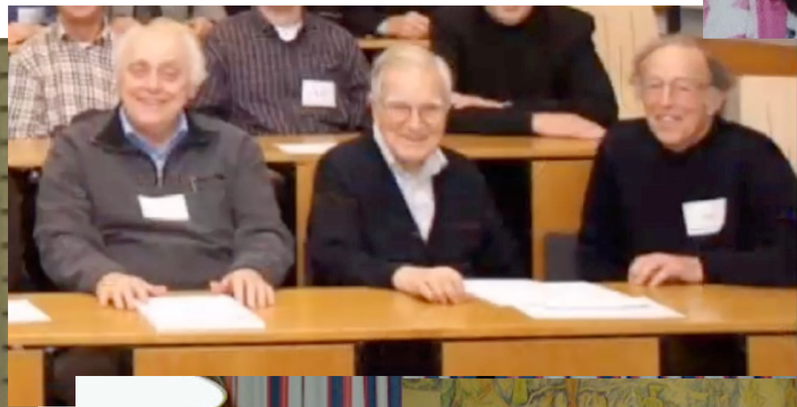
1998

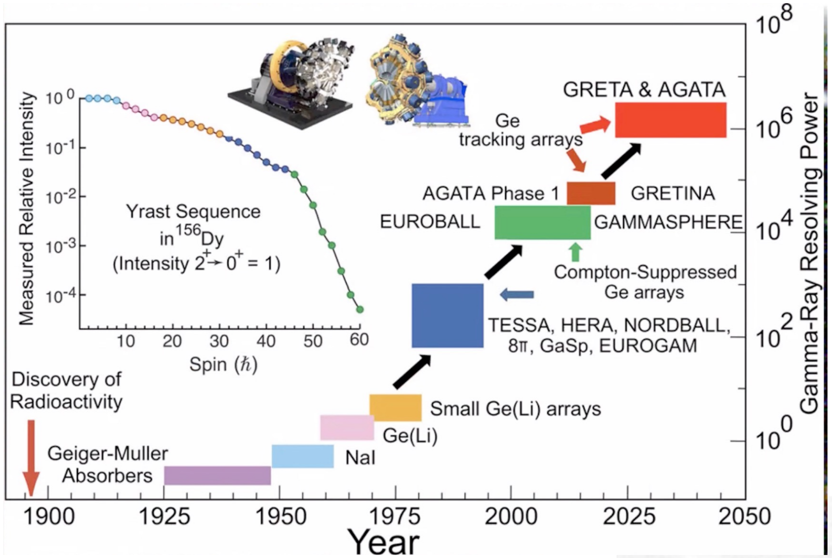
1985-2011: Full Professor at Milano University

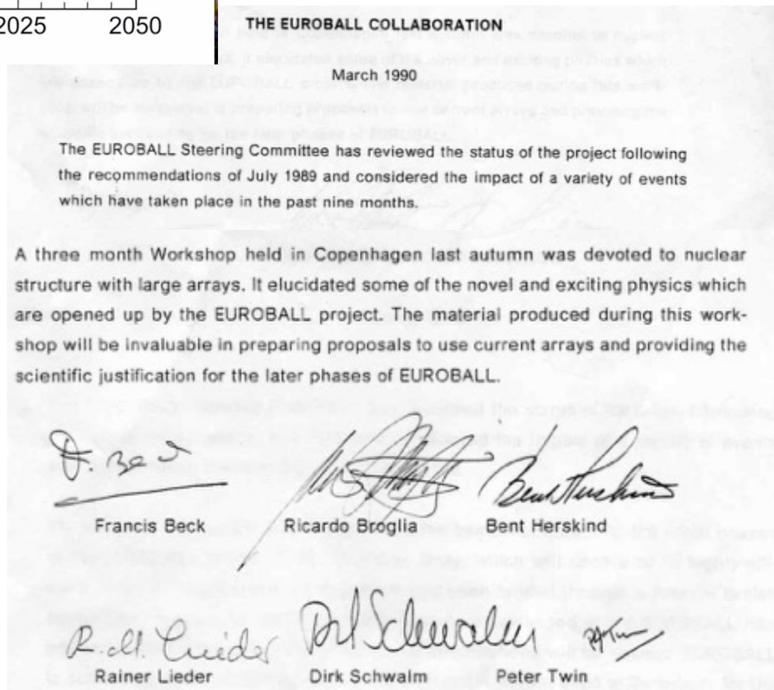
"It might seem unnatural that I have left what is one of the most prestigious physics institutes in the world (even though I have kept my research chair there) to create a new theoretical nuclear physics group in Milan.
Having learned in Copenhagen, from the school created by Niels Bohr, not only physics but above all what a great school of research and thought at the highest level was, I did not doubt back in 1986 that the time had come to move again.
Basic scientific research needs only one thing in order to develop: a positive atmosphere.
The antiscientific period that Denmark went through at that time was not the right one to be able to continue developing what was at the time the most important nuclear theoretical physics group in the world.
In particular, in a few years we had lost all the brightest young people to the United States for lack of research positions.

At the Department of Physics of the University of Milan I was able to create a theoretical nuclear physics group whose theoretical production places it today among the strongest in the world. Furthermore, I have been able to create an interdisciplinary group that deals with neutron stars, molecular aggregates, protein folding and the design of unconventional drugs.
Our group has gone from a dream (shared only with the late Prof. Francesco Resmini, former director of the Milanese superconducting cyclotron project) to a reality of great value."

A strong collaboration with the γ-spectroscopy community between Milano and Copenhagen and experimentalists and theoreticians







THE EUROBALL COLLABORATION

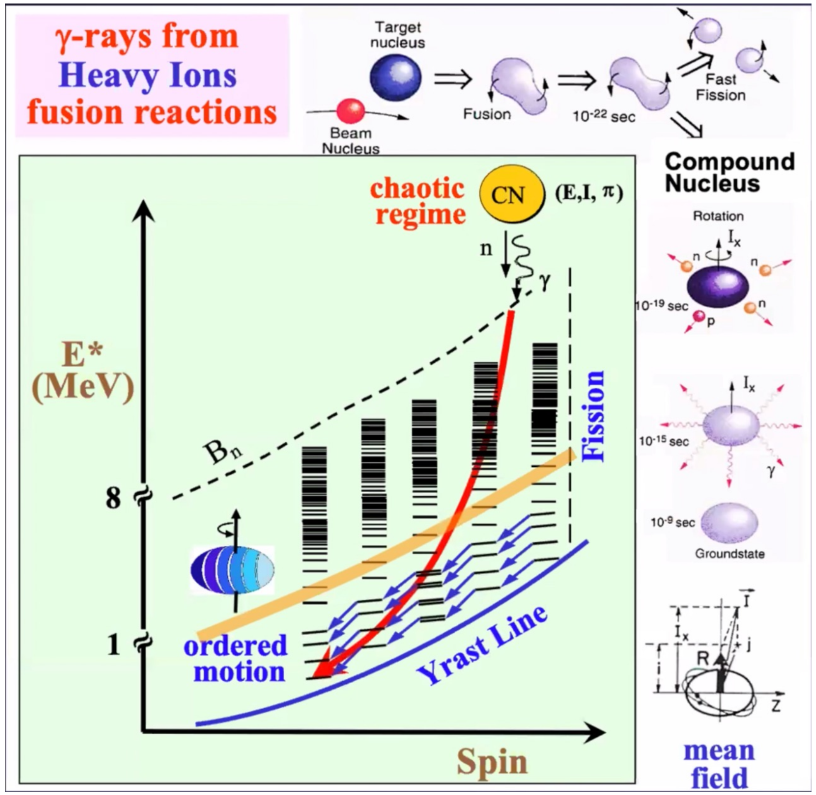
March 1990

The EUROBALL Steering Committee has reviewed the status of the project following the recommendations of July 1989 and considered the impact of a variety of events which have taken place in the past nine months.

A three month Workshop held in Copenhagen last autumn was devoted to nuclear structure with large arrays. It elucidated some of the novel and exciting physics which are opened up by the EUROBALL project. The material produced during this workshop will be invaluable in preparing proposals to use current arrays and providing the scientific justification for the later phases of EUROBALL.

Francis Beck Ricardo Broglia Bent Herskind

Rainer Lieder Dirk Schwalm Peter Twin



Nuclear Physics **A457** (1986) 61–83

DAMPING OF ROTATIONAL MOTION

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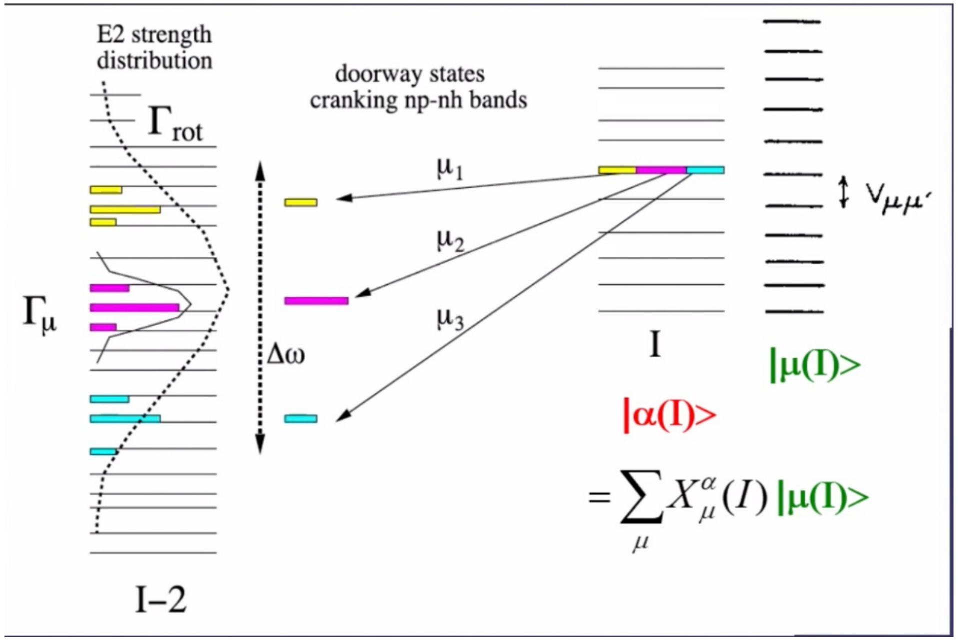
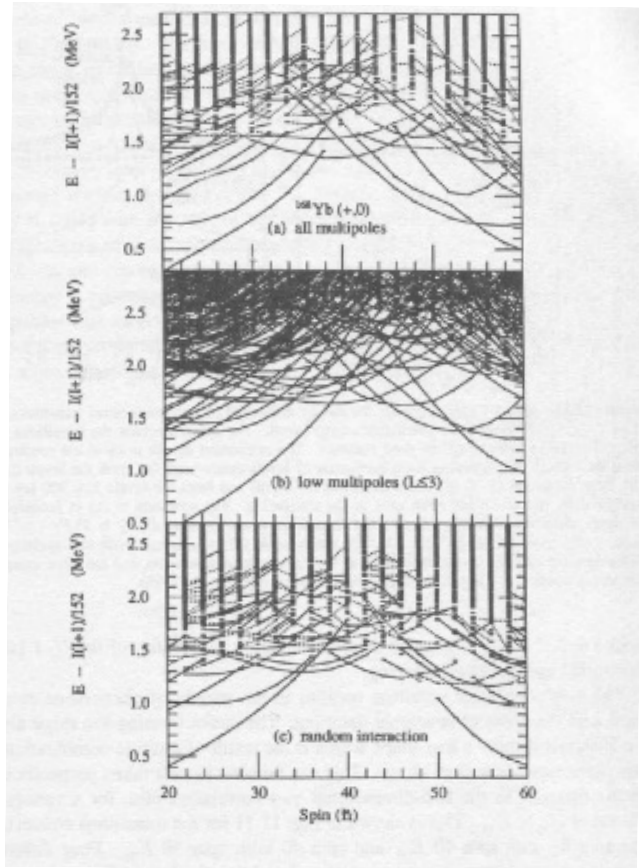
R.A. BROGLIA

The Niels Bohr Institute, University of Copenhagen, Blegdamsvej 17, DK-2100 Copenhagen Ø, Denmark
and
Dipartimento di Fisica, Universita di Milano, Via Celoria 16, and INFN Sez. Milano, 20133 Milano, Italy



Understanding the rotational decay of warm nuclei: rotational damping



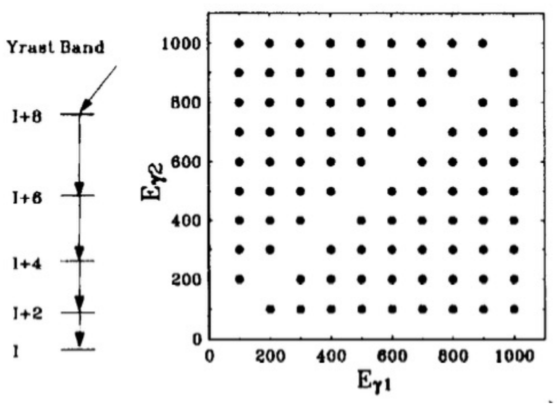
Physics Reports 268 (1996) 1–84

FLUCTUATION ANALYSIS OF ROTATIONAL SPECTRA

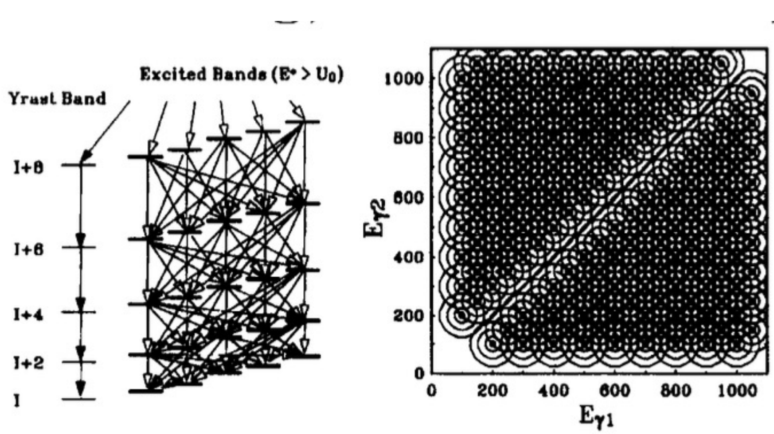
T. DØSSING, B. HERSKIND, S. LEONI, A. BRACCO, R.A. BROGLIA, M. MATSUO, E. VIGEZZI

[a]*The Niels Bohr Institute for Astronomy, Physics and Geophysics, University of Copenhagen, Risø 4000 Roskilde, Denmark*
[b]*Dipartimento di Fisica, Università di Milano, Milano, Italy*
[c]*INFN, Sezione di Milano, Milano, Italy*
[d]*Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto, Japan*

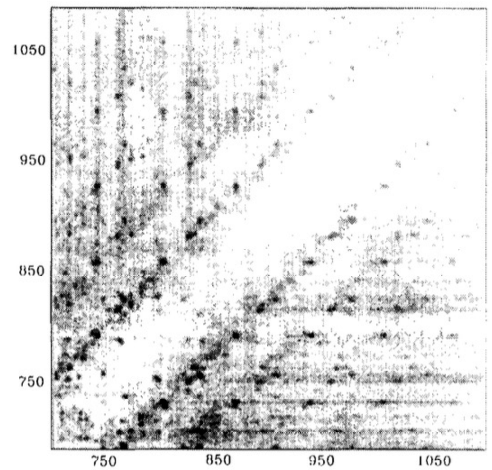
Regular bands



Mixed bands



Experiment



Pairing fluctuations in rapidly rotating nuclei

Y. R. Shimizu* and J. D. Garrett†
The Niels Bohr Institute, University of Copenhagen, DK-2100 Copenhagen Ø, Denmark

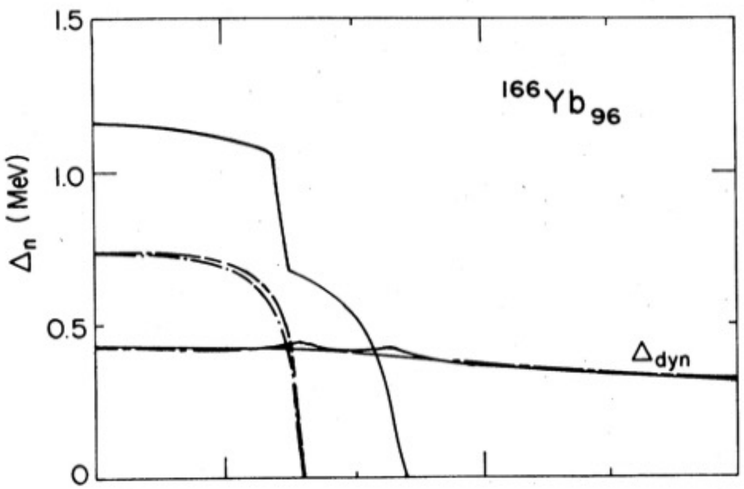
R. A. Broglia
The Niels Bohr Institute, University of Copenhagen, DK-2100 Copenhagen Ø, Denmark and Dipartimento di Fisica, Università di Milano, and Istituto Nazionale di Fisica Nucleare, Sezione di Milano, 20133 Milano, Italy

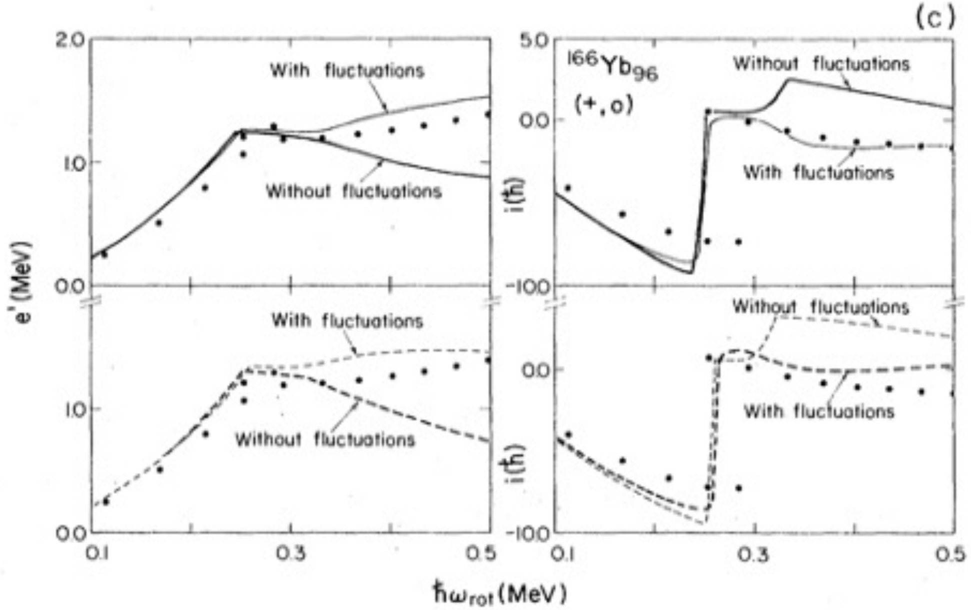
M. Gallardo
Departamento de Fisica Atomica, Molecular y Nuclear, Universidad de Sevilla, 41080 Sevilla, Spain

E. Vigezzi
Istituto Nazionale di Fisica Nucleare, Sezione di Milano, 20133 Milano, Italy

Reviews of Modern Physics, Vol. 61, No. 1, January 1989

Nuclear rotation kills the static pairing gap in deformed nuclei but pairing fluctuations can still play an important role





40 years of collaboration: Francisco Barranco


DEPARTAMENTO DE
FISICA ATOMICA Y NUCLEAR

Universidad de Sevilla

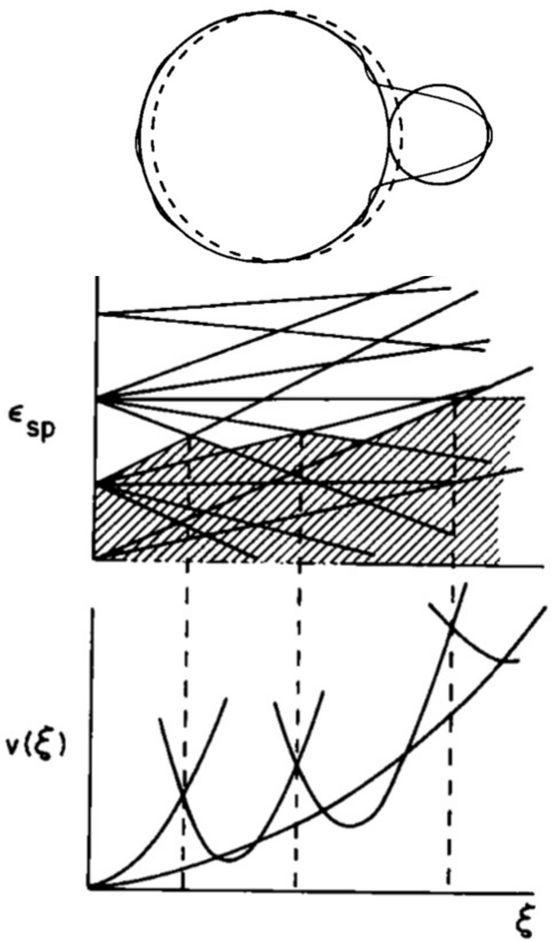
ESTUDIO DE LAS FLUCTUACIONES Y CORRELACIONES
EN EL ESTADO FUNDAMENTAL DEL NUCLEO

Francisco Barranco Paulano

Tesis Doctoral — Diciembre 1985

A MODEL FOR ADIABATIC LARGE AMPLITUDE MOTION: SUPERFLUID TUNNELING

$^{223}Ra \rightarrow \, ^{209}Pb + ^{14}C$

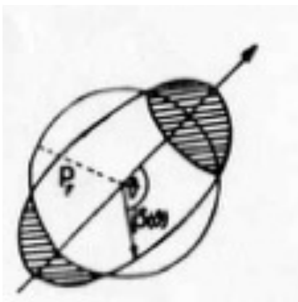


Nuclear Physics **A512** (1990) 253–274

LARGE-AMPLITUDE MOTION IN SUPERFLUID FERMI DROPLETS

F. BARRANCO
G.F. BERTSCH
R.A. BROGLIA and E. VIGEZZI

Local minima as a function of deformation parameter correspond to a spherical Fermi sphere in momentum space.
Shape changes distort the fermi sphere. Sphericity is restored by jumps of pairs of particles a level crossings, connecting local minima.
This gives a criterion to determine the number of level crossings between the ground state and the scission point.
The pairing interaction makes pairs of particles jump at level crossings: pickup from upsloping levels and stripping unto downsloping orbitals ;
The collective inertia **D** depends on the number of crossings **n** and on the strength of the pairing interaction **G:**



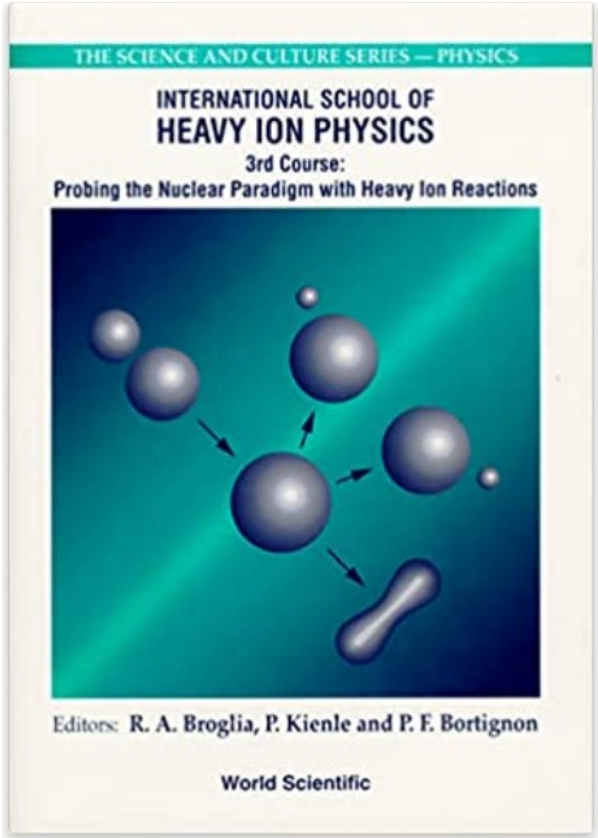
$$\left(-\frac{\hbar^2}{2D}\frac{d^2\Phi(\xi)}{d\xi^2}+V(\xi)\right)\Phi_\alpha(\xi)=E\Phi_\alpha(\xi)\,.$$

$$D=\hbar^2\frac{2G\,n^2}{\Delta_\nu^2+\Delta_\pi^2}$$

Decay	Q (MeV)	$\log t_{1/2}$ (s) theory	$\log t_{1/2}$ (s) exp.
^{221}Fr (^{14}C)	31.28	13.5	> 15.77
^{221}Ra (^{14}C)	32.39	11.7	> 14.35
^{222}Ra (^{14}C)	33.05	10.6	11.02 (0.06)
^{223}Ra (^{14}C)	31.85	13.2	15.2 (0.05)
^{224}Ra (^{14}C)	30.53	16.3	15.9 (0.12)
^{225}Ac (^{14}C)	30.47	17.7	> 18.34
^{226}Ra (^{14}C)	28.21	22.0	21.33 (0.2)
^{230}Th (^{24}Ne)	57.78	26.2	24.64 (0.07)
^{232}Th (^{26}Ne)	55.97	31.7	> 27.94
^{231}Pa (^{24}Ne)	60.42	22.8	23.38 (0.08)
^{232}U (^{24}Ne)	62.33	21.0	21.06 (0.1)
^{233}U (^{24}Ne)	60.50	24.3	24.82 (0.15)
^{234}U (^{24}Ne)	58.84	27.5	25.25 (0.05)
^{234}U (^{26}Ne)	59.47	28.0	
^{234}U (^{28}Mg)	74.13	28.2	25.75 (0.06)
^{237}Np (^{30}Mg)	75.02	29.1	> 27.27
^{238}Pu (^{30}Mg)	77.03	27.5	25.7 (0.25)
^{238}Pu (^{28}Mg)	75.93	28.8	
^{238}Pu (^{32}Si)	91.21	28.6	25.3 (0.16)
^{241}Am (^{34}Si)	93.84	26.4	> 25.3; > 24.2

APPLICATIONS TO:
DECAY OF SUPERDEFORMED BANDS
DECAY OF K-ISOMERS

Co-director of 10 summer schools



Varenna 1987

1987
7 - 17 July

CIV COURSE
Directors: R.A. BROGLIA and J.R. SCHRIEFFER

Frontiers and borderlines in many-particle physics

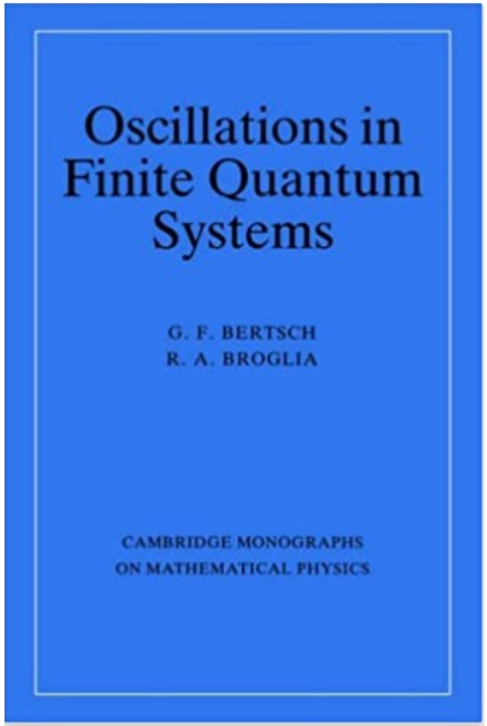
E. MARINARI - The lattice strong interactions: an introduction.
A. J. LEGGETT - The quantum mechanics of a macroscopic variable: some recent results and current issues.
T. M. RICE - Heavy fermions.
R. A. BROGLIA - Theory of relaxation, phase transitions and tunneling in nuclei.
D. M. BRINK - Quantum effects in heavy ion reactions.
G. BERTSCH - Collective motion in Fermi droplets.
R. SCHRIEFFER, D.P. AROVAS - The quantum Hall effect.
P. W. ANDERSON - 50 years of the Mott phenomenon: insulators, magnets, solids and superconductors as aspects of strong-repulsion theory.
D. J. SCALAPINO - Numerical simulation of many electron condensed matter systems.
G. BAYM - Moments at the relativistic borderline: nuclei and rotating superconductors.

Symposium on
"Finite Many-Body Systems" on the occasion
of the conferral of the laurea honoris causa
on George F. Bertsch

Università degli Studi di Milano
and INFN, Sez. of Milano

Tuesday, March 2nd, 2004

"For his countless contributions to the theory of nuclear structure and reactions which have made it possible, inter alia, to understand the elastic and plastic properties of these systems"

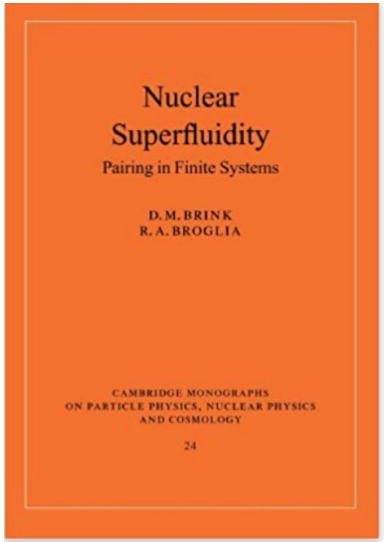


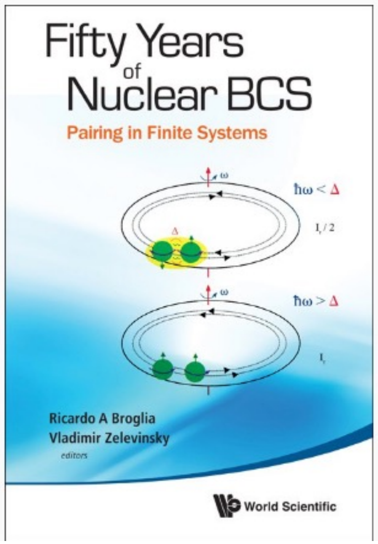
Rotating Superfluidity in Nuclei.

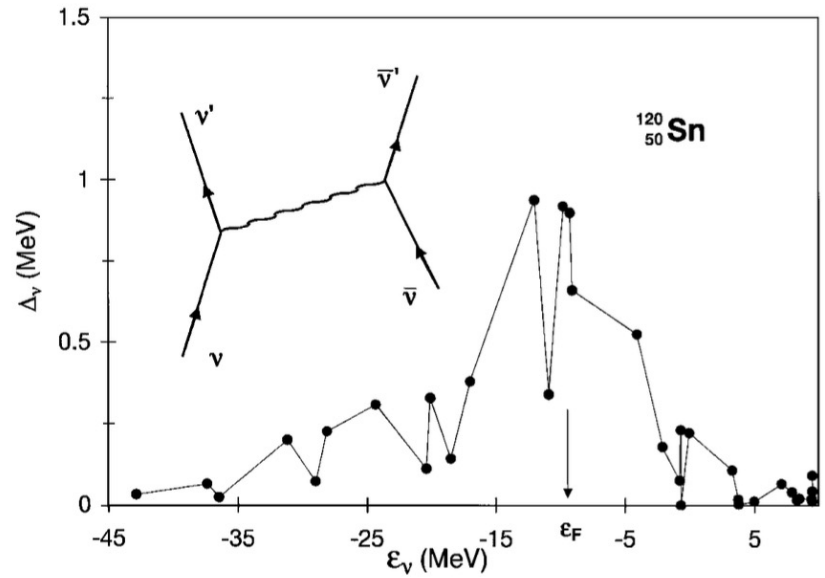
G. F. Bertsch (*), R. A. Broglia (**) and R. Schrieffer (***)

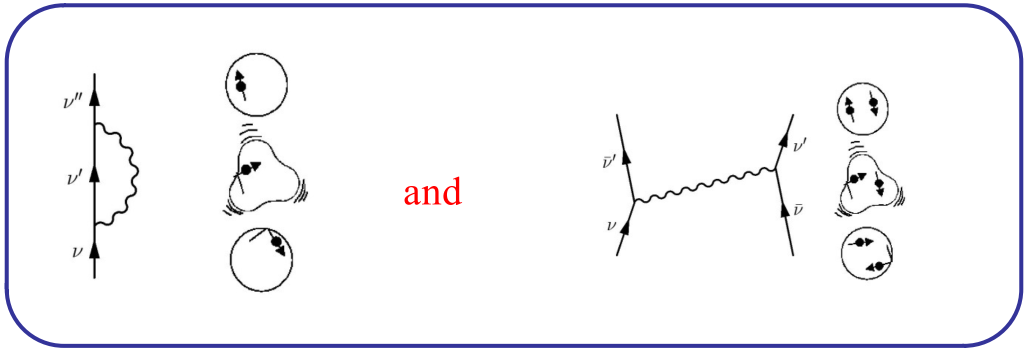
Villa Monastero, Varenna sul Lago di Como - Como

SUPERFLUIDITY AND PARTICLE-VIBRATION COUPLING









J. Terasaki et al., Nucl.Phys. **A697**(2002)126;

F. Barranco et al, EPJ A21 (2004) 57

A. Idini et al. PRC 85 (2012) 014

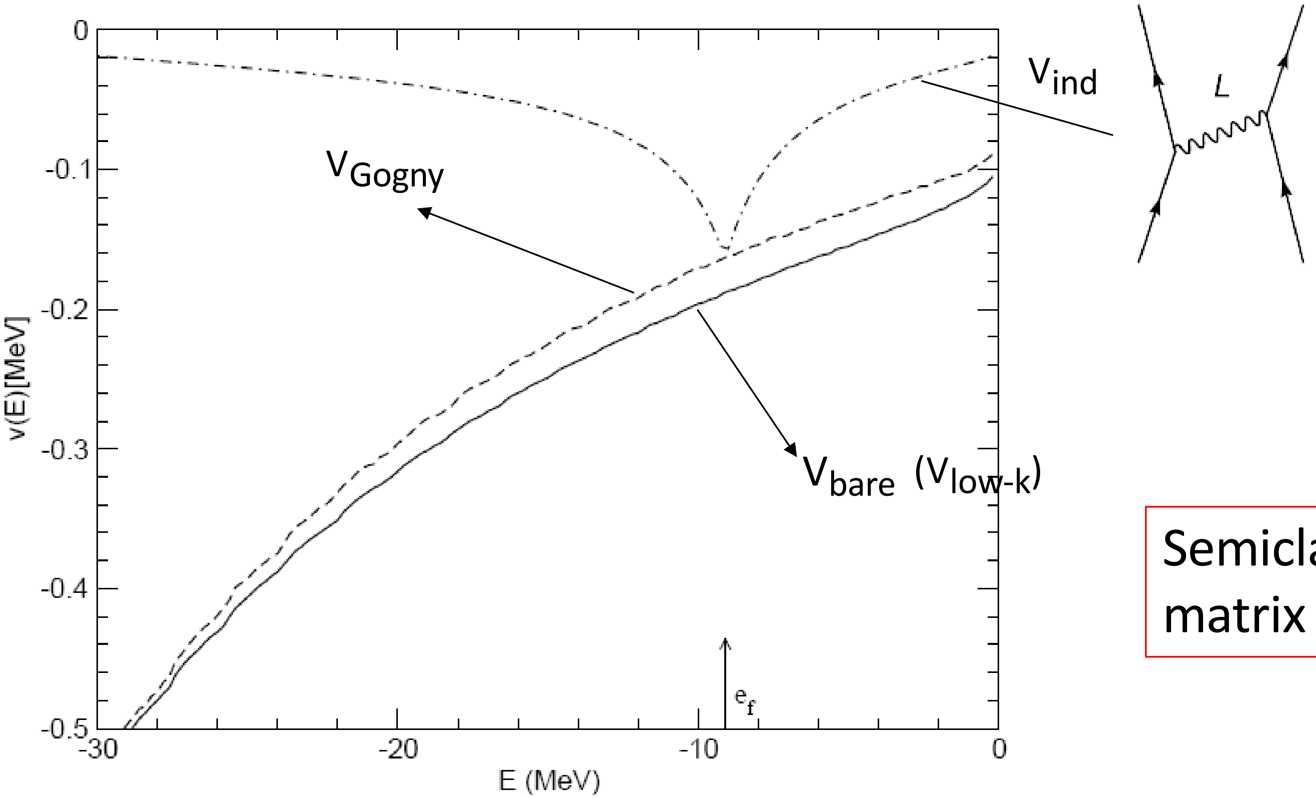
cf. V. Soma' , C. Barbieri, T. Duguet,

PRC **84** (2011) 064317 ;PRC87 (2013) 011303

PHYSICAL REVIEW C **72**, 054314 (2005)

Pairing matrix elements and pairing gaps with bare, effective, and induced interactions

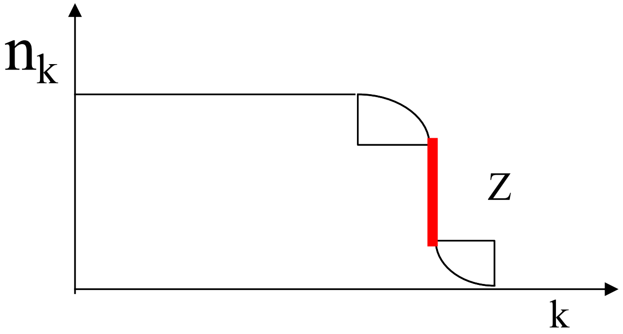
F. Barranco,[1] P. F. Bortignon,[2,3] R. A. Broglia,[2,3,4] G. Colò,[2,3] P. Schuck,[5] E. Vigezzi,[3] and X. Viñas[6]



Semiclassical diagonal pairing matrix elements (^{120}Sn)

Z=1 free Fermi gas

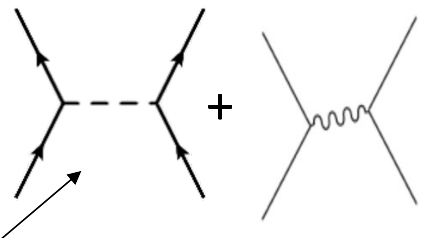
Z<1 correlated Fermi system



FROM ‘BARE’ TO RENORMALIZED PAIRING GAPS

Quasiparticle strength <1

Bare+Induced interaction



$$\Delta_p = -\frac{1}{2}\int d^3p' \frac{Z_p V_{pp'} Z_{p'}}{\sqrt{(\tilde{\varepsilon}_{p'}-\varepsilon_F)^2+\Delta_{p'}^2}}\Delta_{p'}$$

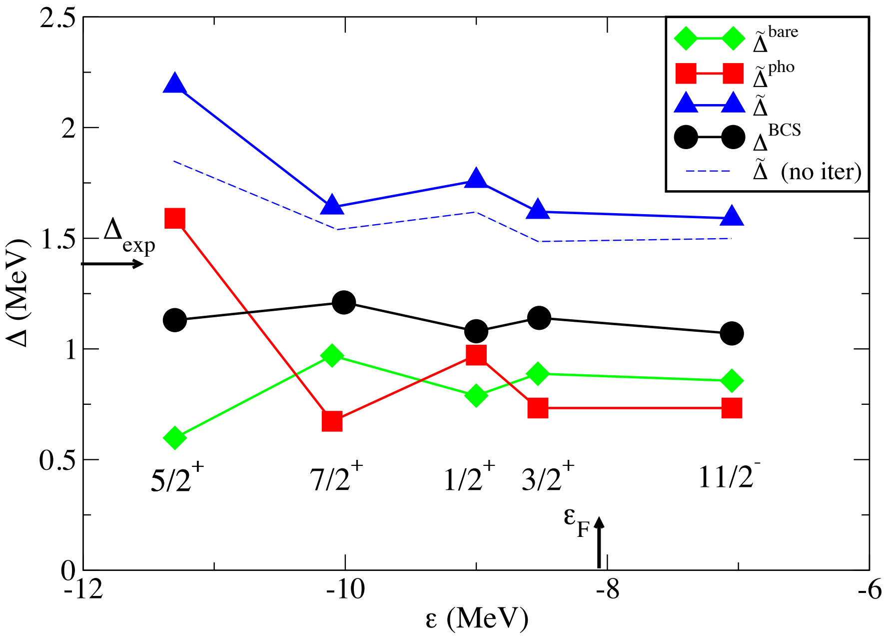
Renormalized s.p. energy

Bare interaction: Δ^{BCS}

Reduced occupation factor: $\Delta^{bare} = Z\ \Delta^{BCS}$

Induced pairing interaction: Δ^{ind}

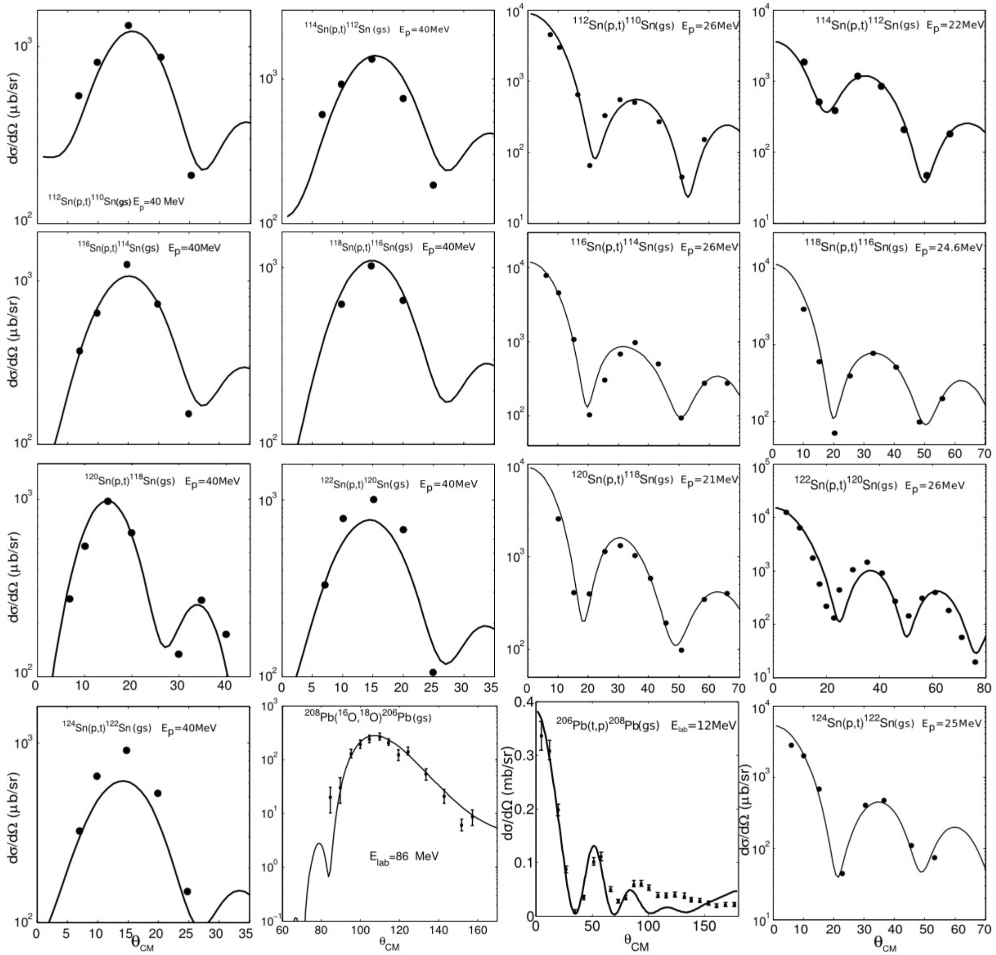
Total gap : $\Delta^{bare} + \Delta^{ind}$



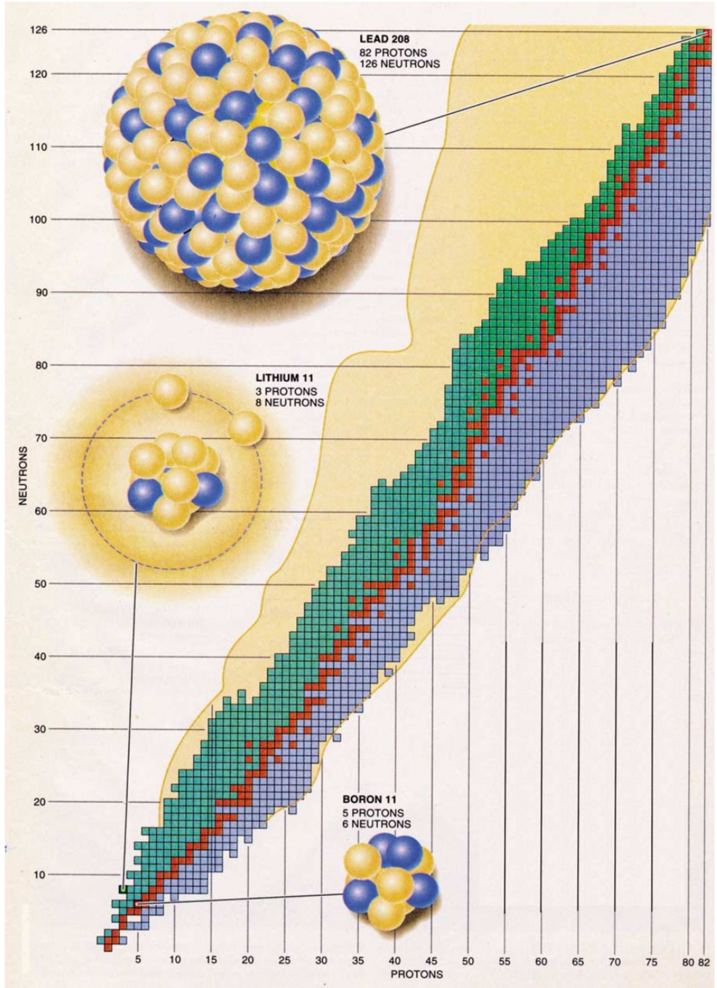
Software developed by Gregory Potel during his stay in Milano, following Ben Bayman's footsteps led to quantitative agreement between theoretical and experimental absolute cross sections with finite-range sequential DWBA

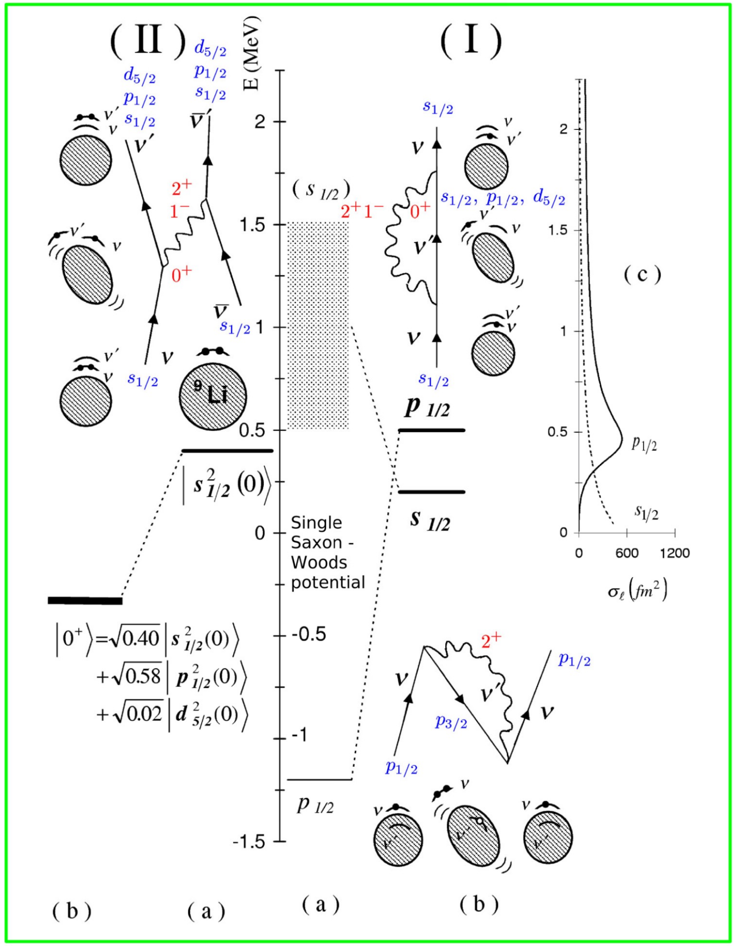
TWO-PARTICLE TRANSFER

Rep. Prog. Phys. **76** (2013) 106301 G Potel *et al*



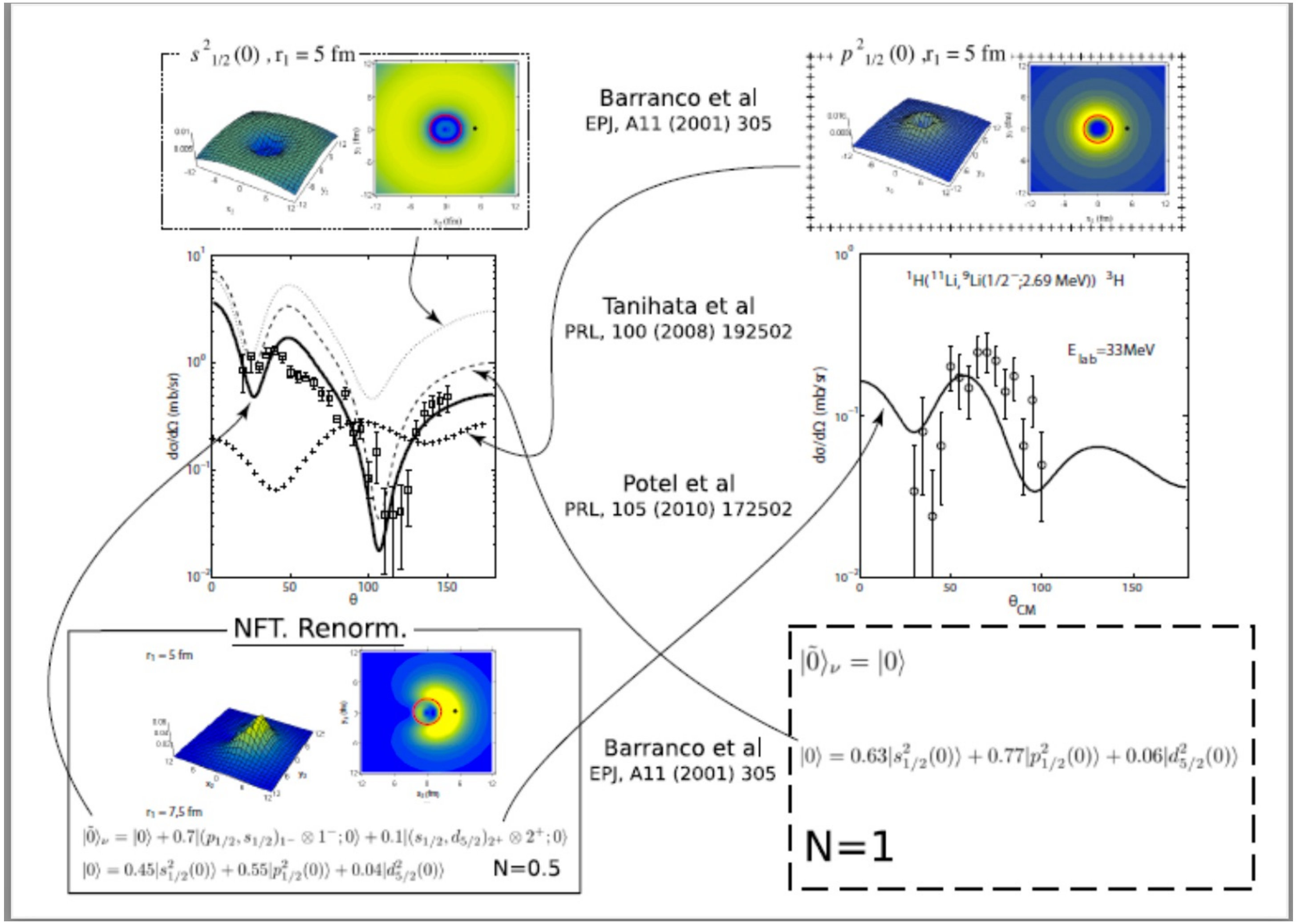
HALO NUCLEI: STRUCTURE AND REACTIONS OF ^{11}Li





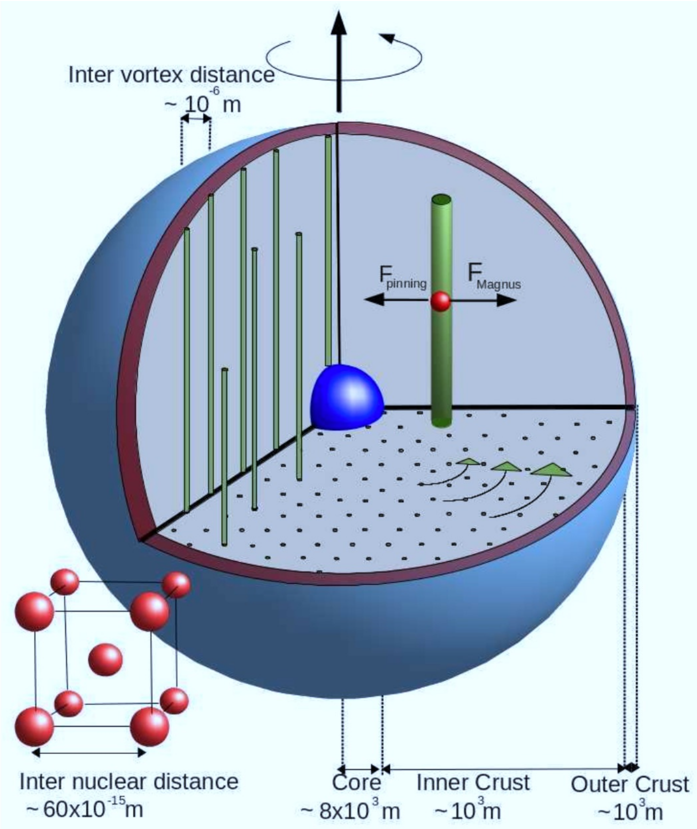
F. Barranco, P.F. Bortignon, R.A. Broglia, G. Coló and E. Vigezzi, *The halo of the exotic nucleus ^{11}Li: a single Cooper pair*, Eur. Phys. J. **A11** (2001) 385-392

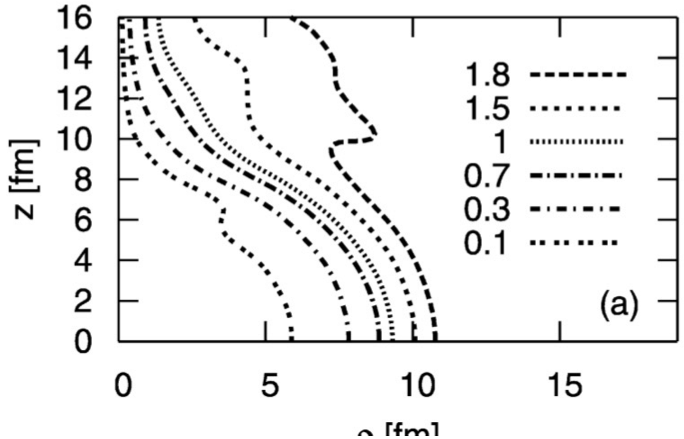
HALO NUCLEI: STRUCTURE AND REACTIONS OF ^{11}LI



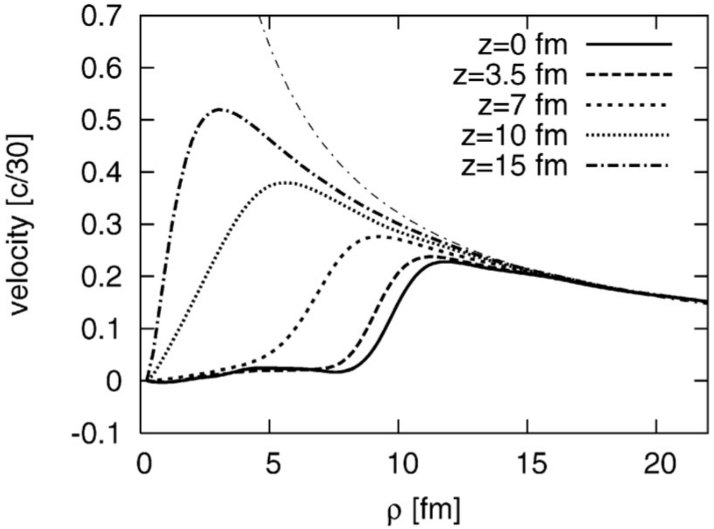
Neutron stars: first quantum calculation of the structure of vortices in the inner crust

Nucl. Phys. A 811 (2008) 378



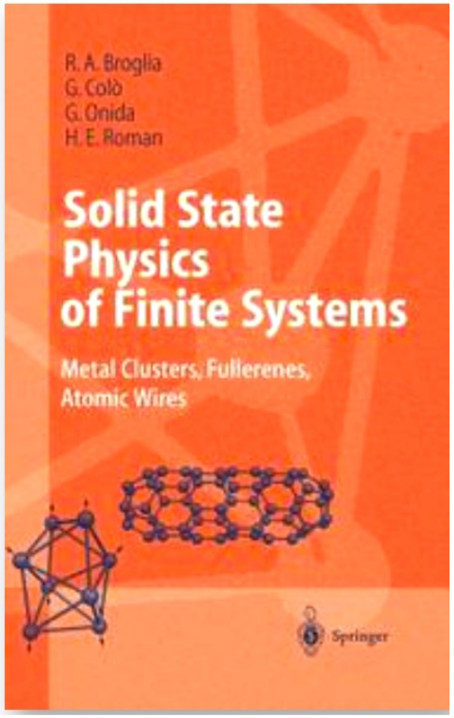


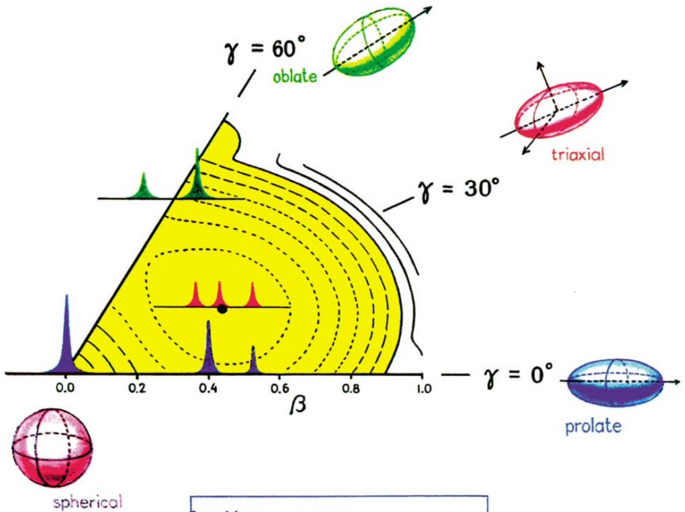
Pairing gap

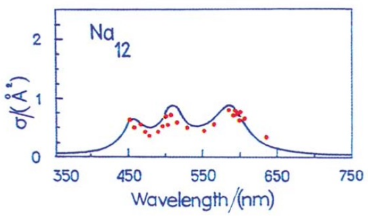


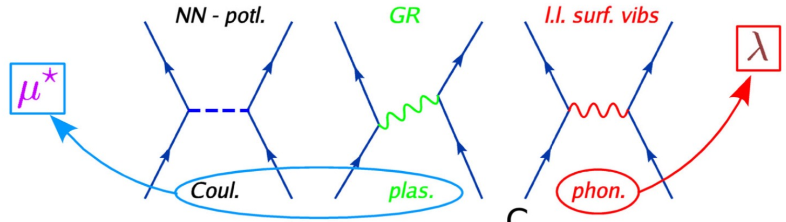
Velocity

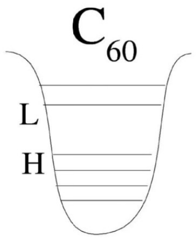
METAL CLUSTERS AND FULLERENES: ANALOGIES WITH ATOMIC NUCLEI



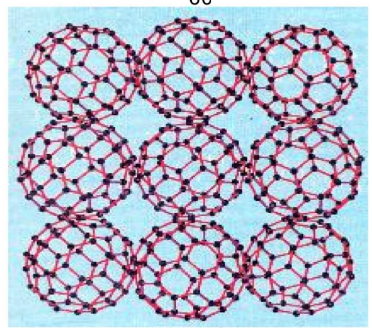








C_{60}



$$T_c = \frac{\langle \hbar\omega_{ph} \rangle}{1.2} \exp\left[-\frac{1.04(1+\lambda)}{\lambda - \mu^\star(1+0.62\lambda)}\right]$$

$$\lambda = 1.3, \quad \mu^\star \approx 0.3, \quad T_c \approx 29.5\ \mathrm{K}$$

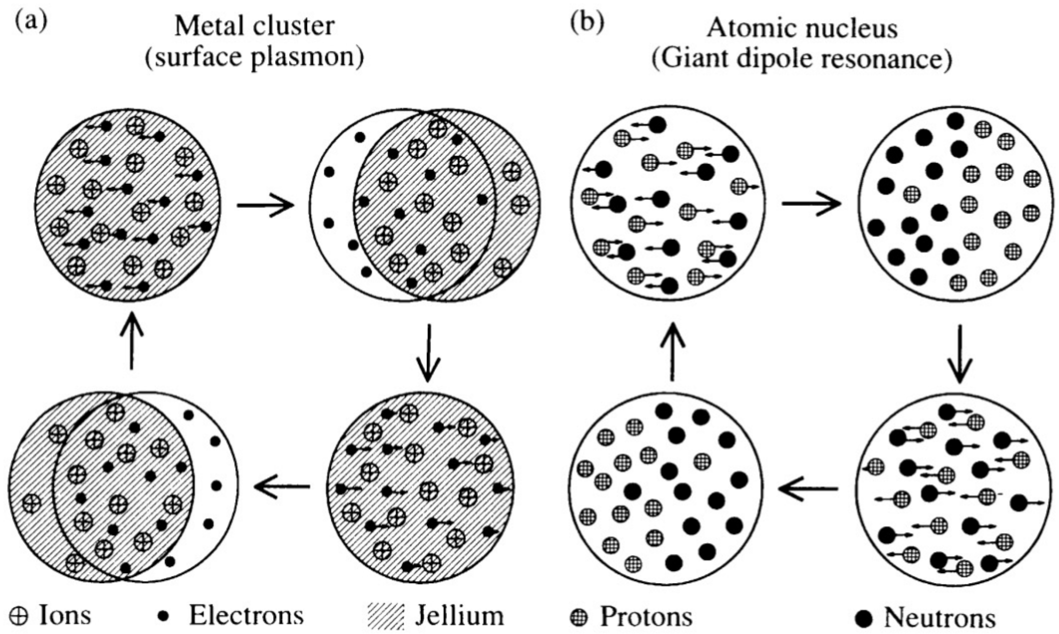
ELSEVIER

Surface Science 500 (2002) 759–792

The surfaces of compact systems: from nuclei to stars

R.A. Broglia [a,b,*]

The vibrations of the surface of finite many-body systems dress the single-particle motion, renormalizing its properties and consequently, the properties of the entire system. In fact, in their trajectories particles bounce, most of the time, elastically off the surface. From time to time, however, they set the surface into vibration, vibration which can be reabsorbed at a later time by the same particle or by another particle. In the first case the particle carries around a vibration and becomes effectively heavier, which thus modifies, among other things, the specific heat of the system. In the second case, the vibration becomes a messenger between two particles, and thus acts as a glue. The resulting interaction is particularly efficient in producing pairs of particles. These pairs of particles have properties that are very different from those of single particles. In particular they may behave collectively as a liquid without viscosity, or, if charged, without resistance. That is, as a superfluid or as a superconductor.



A FINAL REFLECTION- P.W. ANDERSON

4 August 1972, Volume 177, Number 4047

SCIENCE

More Is Different

Broken symmetry and the nature of the hierarchical structure of science.

P. W. Anderson

Emergent properties vs .reductionism

The reductionist hypothesis may still be a topic for controversy among philosophers, but among the great majority of active scientists I think it is accepted without question. The workings of our minds and bodies, and of all the animate or inanimate matter of which we have any detailed knowledge, are assumed to be controlled by the same set of fundamental laws, which except under certain extreme conditions we feel we know pretty well.

"state" ever has that structure. It is fascinating that it was not until a couple of decades ago (2) that nuclear physicists stopped thinking of the nucleus as a featureless, symmetrical little ball and realized that while it really never has a dipole moment, it can become football-shaped or plate-shaped. This has observable consequences in the reactions and excitation spectra that are studied in nuclear physics,

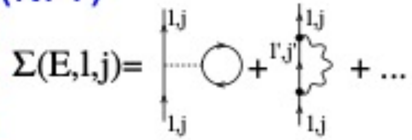
But it needed no new knowledge of fundamental laws and would have been extremely difficult to derive synthetically from those laws; it was simply an inspiration, based, to be sure, on everyday intuition, which suddenly fitted everything together.

The basic reason why this result would have been difficult to derive is an important one for our further thinking. If the nucleus is sufficiently small there is no real way to define its shape rigorously: Three or four or ten particles whirling about each other do not define a rotating "plate" or "football." It is only as the nucleus is considered to be a many-body system—in what is often called the $N \to \infty$ limit—that such behavior is rigorously definable. We say to ourselves: A macroscopic body of that shape would have such-and-such a spectrum of rotational and vibrational excitations, completely different in nature from those which would characterize a featureless system. When we see such a spectrum, even not so separated, and somewhat imperfect, we recognize that the nucleus is, after all, not macroscopic; it is merely approaching macroscopic behavior. Starting with the fundamental laws and a computer, we would have to do two impossible things—solve a problem with infinitely many bodies, and then apply the result to a finite system—before we synthesized this behavior.

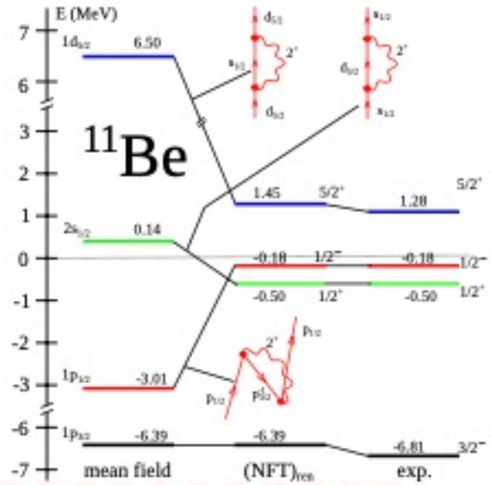
A. Bohr:

The condensates in superfluid systems involve a deformation of the field that creates the condensed bosons or fermion pairs. Thus, the process of addition or removal of a correlated pair of electrons from a superconductor (as in a Josephson junction) or of a nucleon pair from a superfluid nucleus constitutes a rotational mode in the gauge space in which particle number plays the role of angular momentum (73). Such pair rotational spectra, involving families of states in different nuclei, appear as a prominent feature in the study of two-particle transfer processes (74). The gauge space is often felt as a rather abstract construction but, in the particle-transfer processes, it is experienced in a very real manner.

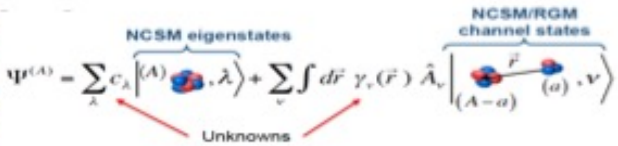
Nuclear Field Theory (NFT)



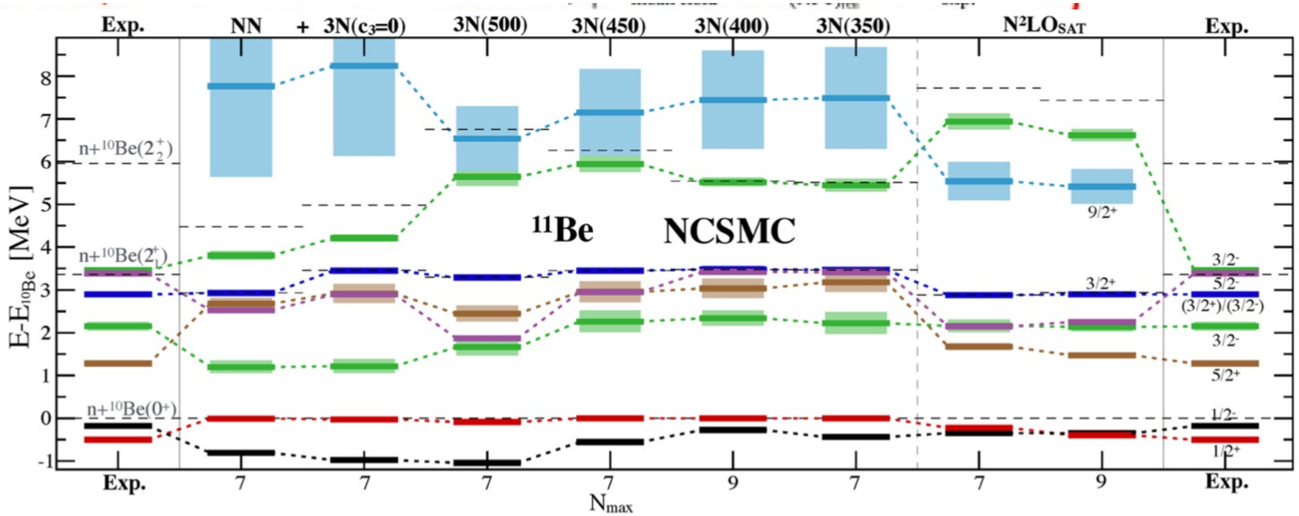
Barranco, Potel, Broglia, Vigezzi
PRL 119, 082501 (2017)



No-Core Shell Model with Continuum (NCSMC)



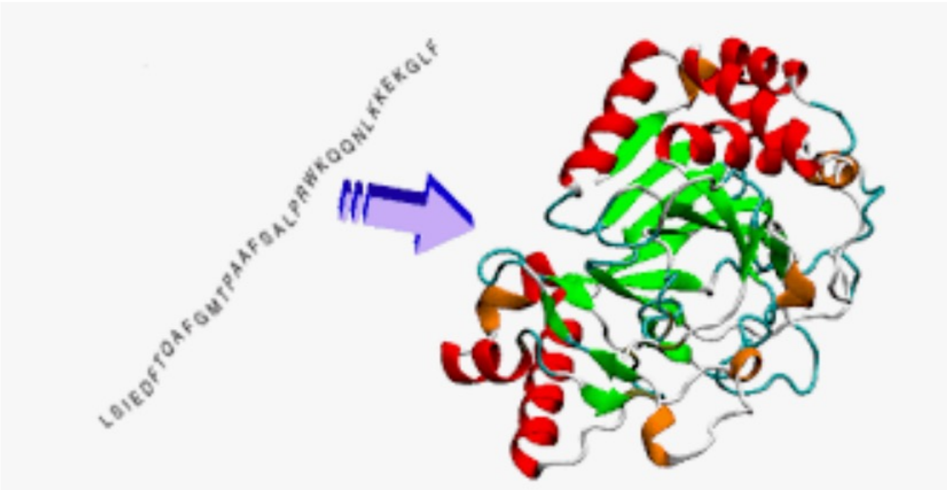
Calci et al. PRL 117, 242501 (2016)



Protein folding

I have always done the same thing …
If you do something new, you have to play in Premier League…

The protein folding problem



How can a linear sequence of aminoacids fold into a specific, biologically active, three-dimensional structure in a short time ?It is extremely difficult to answer with ‘ab initio’   molecular dynamics simulations

Broglia’s idea: there must exist specific, strongly interacting aminoacids that once in contact, determine the process. This is in analogy with the case of nuclei, where e a few ‘hot orbitals’ can determine a symmetry breaking phenomenon, like the transition from spherical to deformed shapes.

J. Chem. Phys. **108** (2), 8 January 1998

Folding and misfolding of designed proteinlike chains with mutations

G. Tiana
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R. A. Broglia
Dipartimento di Fisica, Università di Milano, Via Celoria 16, I-20133 Milano, Italy and INFN, Sezione di Milano, Via Celoria 16, I-20133 Milano, Italy and The Niels Bohr Institute, University of Copenhagen, 2100 Copenhagen, Denmark

H. E. Roman
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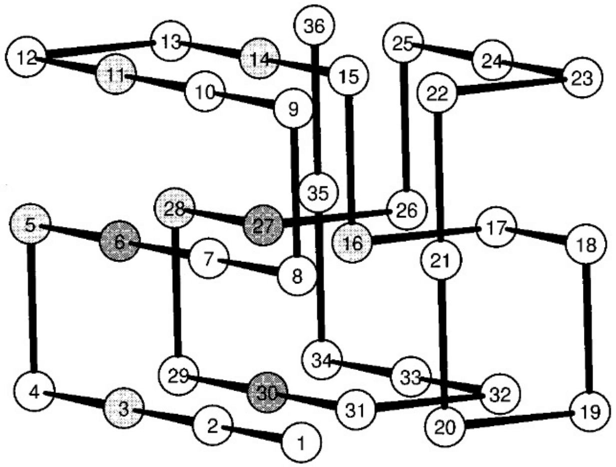
E. Vigezzi
Dipartimento di Fisica, Università di Milano, Via Celoria 16, I-20133 Milano, Italy and INFN, Sezione di Milano, Via Celoria 16, I-20133 Milano, Italy

E. Shakhnovich
Department of Chemistry, Harvard University, 12 Oxford Street, Cambridge, Massachusetts 02138

(Received 2 May 1997; accepted 2 October 1997)



$$E=\frac{1}{2}\sum_{i,j}^{N} U_{m(i),m(j)}\Delta(|\mathbf{r}_i-\mathbf{r}_j|),$$

Guido Tiana

ROTTAPHARM

Spin-off universitario Fold*LES*

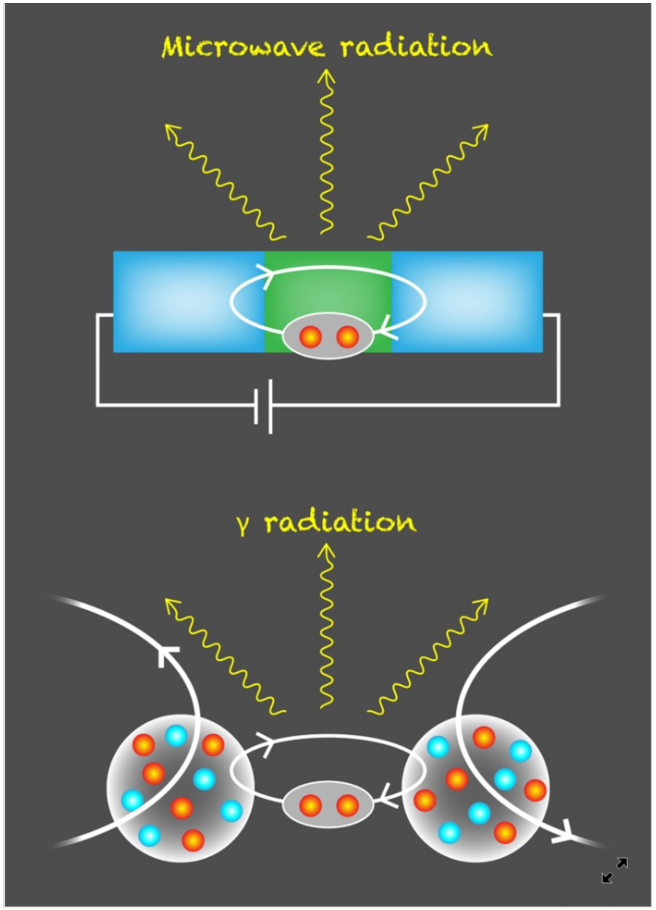
nuovo paradigma per il disegno di farmaci

R. A. Broglia
June 20th, 2008

Broglia worked almost up to the end of his life. Next year an experiment at INFN Legnaro Laboratory will test his idea, concerning the gamma-ray emission in coincidence with two-particle transfer between superfluid nuclei, in analogy to gamma-ray emission from Josephson junctions in condensed matter.
PRC 103 L021601 (2021)

The Tiniest Superfluid Circuit in Nature

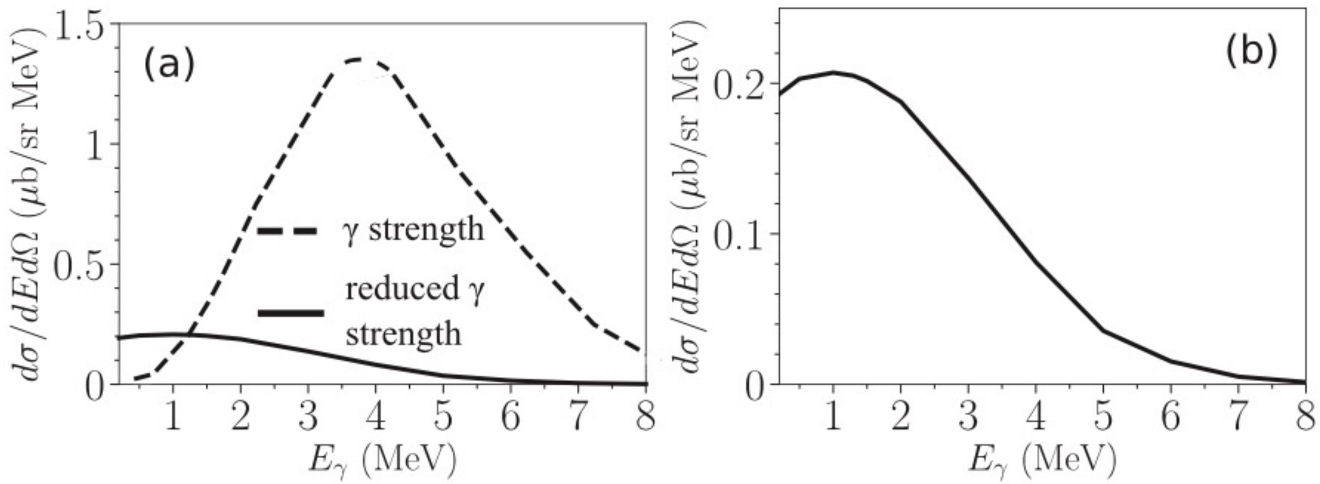
Piotr Magierski



APS/Alan Stonebraker

Figure 1: (Top) Sketch of a Josephson junction, in which Cooper pairs tunnel through a barrier (green) between two superconductors (blue). In the ac Josephson effect, an applied dc voltage produces an oscillating, or ac, current, leading to the emission of microwave photons. (Bottom) Potel and co-workers have shown that a similar description applies to colliding nuclei [4]. As the nuclei approach, neutron pairs tunnel back and forth between them, causing the emission of gamma-ray photons. **Show Less**

P. Magierski
Physics 14, 27 (2021)



A similar, incipient superradiant Josephson-like phenomenon is expected to arise in the case of the nuclear heavy-ion reaction under discussion from an ensemble of correlated Cooper pairs [$\alpha_0' \approx 8$ (2), ^{116}Sn (^{60}Ni)] undergoing the coherent back and forth quasielastic Cooper-pair transfer process. In what follows the associated γ-emission probability is calculated.