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

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B. Project leader

B1. Scientific visibility and prestige (maximum 2 pages)

B.1.1. *Main research results.*

1. **Deformed two-center shell model.** The model, developed by the project director, is the most advanced two-center shell model at this moment. It accounts for spheroidal deformations of the reaction partners in the overlapping region within the binary configuration. One original feature is elaborated by using the potential theory and elements of differential geometry leading to the adapted neck potential. The introduction of matching surfaces between interposing level schemes ensures potential continuity, a problem solved for the first time when working with dual potentials. The model is directly related to the subject of the project in the study of nuclear binary processes. The model and some derived applications are published in Physical Review C67: 014309 (2003).

2. **Prediction of non-axiallity for superheavy elements.** Disintegration and stability of superheavy nuclei was investigated using cranking mass parameters and Woods-Saxon potential. For the first time fission calculations have been performed in this region using non-axial space of deformation (β_2, γ, β_4) . It has been shown that non-axiality has a lowering effect on the fission barrier for superheavy nuclei with $Z>120$. The director of the project derived also an original procedure for the minimization of the action integral in the multidimensional space of deformation in order to compute the half-lives. The results have been published in Nuclear Physics A651, 237 (1999).

3. **Hyperdeformed rotational states.** The existence of hyperdeformed rotational states is demonstrated as a result of shell effects creating a minima along the path of a given fusion channel. The idea sustaining the result was that in some situations fusion is incomplete due to the formation of potential pockets in the fusion barrier which can accommodate isomeric rotational quasi-stable states. The results have been published in Physical Review C68:014315 (2003).

4. **Deformed potential valleys for superheavy nuclei.** The director of the project demonstrated the existence of deformed valleys in the potential deformation energy, shaped by magic number of protons and/or neutrons from target and projectile. These valleys constitute possible cold fusion paths by tunnelling on potential energy surfaces. The calculations have been published in Journal of Physics G23, 1715 (1997).

B.1.2. *The visibility of the scientific contributions.*

Author or co-author of invited lectures at International conferences: 25. Selected conferences with invited lectures are given bellow:

1. R. A. Gherghescu, D. N. Poenaru, W. Greiner: Binary and ternary emission from superheavy nuclei, First Workshop on State of the Art in Nuclear Cluster Physics, Institut Pluridisciplinaire Hubert Curien, Universite Louis Pasteur, Strasbourg, May 13-May 16, 2008.

2. R. A. Gherghescu, D. N. Poenaru, W. Greiner and A. Solovyov, Ground state and shape isomer deformations of alkali metal atomic clusters. 3^{rd} International Symposium on Atomic Cluster Collisions: Structure and dynamics from the nuclear to the MesoBioNano scales (ISACC2008), St. Petersburg, June 3-7, 2008.

3. R. A. Gherghescu, D. N. Poenaru and W. Greiner, Colinear spherical three-center shell model, International Workshop on Nuclear Theory, June 26- July 1, 2006, Rila Mountain, Bulgaria.

4. R. A. Gherghescu, Cold fusion valleys towards synthesis of Z=118 isotopes, Third Sandanski Collaboration Meeting on Nuclear Physics, Sandanski-Albena, Bulgaria, 26-30 September 2005.

The director of the project, R. A. Poenariu-Gherghescu (R. A. Gherghescu in publications) has received the Horia Hulubei National Academy Prize for Physics in 2006 for the group of articles: Two-center shell model and its application to binary processes.

One of his publications has been selected as highlighted article in 2006 by IOP Science Publications: Synthesis of 286-114 and 290-114 using low-energy fusion channles, JOURNAL OF PHYSICS G 32, L73-L84 (2006).

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

Dr. Radu Alexandru Poenariu-Gherghescu (in publications R.A. Gherghescu). Born: May 03, 1958 in Bucharest, Romania. Senior researcher 1st degree. Department of Theoretical Physics, HH-NIPNE, P.O.Box MG-6, Bucharest-Magurele.

1982: B.S. Faculty of Physics, University of Bucharest, Romania. 1992: PhD in nuclear physics, Institute of Atomic Physics, Bucharest.

Degrees acceded by contest: 1993: principal researcher 3rd degree; 1999: principal researcher 2nd degree; 2006: senior researcher 1st degree (equivalent with full professor).

Member of the Romanian Physical Society and German Physical Society.

Referee for: Physical Review C, Journal of Physics G, International Journal of Modern Physics E.

Scientific collaborations related to the subject of the project:

1995-present: Institut fuer Theoretische Physik and Frankfurt Institute for Advanced Studies, J. W. Goethe Universitaet, Frankfurt am Main, Germany: Synthesis reactions for heavy and superheavy nuclei.

2004: Advanced Science Research Center of the Japan Atomic Energy Research Institute, Tokai, Ibaraki: Sub-barrier fusion reactions for synthesis of superheavy nuclei.

2003: Centre d'Etudes Nucleaires, Universite de Bordeaux, France: Deformation dependence and neck influence on potential barriers

1992-2002: SUBATECH-Physique Theorique, Universite de Nantes, France: Influence of rotations on fusion reactions.

2000: Senior Postdoc, Lousiana State University, Dept. of Physics and Astronomy, Baton Rouge, LA, USA: Solitons as emitted nuclear clusters.

List of ISI publications

1. D. N. Poenaru, R. A. Gherghescu and W. Greiner, *Physical Review C*83: 014601 (2011).

2. R. A. Gherghescu, D. N. Poenaru, W. Greiner and A. Solovyov, *European Physical Journal* B77, 123 (2010)

3. R. A. Gherghescu, D. N. Poenaru, W. Greiner and A. Solovyov, *Physica E*42, 1555 (2010)

4. R. A. Gherghescu, D. N. Poenaru, W. Greiner, M. Raportaru and B. Popovici, *International Journal of Modern Physics E*19, 1411 (2010).

5. D. N. Poenaru, R. A. Gherghescu and W. Greiner, *Journal of Physics G*37, 085101 (2010)

6. D. N. Poenaru, R. A. Gherghescu and W. Greiner, *International Journal of Modern Physics B*24, 3411 (2010)

7. R. A. Gherghescu and N. Carjan, *Journal of Physics G36,* 025106 (2009).

8. D. N. Poenaru, R. A. Gherghescu and W. Greiner, *Journal of Physics G36*, 125101 (2009).

9. D. N. Poenaru, R. A. Gherghescu, A. V. Solovyov and W. Greiner, *EPL 88,*23002, (2009).

10. R. A. Gherghescu, D. N. Poenaru and W. Greiner, *Physical Review C78,* 024604 (2008).

11. R. A. Gherghescu, D. N. Poenaru and N. Carjan, *Physical Review C77,* 044607 (2008).

12. R. A. Gherghescu, D. N. Poenaru, A. Solovyov and W. Greiner, *International Journal of Modern Physics B22,* 4917 (2008).

13. D. N. Poenaru, R. A. Gherghescu, A. V. Solovyov and W. Greiner, *Physics Letters A372,* 5448 (2008).

14. D. N. Poenaru, R. A. Gherghescu, I. H. Plonski, A. V. Solovyov and W. Greiner, *The European Physical Journal D47,* 379 (2008).

15. R. A. Gherghescu, D. N. Poenaru and W. Greiner, *International Journal of Modern Physics E17,* 2221 (2008).

16. D. N. Poenaru, R. A. Gherghescu and N. Carjan, *EPL 77,* 62001 (2007).

17. D. N. Poenaru, R. A. Gherghescu, I. H. Plonski and W. Greiner, *International Journal of Modern Physics E16,* 995 (2007).

18. D. N. Poenaru, R. A. Gherghescu, A. V. Solovyov and W. Greiner, *EPL 79,* 63001 (2007).

19. R. A. Gherghescu, W. Greiner and S. Hofmann, *European Physical Journal A,* 23 (2006).

20. R. A. Gherghescu, D. N. Poenaru, W. Greiner and Y. Nagame, *Journal of Physics G32,* L73

(2006).

21. R. A. Gherghescu and Y. Nagame, *Physical Review C74,* 014611 (2006).

22. D. N. Poenaru, I. H. Plonski, R. A. Gherghescu and W. Greiner, *Journal of Physics G32,* 1223 (2006).

23. D. N. Poenaru, R. A. Gherghescu and W. Greiner, *Physical Review C73,* 014608 (2006).

24. R. A. Gherghescu and W. Greiner, *Journal of Physics G31,* 1225 (2005).

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26. R. A. Gherghescu and N. Carjan, *Physical Review C71:* 054612 (2005).

27. D. N. Poenaru, R. A. Gherghescu and W. Greiner, *European Physical Journal A24,* 355 (2005).

28. D. N. Poenaru, R. A. Gherghescu and W. Greiner, *Nuclear Physics A747,* 182 (2005).

29. R. A. Gherghescu, W. Greiner and G. Muenzenberg, *Physical Review C68:* 054314 (2003).

30. R. A. Gherghescu and W. Greiner, *Physical Review C68:* 044314 (2003).

31. R. A. Gherghescu and G. Royer, *Physical Review C68:* 014315 (2003).

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35. G. Royer and R. A. Gherghescu, *Nuclear Physics A699,* 479 (2002).

36. G. Royer, K. Zbiri and R. A. Gherghescu, *Heavy Ion Physics 16,* 267 (2002).

37. D. N. Poenaru, Y. Nagame, R. A. Gherghescu and W. Greiner, *Physical Review C65:* 054308 (2002).

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39. R. A. Gherghescu and G. Royer, *International Journal of Modern Physics E9,* 51 (2000).

40. R. A. Gherghescu, J. Skalski, Z. Patyk and A. Sobiczewski, *Nuclear Physics A651,* 237 (1999).

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44. R. A. Gherghescu, D. N. Poenaru and W. Greiner, *Il Nuovo Cimento A111,* 105 (1998).

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46. D. N. Poenaru, W. Greiner and R. A. Gherghescu, *Atomic Data and Nuclear Data Tables 68,* 91 (1998).

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Hirsch index according to Web of Science H=13.

Total number of citations in ISI articles C= 257.

B3. Scientific contributions from the period 2001-2011

1. R. A. Gherghescu, D. N. Poenaru, W. Greiner and A. V. Solovyov,

   Spheroidal cap configuration of atomic clusters on planar surfaces,

   European Physical Journal B77, 123-132 (2010).

   No. of citations = 0.

   DOI: 10.1140/epjb/e2010-00244-9

2. R. A. Gherghescu and N. Carjan

   Two and three fragment emission from Z=120 isotopes

   Journal of Physics G36, 0125106 (2009).

   No. of citations = 1

3. R. A. Gherghescu, D. N. Poenaru and W. Greiner

   Proton gap due to the necking potential

   Physical Review C78: 024604 (2008).

   No. of citations = 0

4. R. A. Gherghescu, D. N. Poenaru and N. Carjan

   Neck influence on fission paths

   Physical Review C77: 044607 (2008).

   No of citations = 0

5. R. A. Gherghescu, D. N. Poenaru, W. Greiner and Y. Nagame

   Synthesis of ^{286}114 and ^{290}114 using low-energy fusion channels

   Journal of Physics G32, L73-L84 (2006).

   No. of citations = 3

6. R. A. Gherghescu and Y. Nagame

Isobaric cold-fusion channels for synthesis of $^{276}114$, $^{286}114$ and $^{290}114$

Physical Review C74: 014611 (2006).

No of citations = 0

7. R. A. Gherghescu and D. N. Poenaru

Werner-Wheeler mass tensor for fusion-like configuration

Physical Review C72: 027602 (2005).

No of citations = 1

8. R. A. Gherghescu, W. Greiner and G. Muenzenberg

Shell effects in cold fusion reactions

Physical Review C68: 054314 (2003).

No of citations = 11

9. R. A. Gherghescu and G. Royer

Shape isomerism of rotating ^{44}Ti and ^{48}Cr

Physical Review C68: 014315 (2003).

No of citations 2

10. R. A. Gherghescu

Deformed two center shell model

Physical Review C67: 014309 (2003).

No of citations = 13

C. Project description (max. 10 pages)

Title: BINARY NUCLEAR SYSTEMS

C1. *Scientific context and motivation.*

The large, general scientific context in which this project aims to deliever its contribution is the synthesis of superheavy elements. One intends to calculate very accurate fusion barriers for low energy reactions and finally fusion cross sections. In these binary reactions the macroscopic charged liquid drop type barrier for very heavy nuclei is due to the large Coulomb repulsion. The terms that concur in the survival of the final compound nucleus are the shell and pairing corrections. When added to the macroscopic part, these microscopic terms produce minima in the total deformation energy. In this way the relatively stable, newly formed ground state (with lifetimes up to tenths of seconds for superheavy nuclei) is created and these massive systems could exist.

At present the search for new elements plays a key role in nuclear physics. Numerous experimental groups over the world are driving expensive experiments toward synthesizing new superheavynuclei. By using the large cyclotrons built in Dubna [1] and the heavy ion UNILAC accelerator of GSI- Darmstadt, experimentalists managed to obtain a row of new elements [2]. In 2003 the IUPAC Council officially approved the name Darmstadtium for Z=110, with symbol Ds. The binary processes in which the superheavies are produced are based mainly on two methods: in Darmstadt a target of ^{208}Pb and ^{209}Bi takes advantage of the proton and neutron close shells. While in Dubna the double magic ^{48,40}Ca is used as a projectile on targets as ^{248}Cm, ^{249}Bk and ^{249}Cf. Other important research projects are on their way at GANIL – France and Riken – Japan.

From the theoretical point of view, many existing models predict the best target-projectile combination in order to achieve a large cross section value. The main ones are: macroscopic-microscopic (to which this project belongs) [3], dissipative diffusion and dinuclear concept (mainly in Dubna) [4], Hartree-Fock and mean-field calculations [5,6].

At this moment there is no satisfactory microscopic description of the binary nuclear system during its overlapping stage of the process. All models employed by now fail to resolve how the two level schemes of the target and projectile mingle towards the final, compound nucleus energy arrangement. One can assert here that the model developed by our group, the deformed two-center shell model (DTCSM) [7] is one of the most advanced in describing the transition of the level schemes. In this context, the shell and pairing energies along the overlapping region are crucial in lowering the fusion barrier. Due to our binary single particle model and its dual properties, we claim that this project is justified to describe the main features of the transitory fusion stages at every point along the modification of the binary nuclear shape. The most part of other models consider the binary configuration under the assumption of one single center potential. Thus the major issue to be addressed by the project is the microscopic description of the overlapping region in the process of nuclear synthesis. During the overlap, the nuclear shape is strongly influenced by its binary character. The use of dual potentials like the finite-range Gogny force [8] or dinuclear systems [4] are still not complete. Three theoretical new aspects will improve consistently the view upon binary nuclear shapes: the transition of the charge density from two initial to one final value (CN); the description of the pairing energy change along the overlapping region; the evolution of the cranking mass tensor within the dynamics of the process.

C2. *Objectives*.

The general objective of the project is the exact calculation of the potential barrier, and subsequently of the cross sections, in fusion reactions aimed to the synthesis of superheavy elements. The fusion barrier determines the synthesis cross section and, since this quantity is extremely low for superheavy nuclei, the exact energy curve along the binary deformation is essential. In this domain of nuclear masses only the shell and pairing corrections secure the survival of the compound nucleus. All the models in use at this moment make only approximations of the overlapping region. The dinuclear model (Dubna) reduces the binary configuration to the two tangent spheres. A model used at GSI-Darmstadt [9], though it considers different orientations of the projectile, takes into account only configurations up to the saddle point. The japanese approach and some Dubna groups use Langevin equation set to describe the shape evolution. This is a mostly classical approach, without the influence of the microscopic changes. Relativistic mean field and Hartree Fock models are able to produce single particle sequence of levels but they still lack the proper description from two to one nucleus. At this time there is no microscopic binary treatment of the three major quantities designated as the objectives of this project: the exact law of variation of the charge density from the value of the target and projectile up to the final value of the compound nucleus; a binary BCS treatment for the transition of the pairing interaction within the pass of two independent level schemes to one (especially important when two odd nuclei form the even superheavy nucleus); the cranking model and its behaviour when the superposed energy levels are used in the appropiate matrix elements towards the final goal to calculate the tensor of inertia and complete the dynamics of the process.

C3. *Method and approach*.

The macroscopic-microscopic method will be used to calculate the deformation energy within the multidimensional space of deformation. The binary shape consists in two partially overlapped spheroids. It is a typical fusion configuration (tip-to-tip). The two semiaxis ratios and the distance between centers are the free geometrical parameters. One shall calculate the macroscopic part (liquid drop) with the Yukawa-plus-exponential finite range potential. The Coulomb term is affected by the binary character of the process through the intermediary (overlap region) number of protons. The intermediary proton number on each side of the shape is obtained from the charge density law of variation.

The shell corrections will be computed within the Strutinsky method, using the two-center shell model as the tool to obtain the necessary energy levels as the input data. Much of the above part has been solved in our previous project. In order to complete the macroscopic-microscopic method, this project will develop a new theoretical approach to fullfil the three specific objectives: charge density variation, binary BCS formalism and the cranking inertia tensor for dual systems.

Charge density

Almost all theoretical models in the field take the charge density variation as follows: constant values, equal to the target on one side and to the projectile value on the other, even within overlapping region up to a certain distance between the centers [9]. Others consider even the hypothesis of unchanged charge density [10]. Then, a sudden abrupt shift change the charge density to its final value (compound nucleus). The only reason for such a treatment is that is theoretically easier. In this project we propose a geometry-dependent law of variation. This law will be included in the potential energy part of the Hamiltonian, then one will calculate the corresponding new matrix elements. The variation of the charge density will be related to the internal rearrangement of protons, when the most stable configuration is reached for every given set of geometrical parameters. This law of charge density variation assumes that, due to adiabacity, protons and neutrons distribute themselves at every fixed distance between centers. It is a different approach compared to the sudden approximation. In this way the intermediate isotopic composition of the target and projectile depends on the momentary isospin equilibration of the composite binary system, i.e. on the N/Z of the three reaction components. We will work under the assumption of constant mass density, hence at every stage of the overlapping process, the left and right part of the binary system will take over the charge density value proportional to the non-overlapped volume. As a result, the level scheme will change according to the variation of the proton number in each side of the binary shape (only the total number of protons is conserved).

BCS – pairing in binary systems

The actual methods of calculating the pairing energy use only one-center type potentials. Even when this residual term refers to interacting projectile and target, the models calculate the pairing term as being for one single nucleus [9,13]. This project shall extend the BCS theory to binary shapes. This achievement allows one to be able to pass from two odd nuclei (small gap) to one even (large gap) nucleus. Instead of one typical BCS set of equations, two coupled sets will be solved when allowing the pairing strength, and consequently the gap, to evolve from the values of the separated partners up to the compound nucleus. These parameters depend on the mass number. The present project will assume an evolution law related to the partially non-overlapped masses of the two partners in a specific way: the intermediary proton and neutron numbers on each side of the two-nuclei configuration are linked to the geometrical degrees of freedom. The two sets of BCS equations are coupled by the quasi-dependence of the two-pairing force intensities (the G-factor), one for each of the interacting nuclei. For the gap equation, we will construct the BCS ground state from the two-center shell model single particle states. In this way the pairing strengths (intensities) for separated nuclei will transit and smoothly reach the value of the final synthesized nucleus. Consequently the pairing interaction carries the variation directly induced by the binary characteristics of the process. The original features of our approach reside in the printing of binarity upon the pairing calculation, as follows:

Binary character in BCS – pairing interaction

1. Use of the two-center shell model energy levels in the calculation of the occupation probabilties for particles and holes of a certain state by the nucleon pair. Due to the two-center potential, the pairing force Hamiltonian will exhibit the binary character via the single particle energy levels obtained with two superposed level schemes.

2. Use of the same set of two-center shells in the computation of the pairing correction for every given binary deformation parameters.

3. The blocking effect in odd nuclei is affected by the binary influence of the system: for one-center shape the last single particle occupied level imposes its spin conservation upon the ground state. In our case, the binary process (fusion of fission) introduces the need of transition from the compound nucleus spin towards two different, independent ground state spin values (target and projectile, or daughter and emitted fragment). This transition, a totally new effect regarding the blocking (the unpaired nucleon) in pairing correlation, will be treated as depending on the smooth pass from two to one energy level schemes, separately (and comparatively) for even and odd nuclei.

The cranking tensor of inertia

In order to complete the dynamics of the binary process one needs the mass tensor parameters. The degree to which the system opposes the geometrical changes is expressed by the influence of the inertia mass upon the action integral. In our binary type approach the total two-center potential is divided in two parts, (corresponding to the heavy and light partners) which smoothly pass from one side to the other via the potential matching surfaces [7]. Due to this potential division, every cranking matrix element has two components instead of one, each of them covering the region extended up to the surface of the matching potential boundary. The original features in treating the inertia tensor come up from the binary character of the Hamiltonian.

1. The two-center Hamiltonian will be used to obtain the collective coordinate derivatives, necessary to compute the tensor components.

2. Instead of only the oscillator potential derivative (like for. ex. [14]), we shall also calculate the derivative of the spin-orbit and pairing parts with respect to the spheroidal deformations and distance between centers.

3. The probabilities for particle and hole occupation used in typical Inglis formula for cranking will be taken from the previous point, the binary BCS calculation.

Action integral

Once the shell and pairing corrections are obtained, the total deformation energy for a typical binary shape will be calculated. Together with the cranking mass tensor, the two terms provide the integrand for the action integral. One will apply the least action principle to minimize the action integral in the multidimensional space of deformation. Some benchmarks must be emphasized at this stage of the project, since they also underline the binary character of the approach. The shape will be taken so as to reproduce typical fusion configurations. Hence, for a given final compound nucleus, the whole range of mass and charge asymmetry will be browsed. Up to now such studies took into account only the favourable effect of shell closures for the separated partners, as the double magicity of ^{208}Pb target. Due to the possibility to include binarity when the two partners are superposed, one will be able to stress the influence of shell and pairing effect within the partially overlapping region. In this context, only the initial (A_1, Z_1) and (A_2, Z_2), and the final (A, Z) are compulsory boundary conditions, but these quantities are subject to independent changes within the intermediary stages of fusion.

The final step of the project consists in the calculation of synthesis cross sections. One shall cover a range of Z=104 – 130 for the superheavy nuclei production. The neutron range is taken from the extension of drip lines in published literature.

Workplan

The project extends over three years, 36 months. This working period is divided as follows:

Months 1-6: Objective 1 – charge density variation and consequent intermediary proton level scheme calculation.

Months 6-18: Objective 2 – development of binary BCS theory.

Months 18-30: Objective 3 – development of binary cranking mass tensor.

Months 30-36: Objective 4 – calculation and minimization of the action integral in the multidimensional space of deformation. Fusion cross section calculation along the fusion path.

Man-months per member:

The director of the project, R. A. Poenariu-Gherghescu will be 100% devoted to the project, hence he will work the entire 36 months period for the fullfilment of the objectives.

The second senior researcher, member of the project, prof. D. N. Poenaru, is a highly reknown specialist in alpha and cluster decay phenomena. He will be also the whole 36 months period occupied with the project.

The third senior researcher, author of many articles in fission , will work an estimate of 12-18 months in the project.

The PhD student we intend to employ has already a contribution in our group, in macroscopic energy calculation. The time spend by the PhD student with this project: 12-18 months.

C4. *Impact, relevance, applications.*

There is a major problem rising in the experiments aiming to the synthesis of superheavy nuclei: the very low production cross section. There is also an important issue with the stability of these massive systems: the very short lifetime against alpha decay. In experiments these items are translated as: what is the most favourable target-projectile pair and how much the kinetic energy should be. Up to now, synthesis experiments used one of the partners with at least one magic number, proton Z and/or neutron N, in order to utilize the very stable closure of the nucleon shell. Dubna groups [1, 3] focus on ^{48}Ca projectiles, while the GSI experiment take advantage of the target nucleus magicity (Pb or Bi). The expected results of the present project rely on finding the stable binary configuration in between the moments of complete separation and compound nucleus. Such a fusion path will lower the potential barrier and increase the total cross section even for pairs of target-projectile that are far from shell closures, but which go through very stable binary configurations when they are partially overlapped. All fusion barriers obtained up to now stop calculation at the touching point configuration, from the microscopical point of view. It is assumed that beyond the touching point the path is more or less prescribed. This project will introduce the microscopy of the two superposed level schemes into the cross section calculation.

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C5. *Resources and budget*.

The Department of Theoretical Physics of the Horia Hulubei National Institute for Physics and

Nuclear Engineering is situated in Bucharest-Magurele, the largest research center in Romania. All members of the project have their own working desk, as well as a PC, performant enough to fullfil the necessary computations for the project. Large multidimensional minimizations are needed when running our computer codes, and consequently we are using a multicore type processor desktop to cover the whole range of mass asymmetry.

The international cooperation with Frankfurt Institute of Advance Studies, Frankfurt am Main, Germany will be continued in order to achieve the objectives of the project. That's why we shall spend money for the mobility. We shall also use a part of the mobility budget to cover the expenses of participating at International Scientific Meetings.

We received from our Institute the following justification of the large overhead of 50% of the direct costs, also uploaded as a file 'OverheadJustificationIFINHH.pdf' on the web site of the Project. National Research Institute for Physics and Nuclear Engineering "Horia Hulubei" is the largest national institute in Romania in all aspects, including assets and infrastructure. Funding the administrative activities of the institute is made only by overheads applied to research projects. Overheads are those expenses not directly attributable to a project and must be distributed based on distribution keys. Those distribution keys, as required by law, shall be determined by each institution in accordance with the accounting policies applied under the Order 3055/2009.

The indirect costs are: administrative staff salaries (about 11% of the direct costs); paid leave (vacations) for the staff involved in the project (about 13% of the direct costs); depreciation of equipment (about 11% of direct costs); fees and taxes (other than those for salaries) (about 5% of the direct costs); utilities (about 5% of direct costs), and others (materials, repairs, bank fees, insurances, etc) (about 5% of direct costs).

If these costs are not covered, a series of institute's expenses will remain uncovered with negative financial implications for the financial results of the institute. In this case the institute will have accounting losses and becomes ineligible to participate in future competitions organized within the national and international research programs.

Under these circumstances the projects implemented by the institute must use an overhead coefficient of 50% from direct costs.

Budget Breakdown (lei)

Budget chapter (expenses)	2011 (lei)	2012 (lei)	2013 (lei)	2014 (lei)	Total (lei)
Salaries	83333	310333	310333	227001	**931000**
Inventory					
Mobility		23000	23000	23000	**69000**
Overhead	41666	166667	166667	125000	**500000**
Total	**125000**	**500000**	**500000**	**375000**	**1500000**

Budget Breakdown (euro)

Budget chapter (expenses)	Total (euro)
Salaries	216511,63
Inventory	
Mobility	16046,51
Overhead	116279,07
Total	**348837,21**

Excange rate 1 EUR = 4,3 LEI.

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

Project leader,

Last name, first name: Gherghescu, Radu Alexandru

Signature:

Date: 28.04.2011