FUNDING APPLICATION FOR
EXPLORATORY RESEARCH PROJECTS - PN-II-ID-PCE-2011-3
Section 3

This document uses Times New Roman font, 12 point, 1.5 line spacing and 2 cm margins. Any modification of these parameters (excepting the figures and their captions), as well as exceeding the maximum number of pages set for each section can lead to the automatic disqualification of the application. The grey text contains instructions for the candidates and it may be removed and replaced with the required information. The black text must be kept, as it marks the mandatory information and sections of the application.

B. Project leader

B1. Scientific visibility and prestige (maximum 2 pages)

B.1.1. ***Main research results.***

Since 1965 I published 205 papers on various topics.The main achievements are:A) Microscopic description of quadrupole-octupole collective state. The nondegenerate quintuplet $1^-,2^-,3^-,4^-,5^-$ which is seen in some spherical and transitional nuclei is described as two quadrupole-octupole phonon states. The energies as well as the E2 and E3 decay properties of these states were calculated by several microscopic original models. B) The dependence on gamma deformation of the eigenfunctions of the Bohr-Mottelson harmonic Hamiltonian was not known for about 27 years after the liquid drop model was emitted. An elegant solution was found using the general theory of the harmonic functions. The solution provides very compact formulae for the matrix elements of any monomial of quadrupole bosons and their hermitian conjugates. C) A new collective model for the description of three interacting bands, ground, beta and gamma bands was proposed. The model is known in the literature under the name of The Coherent States Model (CSM)}. This is able to describe data concerning energies and e.m. transitions for states of angular momentum up to 40^+. Adding the octupole degrees of freedom CSM was extended which results in describing simultaneously eight bands four of positive and four of negative parity. Taking into account the particle-core interaction the extended CSM was used for even-odd nuclei being able to describe another six bands, 3 of positive and six of negative parity. Making distinction between proton and neutron bosons, CSM has been generalized being applied to magnetic states. CSM was successfully used to describe about 50 nuclei exhibiting various symmetries. We were the first who described the magnetic states in even-odd nuclei F) A spherical projected single particle basis depending on a deformation parameter was obtained. When the deformation goes to zero one obtains the spherical shell model basis while when the deformation is different from zero the corresponding energies are close to those of Nilsson scheme. The new basis allows for an unitary description of spherical and deformed nuclei. G) Higher RPA effects on the Gamow-Teller transition amplitude of the $2\nu\beta\beta$ process , was calculated through the boson expansion procedure. The dominance of the spin-flip configuration on the decay rate has been pointed out. The first calculation of double beta decay rate to excited states has been provided. A fully renormalized pnQRPA formalism has been elaborated by defining a new pnQRPA phonon which involves scattering terms. Recently the gauge symmetry of the new theory is restored which results in getting a renormalized theory which obeys the Ikeda Sum Rule. Numerical applications show a good agreement of the results with the available data. H) The classical origin of the many body approaches, like the BCS, RPA, boson expansion formalism, was proved. All the associated equations are obtained in the classical phase space. Several procedures of quantizing the classical trajectories are suggested. A new boson representation of the quasispin SU(2) algebra is found out.I) New results for classical and quantal chaos associated with boson Hamiltonian were obtained. J) New results for Dirac like quantization of systems with holonome constraints were obtained. K) Equations for generalized pairing of protons and neutrons have been obtained. A projection procedure for the gauge and isospin symmetries are analytically achieved. L) A new model for microscopic description of the deformed metallic clusters has been proposed. M) Description of the simple and double analog resonance states in medium nuclei.

B.1.2. ***The visibility of the scientific contributions***. The visibility of my contributions is reflected in the big number of citations (over 1200) but also by the memberships, distinctions and prizes which are listed below: **1974-** the Dragomir Hurmuzescu Prize for "Microscopic description of the collective quadrupole octupole double phonon states. **1980-** the Dragomir Hurmuzescu Prize for Complete description of the gamma degree of freedom of the harmonic liquid drop. **1975-1977**, Humboldt Fellow. **1984-** got the right to supervise Ph-D students. **1992-2005,** member of editorial board of Romanian Journal of Physics.**1999-2005**, member of editorial board of European Nuclear News. **2008**- member of editorial board of: The open Nuclear & Particle Physics Journal, Annals of University of Craiova, Annals of Physics, Academy of Romanian Scientists.**1997-2000**, president of the scientific counsil of Institute of Physics and Nuclear Engineering. **1998**-elected as full member of the Academy of Romanian Scientists. **2000**- by Presidential Decree signed by the President Emil Constantinescu I was awarded with the National Order "For Merits:" with the degree of Officer. **2008**- got the title of Distinguished Professor at Complutense University, Madrid. **2000**- got the Prize of Humboldt Foundation called "The Stability Pact of South-East Europe" which granted a visit of 3 month in Tuebingen for me and 6 months for one Ph-D student. **1994**- a visiting professor grant at Napoli University given by EU within the programme Copernicus. **2001**-co-director of a project accepted by NATO for a three years grant. By competition I wone several DFG grants which financed three months visits to Tuebingen University. Scientific Referee at: Journal of Physics A, B, G, Physical Review A, B, C, Physical Review Letters and Review of Modern Physics.In **1980,1986,1991,1995,1998,2006** I organized in Poiana Brasov and Predeal, as School director, International Summer Schools. Proceedings have been published by IFIN-HH (1), Springer Verlag (1) World Scientific (4).Invited to lecture at several International Conferences and Schools :Prague (2000), Rila (2002), Erice (2003), Vico Equense (2005), Antaly (2010). Invited talks at several Universities: Catania, Napoli, Rutgers, Yale, Tuebingen, Frankfurt/Main, Munich, Iulich, Giessen, Orsay, CSIC-Madrid, Complutence-Madrid, Cimbra, Jyvaskyla.

***B2. Curriculum vitae** (max. 4 pages)*

Born in Comuna Ulmi, Jud Giurgiu at 6th of March 1943.

Education:**1965** - graduated the Faculty of Physics, specialized in Theoretical Physics, at Bucharest University. **1972** - graduated the Faculty of Mathematics and Mecanics,specialized in Functional Analysis,Bucharest University. **1972**, I got the Ph.D in Theoretical Physics.

Professional experience, former employers:

1965-1968 Physicist-chemist.**1968-1970** Stagiar researcher. **1970-1971** Researcher at IUCN Dubna.**1971-1975** Physicist. **1975-1981** Senior Researcher of rank III

1981-1990 Senior Researcher of rank II. **1990-present** Senior Researcher of rank I **1975-1976** Senior Fellow al Fundatiei Humboldt.**1999-present**, Full professor, Physics Faculty, Departmnet of Theoretical Physics Bucharest University.

2002-present, Director General of the research center “Theoretical Physics”, Bucharest University (24 members). **2008-** Distinguished Professor at Complutense University.

Work stages of 2-3 months:Dubna, Helsinki, Copenhagen, Frankfurt/Main, Iulich, Tubingen, Orsay, Napoli, Jyvaskyla, Catania, Giessen,CSIC-Madrid, Coimbra, Rutgers, Complutence.

Conferences and Schools: I attended several conferences and schools were I had invited seminars and lectures: Les Houches (1968), Trieste (1971), Tokio (1977), Zagreb (1974), Drezden (1979), Dubrovnik (1986), Poiana Brasov (several editions), Predeal (several editions),Amalfi (1992), Praga (1997, 1999), Rila (2002), Erice (2003),Vico Equense (2007), Antaly (2010).

Summer Schools organizer as director:

1980 Critical Phenomena in Heavy Ion Physics, Poiana Brasov

1986 Symmetries and Dynamical Features of Nuclear Dynamics, Poiana Brasov

1991 New trends in Theoretical and Experimental Nuclear Physics, Predeal

1995 Collective Motion and Nuclear Dynamics, Predeal

1998 Structure and Stability of Nucleon and Nuclear Systems

2006 Collective Motion and Phase Transitions in Nuclear Systems

Proceedings-edited by myself published by IFA (1), Springer (1), World Scientific (4).

Publications: 205 articles from which 152 in major journals from abroad, 66 in the latest 10 years.

Citations:1200; Hirsch index: 20; Individual ISI impact factor =130.7365

Supervised Ph-D students who got the degree:15.

Books:1) Fundaments of Nuclear Theory,624 pp, Bucharest University,2010,ISBN 978-973-737-799-9;2) Elements of Special Relaticity, 230 pp, Bucharest University,2010,ISBN 978-973-737-862-0;3) Coherent State Model for several int. bands,1-70, chapter in the book “Recent Res. Dev. in Nuclear Physics”ISBN:81-7895-124-X, 2004, Tranworld Research Network, Editor S. G. Pandalai.

Selected list of publications:

[1] **A.A.Raduta**, A.Sandulescu, P.O.Lipas, Semimicr. theory of two phonon quadrupole octupole vibrations in spherical nuclei, **Nucl.Phys.A. 149(1970) 11**.

[2] **A.A.Raduta**, A.Sandulescu, Micr. theory of two phonon quadrupole-octupole vibrations in spherical nuclei, **Nucl.Phys.A.181 (1972) 153**.

[3] **A.A.Raduta,** V.Ceausescu,G.Stratan, A.Sandulescu, Boson expansion method and the collective negative parity states in even-even spherical nuclei, **Phys.Rev. C8 (1973) 1525.**

[4] V.Ceausescu, **A.A.Raduta.** The comp. between different degrees of freedom in the structure of the quintet states of negative parity of some even - even Sn isotopes, **Ann of Phys.100 (1976) 94**.

[5] **A.A.Raduta**, R.M.Dreizler, On the description of the groundstate bands by means of boson Hamiltonian, **Nuclear Physics A 258 (1976) 109**.

[6] **A.A.Raduta**, M.Badea, On the simultaneans description of the groundstate and beta bands by means of a boson Hamiltonian. Z. fur Physik A 278 (1976) 51.

[7] **A.A. Raduta,** Toward a new hybrid. model for two adjacent bands**, Phys. Lett.63 B (1976) 14.**

[8] **A.A.Raduta**, M.Badea, E.Badralexe,A simple derivation of a closed formula for Bogoliubov boson transformation, **J. Math. Phys. 18, (1977) 648**.

[9] **A.A.Raduta**, V.Ceausescu, R.M.Dreizler, Toward a new approch for the description of the decoupled bands, Nucl. **Phys.A 272 (1976) 11.**

[10] **A.A.Raduta,** A.Gheorghe, M.Badea,The structure of high spin states in terms of coherent states. The vibrational and rotational limits. **Z.fur Physik A 283 (1977) 79**.

[11] A.Gheorghe, **A.A.Raduta**, V.Ceausescu, On the exact solution of the harmonic quadrupole collective Hamiltonian, **Nucl. Phys. A 296 (1978) 228,**

[12] **A.A.Raduta**, V.Ceausescu and A.Gheorghe, Closed forms of the matrix elements of the quadrupole collective operators, **Nucl. Phys. A 311 (1978) 118**.

[13] **A.A.Raduta**, V.Ceausescu, A.Gheorghe, R.M.Dreizler, Boson description of ^{190}Pt and ^{192}Pt, **Phys. Lett 99 B (1981) 444**.

[14] **A.A.Raduta**, V.Ceausescu, A.Gheorghe, R.M.Dreizler, Phenomenological description of three interacting bands, **Nucl. Phys. A 381 (1982) 253**.

[15] **, A.A.Raduta**, C.Lima, A.Faessler,Coupling of two quasiparticles to a quadrupole vibrational and rotationa core projected from coherent states, **Phys. Lett. 121 B (1983) 1**.

[16] **A.A.Raduta**, A.Faessler, Th.Koppel, C.Lima, Coherent quadrupole states of three int. bands and the solution of a microscopic Bohr - Mottelson Hamiltonian, **Z. fur Phys. A 312 (1983) 233**.

[17] **A.A.Raduta**, C.Sabac, Coherent states model for three interacting bands of positive parity in the rotational limit and its extansion to negative parity bands, **Ann. Phys. (NY) 148 (1983) 1.**

[18] **A.A.Raduta**, A.Faessler, Th.Koppel,Coupling of one and two quasiparticles to a Bohr - Mottelson core in $^{195-198}$ Hg, M.Treftz, **Z.f.Phys. A 312 (1983) 195.**

[19] **A.A.Raduta**, C.Lima, A.Faessler, Coupling of two quasiparticles to coherent cores in Pt isotopes, **Z.fur Physik A 313 (1983) 69**.

[20] **A.A.Raduta**, V. Ceausescu, A.Gheorghe, M.S.Popa**,** Semiclassical treatment of the interaction between individual and quadrupole collective degrees of freedom, **Nucl. Phys. A 427 (1984) 1.**

[21] **A.A.Raduta**, A.Faessler,V.Ceausescu, Description of the $K^{\pi} = 1^{+}$ magnetic states within a generalised coherent state model, **Phys. Rev. C36 (1987) 2111,**

[22] **A.A.Raduta**, I.I.Ursu and D.S.Delion, Simultaneus G.C.S.M. description of the M1 state and the major collective bans, **Nucl. Phys. A 475 (1987) 439.**

[23] **A.A Raduta**, I.I.Ursu, A.Faessler,The description of the $K^{\pi} = 1^{+}$ isovector M1 state within a boson expansion formalism, **Nucl. Phys. A 489 (1988) 20**.

[24] **A.A Raduta**, D.Delion, Description of the magnetic properties of the proton-neutron asymmetric states within the generalised coherent states model, **Nucl.Phys. A 491 (1989) 24**.

[25] **A.A. Raduta**, N. Lo Iudice, Toward a microscopic description of the M1 states in deformed even-odd nuclei, **Z.fur Phys. A 334 (1989) 403.**

[26]. **A.A. Raduta**, D. Delion, The description of the collective M1 properties of the even-odd nuclei, **Nucl. Phys. A 513 (1990) 11**.

[27] **A.A. Raduta**, A. Faessler, S. Stoica, W. Kaminsky, The two neutrino double beta decay rate within a higher RPA approach, **Phys. Lett. B 254 (1991) 7**.

[28] **A.A.Raduta**, A.Faessler, S.Stoica ,The two neutrino double beta decay rate within a boson expansion formalism, **Nucl.Phys.A 534 (1991) 149**.

[29] **, A.A.Radut**a, D.Delion, N.Lo Iudice, Semimicroscopic description of the alpha clustering in heavy nuclei,**Phys. Rev.C, 44 (1991) 1929**.

[30] N. Lo Iudice, **A.A.Raduta** and D.S.Delion,Scissors mode and nuclear deformation within the generalized CSM, **Phys.Lett. B 300(1993) 195**.

[31] **A.A.Raduta**, I.I.Ursu and N.Lo Iudice, Description of collective spin excitations in deformed nuclei within a projected single particle basis, **Phys.Rev.C46 (1992) 1782.**

[32] **A.A.Raduta**, et al., A projected s.p. basis for deformed nuclei,**Nucl.Phys. A551 (1993) 73**.

[33] N. Lo Iudice, **A.A.Raduta** and D.S.Delion, Scissors mode and nuclear deformation: a generalised coherent state approach, **Phys. Rev. C50 (1994) 127**.

[34] **A.A.Raduta**, Amand Faessler and D.S.Delion, Unified description of the $2\nu\beta\beta$ decay in spherical and deformed nuclei, **Nucl. Phys. A, 564 (1993) 185.**

[35] **A.A.Raduta**, et al., Infl. of nuclear def. on the $2\nu\beta\beta$ decay,**Phys.Lett.B, 312 (1993) 13**.

[36] **A.A.Raduta,** Descr. of scissors mode in Moszkowski model**, Phys. Rev. C51 (1995) 2973.**

[37] **A. A. Raduta,** N. Lo Iudice, I. I. Ursu, Descr. of orbital and spin exc. within a projected spherical single particle basis, **Nucl. Phys. A584 (1995) 84.**

[38] A. Gheorghe, **A. A. Raduta**, V. Ceausescu,Semiclassical treatment of a cranked triaxial rotor, **Nucl. Phys. A 637 (1998) 201.**

[39] **A. A. Raduta**, Baran, D. S. Delion, Semiclassical treatment of the quadrupole boson Hamiltonians, **Nucl Phys. A588 (1995) 431**.

[40] **A. A. Raduta,** D. S. Delion and A. Faessler, Description of the 2nbb transition rate within the Moszkowski model, **Phys. Rev. C51 (1995) 3008**.

[41] **A. A. Raduta** and J. Suhonen,Description of beta decay to excited quadrupole phonon states within a boson-expansion formalism, **Phys. Rev. C53 (1996) 176**,

[42] V. Baran, **A. A. Raduta** and D. S. Delion.Regular and irregular features of classical motion described by a fourth order quadrupole Hamiltonian, **Phys. Rev. E54 (1996) 3264**.

[43] **A. A. Raduta,** Al. H. Raduta and A. Faessler, Phenomenological description of rotational bands in the pear shape nuclei**,Phys. Rev. C 55 (1997) 1747.**

[44] , **A. A. Raduta**, et al., Toward a full selfconsistent RPA approach and a new proton neutron dipole excitation in some even-even nuclei, **Nucl. Phys. A 634 (1998) 497**.

[45] **A. A. Raduta**, Al. H. Raduta and Ad. R. Raduta, Description of the deformed metalic clusters within a projected spherical basis , **Phys. Rev. B 59 (1999) 8209.**

[46] **A. A. Raduta et a**l.,Neutrinoless double betadecay of 76Ge, 82Se,100Mo and 136Xe to excited 0^+ states, **Phys. Rev C 64 (2001)035501.**

[47] A. A, Raduta et al.,Ground state particle-particle correlations and double beta decay, **Ann. Phys. (N.Y.) 294 (2001) 182-202.**

[48]**A.A.Raduta et al.,**Charge exchange operators sum rules and proton-neutron T=0 and T=1 pairing interactions, **Nucl. Phys. A 727 (2003) 3025.**

[49]A.A.Raduta et al.,Description of Single and Double analog States in the f7/2 shell:the Ti Isotopes, **Phys. Rev. C, 68 (2003) 044317.**

[50] **A. A. Raduta** and A. Faessler, Coherent state description of the shape phase transition in even-even Gd isotopes, **Jour. Physics G, 31(2005) 873-901.**

[51] **Raduta** et al.,The CSM extension to the odd-even octupole deformed nuclei**, Phys. Rev. C 80, 044327 (2009).**

[52] **A. A. Raduta et al.,**Closed formulas for ground band energies of nuclei with various symmetries,**Jour. Phys. G**; **Nucl. Part. Phys, 37 (2010) 085108.**

[53] **A. A. Raduta,** et al., Towards a new descr. of triaxial nuclei,**Phys. Rev. C**, 83 (2011) 034313

More details may be found at **researcherid.com: A-6291-2008**, and the site *publications* of IFIN: http://www.nipne.ro/research/publications/publications.php?user=13

B3. Scientific contributions from the period 2001-2011

[1]A.A. **Raduta,** P. Sarriguren, A. Faessler, E. Moya de Guerra, **Ann. Phys. (N.Y.) 294 (2001) 182.**

SRI: 3.46207;   No. of citations: 1

Summary: A self-consistent formalism for the double beta decay of Fermi type is provided. The particle-particle (pp) channel of the two-body interaction is considered first in the mean field equations and then in the quasiparticle radom phase approximation (QRPA). The resulting approach is called the QRPA with a self-consistent mean field (QRPASMF). The mode provided by QRPASMF does not collapse for any strength of the pp interaction. The transition amplitude for the double beta decay is almost insensitive to the variation of the pp interaction. Comparing it with the result of the standard pnQRPA, it is smaller by a factor of 6. The prediction for the transition amplitude agrees quite well with the exact result. The present approach is the only one that produces a strong decrease of the amplitude and at the same time does not alter the stability of the ground state.

[2] **A. Raduta** and D. Ionescu, New signatures for octupole deformation in some actinide nuclei, **Phys. Rev. C 67, 044312 (2003)**.

SRI : 1.37423;   No. of citations: 6

Summary: Energies for three positive and three negative parity bands predicted by the extended coherent model in ^{218,226}Ra, ^{228}Th, ^{232}Th, in four uranium even-mass isotopes, $^{232-238}$U and in ^{238}Pu, are calculated and used to point out new signatures for octupole deformations in ground as well in beta and gamma bands. A beat pattern is found by using a new displacement energy function, which is more appropriate for a spectrum that exhibits large deviations from a linear J(J+1) dependence.

[3] **A**. **A. Raduta,** D. Ionescu, I.I. Ursu and A. Faessler, New features of positive and negative parity rotational bands in 226Ra,**Nucl. Phys. A 720, 43 (2003).**

SRI:1.21166.   No. of citations: 5

Summary: Energies for three positive and three negative parity bands and E1 transitions probabilities predicted by the extended coherent state model (ECSM) in ^{226}Ra, are presented and new signatures for octupole deformation are pointed out. A new displacement energy function, more appropriate for a spectrum exhgibiting large deviations from a linear J(J+1) dependence, is used and a beat pattern is found. Two new alternative expressions for the E1 transition operator involving anharmonicities are introduced. Both of them are able to describe the gross behavior of the E1 matrix elements as function of the angular momentum. In particular, the strong E1 transitions associated with the critical value of angular momentum, where the octupole deformation is set on, are fairly well obtained.

[4] **A. A. Raduta**, L. Zamick, E. Moya de Guerra, A. Faessler and P. Sarriguren, Description of Single and Double analog States in the f7/2 shell:the Ti Isotopes, **Phys. Rev. C, 68, 044317(2003)**.

SRI: 1.37423; No. of citations: 3

Summary: The excitation energies of single analog states in even-odd Ti isotopes and double analog states in even-even Ti isotopes are microscopically described in a single j-shell formalism. A projection procedure for generalized BCS states has been used. As an alternative description, a particle-core formalism is proposed. The latter picture provides a two parameter expression for excitation energies, which describes fairly well the data in four odd and three even isotopes of Ti.

[5] **A. A. Raduta**, A. Escuderos, A. Faessler,E. Moya de Guerra and P. Sarriguren, Two neutrino double beta decay in deformed nuclei with an angular momentum projected basis, **Phys. Rev. C 69, 064321(2004).**

SRI: 1.37423; No. of citations: 2

Summary: Four nucleai which are proved to be 2nbb emitters (^{76}Ge, ^{82}Se, ^{150}Nd, ^{238}U), and four suspected, due to the corresponding Q-values, to have this property (^{148}Nd, ^{154}Sm, ^{160}Gd, ^{232}Th) were treated within a proton-neutron quasiparticle random phase approximation (pnQRPA) with a projected spherical single particle basis. The advantage of the present procedure over the ones using a deformed Woods-Saxon or Nilson single particle basis is that the actual pnQRPA states have a definite angular momentum, while all the others provide states having only K as a good quantum number. The model Hamiltonian involves a mean field term yielding the projected spherical single particle states, a pairing interaction for alike nucleons and a dipole-dipole proton-neutron interaction in both the particle-hole (ph) and the particle-particle (pp) channels. The effect of the nuclear deformation on the single beta strength distribution as well as on the double beta Gamow-Teller transition amplitude (M_{GT}) is analysed. The results are compared with the existent data and with the results from a different approach, in terms of the process half-life $T_{1/2}$. The case of different deformations for mother and daughter nuclei is also presented.

[6] A. A. Raduta, A. Gheorghe and A. Faessler, Remarks on the shape transition from spherical to deformed gamma unstable nuclei, **Jour. Phys. Phys. G:Part. and Nucl. Phys. , 31, 337 (2005).**

SRI:1.28067; No. of citations: 3

Summary: Energies and transition probabilities for low lying states in ^{134}Ba and ^{104}Ru were calculated within a hybrid model. The ground and the first 2^+ states are described alternatively, as a harmonic and anharmonic vibrator states, while the remaining states as states with E(5) symmetry. Results for ^{134}Ba are compared with those predicted by some other methods. One concludes that a gradual setting on of the critical potential yields a better agreement with the experimental data. Very good agreement with the data is obtained for ^{104}Ru. Comparing the present results with those of symmetry E(5), it is conspicuous that the present formalism adds corrections to those with E(5) symmetry, by bringing the predictions closer to the experimental data. An analytical relationship between the states with U(5) symmetry and those given by the E(5) description is established.

[7] **A. A. Raduta** and A. Faessler, Coherent state description of the shape phase transition in even-even Gd isotopes, **Jour. Physics G: Part. and Nucl. Phys. , 31, 873 (2005)**.

SRI:1.28067; No. of citations: 2

Summary: Three versions of the coherent state model called CSM, CSM2 and GCSM, are used to describe excitation energies and itraband as well as interband transition probabilities of three interacting bands, ground, beta and gamma, in the even-even isotopes $^{150\text{-}160}$Gd. Common features and differences in the predictions of the three formalisms are commented. All of them yield results which are in fairly good agreement with the available data. New signatures for the transition U(5)-SU(3) are pointed out. It turns out that for some properties this transition is state dependent. Also, there are some properties indicating that in the isotope chain considered, there are more than two phases satisfying the U(5) and SU(3) symmetries, respectively. The formalisms employed here confirm that ^{154}Gd exhibits features which are specific to the X(5) symmetry.

[8] **A. A. Raduta,** C.M. Raduta and Amand Faessler, Description of positive and negative parity dipole bands in octupole deformed nuclei, **Phys. Lett. B, 635, 80 (2006).**

SRI:3.46667; No. of citations: 1

Summary: The extended coherent state model is further extended as to describe two dipole bands of different parities. The formalism provides a consistent description of eight rotational bands. A unified description for spherical, transitional and deformed nuclei is possible. Projecting out the angular momentum and parity from a sole state, the $K^p=1^+$ band acquires a magnetic character, while the electric properties prevail for the other band. New signatures for a static octupole deformation are pointed out. Interesting features concerning the decay properties of the two bands are found. For illustration the formalism is applied to ^{172}Yb and results are compared with the available data.

[9] A. A. Raduta, C. M. Raduta, Double beta decay to the first 2^+ state within a boson expansion formalism with a prjected spherical single particle basis, **Phys. Lett. B 647, 265 (2007).**

SRI: 3.46667; No. of citations: 4

Summary: The Gamow-Teller transition operator is written as a polynomial in the proton-neutron and quadrupole charge conserving QRPA boson operators, using the prescription of the boson expansion technique of Belyaev-Zelevinski type. Then, the 2nbb process ending on the first 2^+ state in the daughter nucleus is allowed via one, two and three boson states describing the odd-odd intermediate nucleus. The approach uses a single particle basis which is obtained by projecting out the good angular momentum from an orthogonal set of deformed functions. The bases for mother and daughter nuclei have different deformations. The GT transition amplitudes as well as the falf lives have been calculated for eleven transitions. Results are compared with the available data as well as with some predictions obtained with other methods.

[10] A. A. Raduta, R. Budaca, Al. H. Raduta**,**Colective dipole excitations in sodium clusters**, Phys. Rev. A.79, 023202 (2009).**

SRI: 3.16959; No. of citations: 1

Summary: Some properties of small and medium sodium clusters are described within a random-phase approximation (RPA) approach using a projected spherical single particle basis. The oscillator strength calculated with a Schiff-type dipole transition operator and folded with Lorenzian functions are used to calculate the photoabsorbtion cross-section spectra. The results are further employed to establish the dependence of the plasmon frequency on the number of cluster components. Static electric polarizabilities of the clusters excited in a RPA dipole state are also calculated. Comparison of our results with the corresponding experimental data shows an overall good agreement.

Total SRI: 21.46069; Total No. of citations:28

Books and chapter in books:

[1] A. A. Raduta, A. C. Gheorghe, V. Baran and I. I. Ursu,Collective motion and phase transitions in nuclear systems, World Scientific, 2007.

No. of libraries in worldcat.org: 28

List of 10 university libraries:

[1] Technische Informationsbibliothek & Universitätsbibliothek Hannover

TIB / UB Hannover, Hannover, D-30167 Germany

[2] ETH-Bibliothek Zurich , Zurich, 8092 Switzerland

[3] **York University Libraries ,**Toronto, ON M3J 1P3 Canada

[4] **University of Michigan ,** Ann Arbor, MI 48109 United States

[5] **Ohio State University Libraries ,**Columbus, OH 43210 United States

[6] **Library of Congress** **,**Washington, DC 20540 United States

[7] **University of Cincinnati** **,**CINCINNATI, OH 45221 United States

[8] **Columbia University in the City of New York** **, Columbia University Libraries**

NEW YORK, NY 10027 United States

[9] **New York University, Elmer Holmes Bobst Library,NEW YORK, NY 10012 United States**

[10] **Yale University, Sterling Memorial Library, NEW HAVEN, CT 06520 United States**

2) A. A. Raduta, Coherent state model for several collective interacting bands**, Chapter in**

S. G. Pandalai, Recent Research Development in Nuclear Physics**, 2004, Transworld**

Research Network, . 37/661(2), Fort P. O., Trivandrum-695-023, Kerala, India.

No. of libraries in worldcat.org: 5

University libraries:

[1] **ETH-Bibliothek Zurich** **,** Zurich, 8092 Switzerland

[2] **Library of Congress** Washington, DC 20540 United States

[3] **Technische Informationsbibliothek & Universitätsbibliothek Hannover** **TIB / UB**

Hannover, Hannover, D-30167 Germany

[4] **Danish Union Catalogue and Danish National Bibliography**

library.dk; bibliotek.dk; DBC, Ballerup, DK 2750 Denmark

[5] **Bibliothèque interuniversitaire scientifique Jussieu**

PARIS6-BUPMC-Chimie Phys. rech., Paris CEDEX 05, 75252 France

C. Project description (max. 10 pages).

C1. ***Scientific context and motivation*.**

In what follows I shall describe the proposed subjects, their scientific context and content.

1) Pear shaped nuclei; multi-backbending phenomena. For a long time people considered that the negative parity states discovered in the early 50's (F. Asaro et al., Phys. Rev. 92, 1495 (1953), F. S. Stephen et al., Phys. Rev. 100, 1543 (1955)), have similar properties as the positive parity ones and, therefore, no special attention has been payed to them. The interest for this field increased considerably since the first suggestions for a static octupole deformation appeared (R.R. Chassman, Phys. Lett. 96 B (1980)): a) the parity quasi-degenerate doublets for Ac isotopes. b) the microscopic studies of the ground state of actinides showed that the binding energy is increased by 1.5-2 MeV if an octupole deformation term is included in the mean field (P. Moller and J. R. Nix, Nucl. Phys. A361 (1981) 117). A system with static octupole deformation does not have good symmetry against rotation as well as against the space reflection transformation. Having two symmetries simultaneously broken, one expects that a new nuclear phase is settled and, therefore, specific properties may show up. The quadrupole deformation is related to the reduced probability $B(E2;0^+ \rightarrow 2^+)$ which is considered a measure of it. Unfortunately, there is no observable which could be a measure for the octupole deformation. Thereby one looks for indirect signatures for the static octupole deformation. Several features are considered to be signatures for a static octupole deformation: i) an alternating parity sequence; ii) a parity doublet structure; iii) the energy displacement function associated to the two bands (ground and 0^-), projected from a single deformed ground state with a broken reflection symmetry, is vanishing. iv) due to the well known rod effect (saying the charge density is largest there where the surface curvature is maximal), a pear shape nucleus must have a dipole moment which induces a large E1 transition probability for exciting the nuclear system from the ground state to the first 1^- state. It is commonly accepted that the large E1 transition probability to an isoscalar negative parity state is caused by the admixture with the isovector dipole state. This picture is consistent with the octupole deformation formalism. v) The very low position of the state 1^- in some nuclei suggests a flat potential in octupole deformation. We would like to mention that our group is the first one which studied the octupole deformation not only in the ground band but also for other three excited bands, i.e. β, γ and 1^+ bands (A. A. Raduta, Al. H. Raduta and C. M. Raduta, Phys. Rev. C74 (2006) 044312). Recently the latest version of CSM (called ECSM) has been extended for the study of the even-odd nuclei (A. A. Raduta, C. M. Raduta and A. Faessler, Phys. Rev. C 80, 044327 (2009)). For the particle-core system we considered three pairs of parity partner bands: $K^{\pi} = 1/2^{\pm}$, $3/2^{\pm}$, $5/2^{\pm}$. Description includes states of high and very high spin, i.e. up to 40 in even-even and up to 59/2 in even-odd nuclei.

The back-bending phenomenon appears as a reflection of the Coriolis anti-pairing effect in states of high spin. Breaking a neutron pair gives rise to an intersection of the yrast collective band with a two quasiparticle neutron band. The angular momenta carried by quasiparticles are aligned and the resulting angular momentum is aligned to the collective angular momentum. Thus, the first backbending in the rare earth nuclei is caused by breaking a neutron pair in the shell $i_{13/2}$,while the second one is associated to unpairing two protons in $h_{11/2}$. In this way the energies and transition probabilities for the even-even Pt isotopes have been realistically described (A. A. Raduta, C. Lima, A. Faessler, Phys. Lett. B 121 B (1983) 1; Z. f. Physik A 313 (1983) 69). A system of particles moving in deformed single particle orbits is affected by rotation in a different way than those from spherical single particle states. Moreover, the pairing properties for the two situations are different. One expects that a composite system of deformed particles and a deformed phenomenological core might have a spectrum with several backbendings in both yrast and non-yrast bands.

Symmetries, collective motion and phase transitions. A major task for many body theories is to define collective coordinates which account for a certain class of spectroscopic properties. The motion of the selected coordinates is usually described either by a solvable Schrödinger equation or by irreducible representations of some symmetry groups. If the agreement of the predictions with the corresponding data is good, one says that the system exhibits the chosen symmetry. Even if the schematic calculations do not reproduce the similar properties of the neighboring nuclei, one keeps the solvable model as a reference landmark. At a later stage the formalism is improved by adding residual interactions. The transition from one symmetry to another goes always through a critical point. Recently, it was shown that the critical point of the transition between the gamma stable (SU(5)) and the gamma unstable (O(6)) nuclear phases corresponds to a new symmetry E(5) (Phys. Rev. Lett. 85 (2000) 3581). Also, the critical point of the transition between SU(5) and SU(3) is associated to the X(5) symmetry (not known yet). Finding a new symmetry which intermediates between the extreme symmetries gives us the hope of finding a unitary description of the nuclei lying on the chain linking the two extreme phases. Our group studied the ability of the Liquid Drop Model, proposed by Bohr and Mottelson, and the Coherent State Model, proposed by the director of the present project, to describe the phase transitions mentioned above.

New features of the double beta decaying nuclei. One of the most exciting subject of nuclear physics concerns the double beta decay phenomenon which may take place either through a $2\nu\beta\beta$ or by a $0\nu\beta\beta$ mode. The second decay channel is especially important since it may provide an answer to a fundamental question, namely whether the neutrino is a Majorana or a Dirac particle. Thus, the results concerning the $0\nu\beta\beta$ process may provide bounds for the neutrino mass and the right handedness of its electro-weak interaction, SUSY parameters and the leptoquark interaction. Unfortunately, there are not yet reliable tests for the nuclear matrix elements involved in the calculation of the $0\nu\beta\beta$ decay rate. The common trend of all theories is to use the nuclear matrix elements which produce realistic predictions for two neutrino double beta decay. In general, the predictions for the process half life are lower than the experimental data. The method providing results which are closest to experimental data are the proton-neutron quasiparticle random phase approximation (pnQRPA). The GT amplitude for single β^+ decay is very sensitive to the variation of the strength of the nucleon-nucleon interaction in the particle-particle (pp) channel which hereafter will be denoted by g_{pp}. The fact that the second leg of the $2\nu\beta\beta$ decay may be related to the β^+ transition amplitude of the daughter nucleus, was used for improving the GT transition amplitude for the double beta decay. Since the two body interaction in the pp channel is attractive, the result is that a strong suppression of the GT amplitude for g_{pp} close to unity takes place. However, for this value of the pp-interaction strength the RPA calculations are not entirely reliable since for a slightly larger strength one reaches the RPA breaking down value. Results' stability against adding the higher pnQRPA corrections was studied by our group within a boson expansion method (Raduta et al., Phys. Lett. B 254 (1991) 7; Nucl. Phys. A 534 (1991) 149). With this formalism one may study the double beta decay to excited states, such transitions being forbidden in the standard pnQRPA. Another way to improve the pnQRPA is to renormalize it by trying to restore the Pauli principle. Several years ago we proposed an original method of renormalizing the pnQRPA by including the quasiparticle scattering terms in the expression of the dipole phonon operator; the new theory is called FRpnQRPA (A.A. Raduta et al. Nucl. Phys. A 634 (1998) 497). Unfortunately, both higher pnQRPA approaches violate the Ikeda sum rule (by 20-30%) which, as a matter of fact, reflects the degree of consistency of the proposed many body formalism. A combination of the mentioned methods improves ISR, bringing the deviations to about 10% (A. A. Raduta et al., J. Phys. G, 26 (2000) 793). Recently, we constructed a renormalized phonon operator with the gauge restored, which leads to single beta decay rates obeying the Ikeda sum rule (C. M. Raduta and A. A. Raduta, Nucl. Phys. A 756 (2005) 153; Phys. Rev. C 82, 068501 (2010); J.Phys. G 38 (2011) 055102). The resulting formalism is refered to as GRFRpnQRPA. Yet, it is an open question whether such a phonon operator may provide a realistic description of the $2\nu\beta\beta$ process.

C2. *Objectives*. The present project defines its objectives taking into account the following requirements: 1) the treatment of some major subjects in the field; 2) to use the valuable results obtained so far in our group; 3) to increase the international visibility of the team members; 4) to agree with the requirements of the Ideas Programme to be knowledge producer; 5) given the interdisciplinary character of the proposed research, we shall use formalisms and methods which are specific to the adjacent domains to point out new properties of the nuclear matter. In this context the project objectives are as follows: 1) **Pear shape nuclei, multibackbending phenomena**. *We intend to search for new signatures for octupole deformation in the rotational bands associated to* *the even-odd nuclei. We shall search for nuclei which, excited in a high spin state with large quantum number K, may exhibit a chiral symmetry*. We shall calculate the mutual angles between the angular momenta carried by the three components of the system. If there is a set of the particle-core interaction strengths which allow the angular momenta of the three components to be mutually orthogonal and, moreover, the model Hamiltonian energies to be invariant or almost invariant to changing the sign of one angular momentum, we say that the system exhibits a chiral symmetry or a broken chiral symmetry. Since any broken symmetry brings the system to a new nuclear phase, we are interested to describe the specific features. **The multibackbending phenomenon** will be studied by choosing as intrinsic basis a set of deformed single particle states multiplied with three phenomenological functions which generate by projection the collective ground, beta and gamma bands respectively, within the CSM approach. By projecting out the good angular momentum from the intrinsic states, one defines a basis which is further used to diagonalize a particle-core Hamiltonian. *By contrast to the variational approaches where only the yrast states can be described, our formalism can describe also the backbendings in the nonyrast bands.* We intend to make a systematic study applying the formalism to the nuclei where evidences for such a phenomenon are available. **2) Symmetries, collective motion and phase transitions**. Studying the Gd isotopes within the Coherent State Model we have found some signature for the phase transition SU(5) → SU(3), the identified critical point being being ^{154}Gd (A. A. Raduta, A. et al., J. Phys. G, 31 (2005) 873). *Here we address the question whether CSM is able to describe also the other phase transitions like O(6)→ SU(5), O(6) → SU(3).* We shall use a decoupling scheme for the Bohr-Mottelson Hamiltonian where the equations for beta, gamma and Euler angle variables are un-coupled. We choose for the potential in γ a sum of a singular term and a periodic function. For small deviations from $\pi/6$, the differential equation for γ is obeyed by a Mathieu function. We shall study the limits of both, the wave functions and eigenvalues, when the deviation from $\pi/6$ is small or large. As for the potential in β this will be a generalized Davidson potential. One hopes that in this way we could describe the phase transition O(6)→SU(3). *We shall establish, analytically, the relationship between the solvable models proposed by us and the X(5) symmetry approach proposed by Iachello.* 3) **New features of the double beta decaying nuclei.** Restoring the gauge symmetry the ground state is affected. The relationship between the two ground states, with the gauge symmetry violated and restored respectively, will be studied. Having the ground state determined we can calculate the corresponding averages for the quasiparticle number operators and then solve the fully renormalized pnQRPA with the gauge symmetry restored. Applications to the ground to ground and ground to 2^+ for several emitters, will be performed. *Transition amplitudes, half lives and the log ft values characterizing the single beta decay of the intermediate odd-odd nuclei toward the mother and daughter nuclei, respectively, will be calculated with a fully* *renormalized phonon operator with the gauge symmetry restored.* To underline the interdisciplinary character of our investigation we just mention the cooperating fields needed to accomplish the tasks implied by the objectives listed above: collective models, the irreducible representation of the SU(7) and SU(5) groups, the classical theory of phase transitions, the coherent states theory, theory of spontaneously broken symmetries and chiral symmetry. Concerning the subject of the double beta decay, an efficient research requires solid knowledges in the fields: radioactive disintegrations, many body theories, spurious states, weak interactions, boson representation of bi-fermion operators, the Standard Model, the GUT, neutrino theory, neutrinos oscillations, etc. The results so far obtained by the team, guarantee the feasibility of the project. The results contribute also to maintaining a high level scientific climate which is necessary for the young people education. At the global level we could say that the expected results will enrich the scientific national treasure.

C3. ***Method and approach***. The proposed researches require several necessary stages which might be considered as milestones of our project activities. 1) Documentation on the national and international up to date status of the subject. 2) A clear formulation of the hypothesis through brainstormings with all team members. The original points should be clearly highlighted. 3) Checking the logical consistency of the working hypothesis. 4) Fixing a work plan underlying the tasks for every member of the team. 5) Comparison between the analytical expressions obtained by different experienced members of the team. 6) Encouraging the doctorands to perform analytical calculations. Writing the necessary new codes of numerical calculations and implementing them into the existent code chain. In this work the doctorands will take part to a large extent.7) Searching in the electronic arXives for nuclear data concerning the rotational bands of negative parity and keeping those which suggest an octupole static deformation. 8) Searching in the electronic arXives nuclear data for double beta decay with two neutrinos in the final state as well as for Gamow-Teller giant resonances and the half lives of the neighbouring nuclei with respect to the single beta plus decay. 9) Performing numerical calculations. The doctorands have to understand the old codes and to participate to the new codes construction. 10) Comparing the theoretical results with the experimental data. 11) Editing a scientific paper as a result of the activities in the passed period.

12) Submitting the paper to the electronic arXive of Los Alamos. 13) Submitting the paper to a major journal in the field of nuclear physics.14) Results dissemination through all possible means: web page, communicating it to a conference, sending reprints to the persons which potentially are interested in the subject, mass-media, etc.15) Passing to the next objective is equivalent to iterating the steps already described. Plans are comprised by working packages (WP) which consist in summing several tasks establishing the participants responsabilities. Management activity is taken care by the director of the project. This activity is performed for the whole period of the project. The director of the project distributes the tasks to the members of the team. A matrix with the team

members and the working packages which should clearly show the participation of every member of the team. Below, this matrix is given by the PERT diagram. In this diagram the participants are related by arrows having the following significance: To each participant, a label running from 0 to 5 is asigned, the symbol for the director being P0. For example, the arrow which leaves from P0 and ends with P4, having aside the symbol WP112, suggests that the two members collaborate to the 2nd objective from the year 2011 and the responsability is atributed to P0. Also, P4 has the obligation to report on the progress to the participant from where the arrow starts. The working time affected by each member to accomplishing the project objectives is that given in the GANTT diagram from below. Each member of the team participates at several working packages. To each working package is associated a number. For example, WP122 means that activities involved are associated to the 2nd objective from 2012. The working packages from a certain compact period define a stage which is ended with a stage report. The titles of the stage reports together with the member responsible for writing the stage report are given in the work plan. The director of the project will present, at the beginning of the project run, a mobility plan which must be consistent with the buget plan. Also he will inform each member about the salary he gets from this project. The member who is responsible with the web page is P2. The work plan is presented as a table. In another table we give the time commitment for each member of the team.

Time comitment for each team member to accomplish the tasks from a certain work package

	P0	P1	P2	P3	P4	P5	Manmonths
WP111	2.6		3.	3.		2.	10.6
WP112	2.	3.			3.		8.0
WP121	3.6	7.8			4	4	19.4
WP122	3.6		2.2	6.			11.8
WP123	4.	2.	7.8		3		16.8
WP131	3.6	7.8	2.6	6.		3.	23.0
WP132	3.6		2.6		6	6	18.2
WP133	4.	2.2	4.6				10.8
WP141	5.	2.6	2.6		5		15.2
WP142	4.	2.6	2.6	5.		5	19.2
TOTAL	36	28.	28.	20.	20.	20.	153

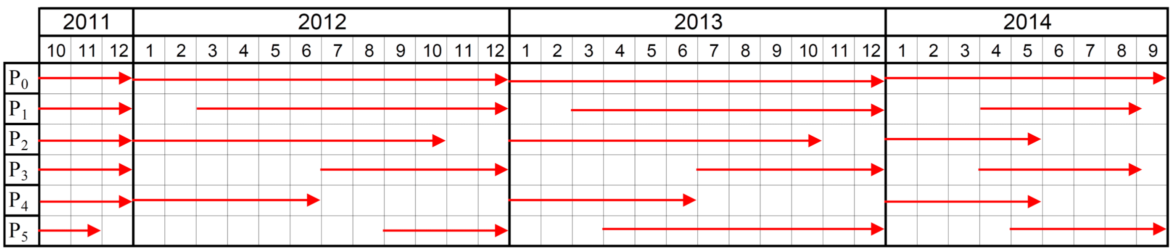
Workplan, objectives, activities

Year		Objectives	Activities
2011	1	WP111. Description of the double beta	Search for experimental data.

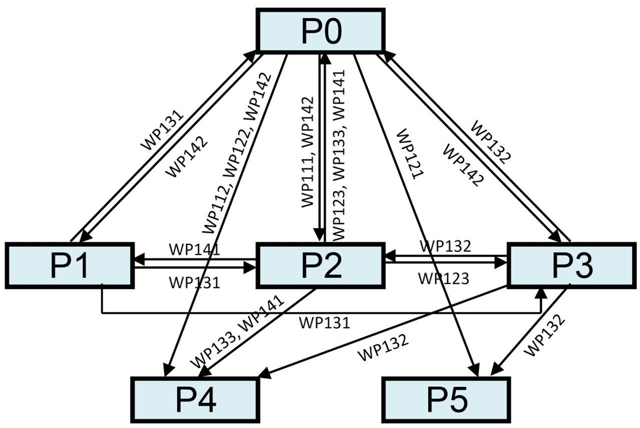
		decay $0^+ \rightarrow 0^+$ within a GRFRpnQRPA Participate P0 and P2. Responsible: P0	Numerical calculations for a large number of nuclei.
	2	WP112. Backbending in the rare earth region. Participate P0 and P4. Resp.: P0 This stage is called *Double beta decay and the backbending phenomenon*. Report expected on 10th of December	Documentation on the experimental data and existent formalism. Preparing the numerical codes. Applications. Working stages abroad. Writing a paper. Diseminating the results. Web page update.
2012	1	WP121.nDescription of the phase transition O(6) → SU(5) within CSM. The relation to other descriptions. Participate P0, P5. Responsible: P0	Documentation and searching for exp. data. Elaborating the formalism. Numerical calculations. Results dissemination. Work stage abroad and attending conferences.
	2	**WP122**: Asymptotic and near vibrational behavior of the CSM approach. The relation to other descriptions. Participate P0, P4. Responsible: P0	Alternative expansions of energies and E2 transition probabilities in terms of d and 1/d. Extensive numerical applications to nuclei of different symmetries.
	3	**WP123**. Double beta decay $0^+ \rightarrow 2^+$ for heavy nuclei. Participate P0, P2, P3. Responsible: P2 . This stage is called: *New results for CSM; The double beta transition to excited states within GRFRpnQRPA*. Report at 10 .12.2012	Existent codes will be adapted to heavy nuclei where one needs a large configuration space. Visits abroad and participation to international conferences. An article will be written. Dissemination by electronic arXive and web page.
2013	1	**WP131**.Formulating a complex model consisting of three components, a set of quadrupole bosons, a set of octupole bosons and a system of nucleons, which exhibits a chiral symmetry. Participate P0,P1,P2,P3. Responsible: P1.	By a cross comparison of the analytical formulas, participants will check all results used in numerical calculations. Applications to nuclei suspected to exhibit chiral symmetry will be performed. Visits abroad and to conferences. A scientific work will be edited.
	2	**WP132**.A new exactly solvable model for the phase transition SU(5)→O(6). Participate P0, P2, P3, P4, P5. Responsible: P3.	An appropriate β and γ potential which allows for the liquid drop Hamiltonian in the intrinsic frame to be separable. An order parameter, which is decisive for the relative position of the bands beta and gamma, will be defined. Work stage abroad and attending conferences

	3	**WP133**. Check the SSD (single state dominance) hypothesis for 2νββ within GRpnQRPA. Participate P0, P2, P4. Resp.: P2. StageIII: *Phase transition. The SSD hypothesis.*	A comparative study of the validity of the SSD hypothesis for ground to ground and ground to 2^+ will be performed. Attending conferences where the new results will be disseminated. An article will be elaborated.
2014	1	Check the magnetic nature of the rotational bands exhibiting a chiral symmetry. Participate P0, P1, P2, P4. Responsible: P2	We shall study the electric and magnetic properties of some nuclei exhibiting chiral symmetry.The specific features for the chiral symmetry are to be identified.
	2	**WP142***:* Multibackbending structure of yrast bands. Participate P0, P1, P2, P3, P5. Responsible: P0. Stage IV: **Chiral symmetry; backbending.** Report: 30.09	We shall write a scientific paper on this subject. Results are to be disseminated by communicating them at conferences, placing the article at Los Alamos arXive.

GANTT Diagram



PERT Diagram



C4. ***Impact, relevance, applications***. Since our investigations have a fundamental character and new knowledges about nuclear matter are expected, one may say that the project results will contribute to the international collective effort for the field development. An important impact is foreseen for a favorable image of the Romanian school of physics. Indeed, the team members have long standing collaborations with first class centers from Germany, Italy, Spain, USA, in the fields of the present project. The fact that the doctorands are already employed at IFIN-HH and, on the other hand, the director of the project is professor at Physics Faculty from Bucharest University, is a good prerequisite for integrating the two components, university and research activities, in the near future. The social impact is concretised by the oportunities opened for the two doctorands to prepare their PhD theses under supervision of the director of this project and later on to be employed permanently in IFIN-HH. We remark the unitary structure of the project. Indeed, the four subjects proposed refer to the symmetry or breaking symmetry associated to various interacting systems. Thus, for octupole and quadrupole deformed nuclei two symmetries are broken: rotation and space reflection. Backbending appears as a result of breaking a neutron or a proton, pair which results in passing from a supeconducting to a normal nuclear phase. Finding a solvable model which describes the properties of the critical point of the transition from one symmetry to another is, to a certain extent, equivalent to pointing out a new symmetry. Violation of the Ikeda sum rule is a reflection of the gauge invariance. On the other hand, the phase transition is a theme intensively studied in many international centers not only in nuclear physics but also in many other fields.We estimate that at the end of the project period at least 10 scientific papers on the proposed subjects will be published in the major journals of Nuclear Physics.

C5. ***Resources and budget***. The most valuable resource of the project is the human one: 2 CSI (P0, P1), 2 CSII (P2, P3), 2 Drd.(P4, P5). As already existent infrastructure, we mention: 3 computers (5years old), 5 laptops (4 years old), 2 computers (7 years old). Also our group takes the benefit of using the big computers from the Center of the Infromation Technic and Communications of IFIN-HH. Actually, we use a cluster devoted to the study of complex phenomena which needs methods of distributed numerical calculations. One of the cluster station will be used as server for the web page of the project. Experienced researchers together with the director share a double room office equipped with new furniture like desks, cupboards and shelves. Each doctorand has one computer equipped with the softwares necessary for activities like: fortran programming or C++, graphics, editing in linux, latex, editing in word, excel, powerpoint, etc. The two doctorands work in a separate office. Each member has access to the internet through the IFIN-HH network, being able to consult online all major journal for Nuclear Physics. Also, they have at their disposal the IFA library, the largest national library, and the library of the Physics Faculty, Bucharest University. We may assert without any risk of being mistaken, that we have all conditions for performing high level research. We intend to buy a workstation for our group, which should be a terminal for all existent computers. Thus, we shall have an independent net which assures a full authonomy for our group.

Also, we plan to buy 5 laptops of latest generation which are to be used for editing articles, speaches, making graphs and performing numerical calculations. We need paper for printers, tonner for printers, requisites, anti-virus soft, soft for graphics like Origin and Mathematika.

Budget Breakdown (lei)

Budget chapter	**2011 (lei)**	**2012 (lei)**	**2013 (lei)**	**2014 (lei)**	**Total (lei)**
Salaries	**92 600**	**340 000**	**340 000**	**255370**	**1 027 970**
Inventory	**0**	**15 000**	**15 000**	**10 000**	**40 000**
Mobility	**0**	**19 260**	**19 260**	**15 000**	**53 520**
Overhead(35%)	**32400**	**125740**	**125740**	**94630**	**378 510**
Total	**125 000**	**500 000**	**500 000**	**375 000**	**1 500 000**

Budget Breakdown (euro)

Budget chapter (expenses)	**Total (euro)**
Salaries	**244 754.76**
Inventory	**9 523.81**
Mobility	**12 742.86**
Overhead	**90 121.43**
Total	**357 142. 86**

The information in this application is hereby certified to be correct.

Project leader:Prof. Dr. Raduta Apolodor Aristotel

Signature:

Date: 20.04.2011