Date: 05-10-2015

The Secretary
University Grants Commission
Bahadur Shah Zafar Marg
New Delhi- 110002

Subject: Submission of final report, utilization certificate

Respected Sir,

I hereby submit the annual report, expenditure statement and utilization certificate for the project entitled **"Formation and decay of exotic nuclear system using energy density formalism"** sanctioned vide file no. **41-978/2012 (SR)** for the year Nov 2012- March 2015. I request you to Kindly release the remaining installment on priority for successful completion of project.

I am enclosing the following documents.

1. Expenditure Statement
2. Annual report of work done
3. Utilization Certificate
4. Final report of the work done
5. Claim Bill
6. Annexure-I
7. List of publications
8. Sanction letter

Thanking You

Yours sincerely

Dr. Manoj Kumar Sharma
Professor and Head
School of Physics & Materials Science
Thapar University, Patiala (147004)

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

STATEMENT OF EXPENDITURE IN RESPECT OF MAJOR/MINOR RESEARCH PROJECT

1. Name of Principal Investigator: **Dr. Manoj Kumar Sharma**
2. Deptt. of University/College : **School of Physics and Material Science, Thapar University Patiala**
3. UGC approval No. and Date: **41-978/2012(SR), 1-7-2012**
4. Title of the Research project: **"Formation and decay of exotic nuclear system using EDF"**
5. Effective date of starting the project: **01/09/2012**
6. Period of Expenditure: **From 01/09/2012 to 31/08/2015**
7. Detail of expenditure

S No.	Items	Amount Approved (Rs.)	Expenditure Incurred (Rs.)
1.	Books & journals	40,000/-	35,886/-
2.	Equipment	4,50,000/-	4,09,395/-
3.	Contingency	90,000/-	89,388/-
4.	Travel	75,000/-	73,176/-
5.	Hiring services	20,000/-	2000/-
6.	Overhead Charges	63,800/-	63,800/-
7.	Total	7,38,800/-	6,73,645/-

8. Staff: **Rajni (Project Fellow)**

Date of appointment: **9/11/2012**

S.No.	Expenditure Incurred	From to	Amount Approved(Rs.)	Expenditure Incurred(Rs.)
1.	Project Fellow@14,000/- p.m. for initial two years and 24,800/- p.m. from the third year onwards.	9/11/2012 to 31/09/2015	5,28,000/-	5,70,867/-*

*Committed amount of Rs. 2,66,600/- (from May, 2014 to Aug, 2015) and according to revised rate of fellowship as per UGC norms.

It is certified that the appointment(s) have been made in accordance with the

terms and conditions laid down by the Commission.

2. It as a result of check or audit objective, some irregularly is noticed, later date, action will be taken to refund, adjust or regularize the objected amounts.
3. Payment @ revised rates shall be made with arrears on the availability of additional funds.
4. It is certified that the grant of **Rs. 9,10,300/-** (Rupees Nine lakhs ten thousand and three hundred only) received from the University Grant Commission under the scheme of support for Major Research Project Entitled "Decay and formation of exotic nuclear system using EDF" vide UGC letter No. **41-978/2012(SR)** dates **1-07-2012** out of the Grant **Rs. 12,44,512/-** has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grant Commission.

Signature of Principal Investigator

Registrar
Thapar University
Patiala-147 004

Registrar/Principal

4/11/15

SANJAY RAMKALI & ASSOCIATES
(CA)
Chartered Accountants
M.No.097181
PATIALA

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

Annual/Final Report of the work done on the Major/Minor Research Project. (Report to be submitted within 6 weeks after completion of each year)

1. Project Report No. Final report

2. UGC Reference No. **41-978/2012(SR)**

3. Period of report : **01/09/2012 to 31/08/2015**

4. Title of research project "**Formation and decay of exotic nuclear system using Energy density formalism**"

5. (a) Name of the Principal Investigator **Dr. Manoj Kumar Sharma**

(b) Deptt. and University/College where work has progressed : **School of Physics and Materials Science , Thapar University Patiala.**

6. Effective date of starting of the project: **01-09-2012**

7. Grant approved and expenditure incurred during the period of the report:

a. Total amount approved **Rs. 12,66,800/-**

b. Total expenditure **12,44,512/-**

c. Report of the work done: (Please attach a separate sheet)

i. **Brief objective of the project:** The main objectives of the proposed research project are to study:

- Role of different Skyrme interactions for fusion using Extended ℓ-summed Wong formula.
- Study of different versions of nuclear proximity potentials in the decay path of nuclear system using DCM approach.
- Comparative behavior of Blocki pocket proximity interaction with EDF based nuclear interaction in the fusion-fission process.
- Effects of static and dynamic deformations and related orientations in heavy ion reactions.
- Analysis of competing decay processes including quasi fission.
- Comparison with experimental data and possible theoretical predictions

ii. Work done so far and results achieved and publications, if any, resulting from the work (Give details of the papers and names of the journals in which it has been published or accepted for publication)

Attached as in Annexure I

iii. Has the progress been according to original plan of work and towards achieving the objective: **Yes**

iv. Please indicate the difficulties, if any, experienced in implementing the project : **No**

v. If project has not been completed, please indicate the approximate time by which it is likely to be completed. A summary of the work done for the period (Annual basis) may please be sent to the Commission on a separate sheet.

vi. If the project has been completed, please enclose a summary of the findings of the Study. Two bound copies of the final report of work done may also be sent to the Commission **Attached as annexure I**

vii. Any other information which would help in evaluation of work done on the project. At the completion of the project, the first report should indicate the output, such as (a) Manpower trained : 1 (b) Ph. D. awarded : (c) Publication of results (d) other impact, if any **N.A**

Signature of Principal Investigator

Registrar
Thapar University
Patiala-147 004

Registrar/Principal

ज्ञान - विज्ञानं विमुक्तये

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

Utilization Certificate

Certified that the grant of **Rs. 9,10,300/-** (Rupees nine lakhs ten thousand and three hundred only) received from the university grant commission under the scheme of support for major research project entitled "**Formation and decay of exotic nuclear system using energy density formalism**" with vide **UGC letter No. 41-978/2012(SR)** dated **1-7-2012** out of the grant, **Rs. 12,44,512/-** has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the university grant commission and **Rs. 3,34,212/-** is still receivable from the UGC.

Principal investigator

Registrar
Thapar University
Patiala-147 004

Registrar/principal

4/11/15

SANJAY RAMKALI & ASSOCIATES
Chartered Accountants
M.No.097151
PATIALA

Annexure – VII

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

PROFORMA FOR SUBMISSION OF INFORMATION AT THE TIME OF SENDING THE FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. **Title of the project:** Formation and decay of exotic nuclear system using EDF.

2. **Name and address of the principal investigator:** Dr. Manoj K. Sharma, Post Box No. 32, School of Physics and Materials Science, Thapar University Patiala, 147004, Punjab.

3. **Name and address of the institution:** School of Physics and Materials Science, Thapar University Patiala, 147004, Punjab, India.

4. **UGC approval letter no. and date :** 41-978/2012(SR), 1-7-2012

5. **Date of implementation:** 01-09-2012

6. **Tenure of the project :** 01-09-12 to 31-08-2015

7. **Total grant allocated :** Rs. 12,66,800/-

8. **Total grant received :** Rs. 9,10,300/-

9. **Final expenditure :** 12,44,512/-

10. **Title of the Project:** Formation and Decay of exotic nuclear system using EDF.

11. **Objectives of the project:** 1. Role of different Skyrme interactions for fusion using Extended ℓ –summed Wong model.
    2. Study of different version of nuclear proximity potentials in the decay path of nuclear system using DCM approach.
    3. Comparative behaviour of Blocki pocket proximity interaction with EDF based nuclear interactions in the fusion-fission process.
    4. Effects of static and dynamic deformations and related orientations in heavy ion reactions.
    5. Analysis of competing decay process including quasi fission.
    6. Comparison with experimental data and possible theoretical predictions.

12. **Whether objectives were achieved (give details):** All work has been done in the committed time period of project. The fusion process of different nuclear systems is analysed using ℓ–summed Wong model. The comparative behaviour of EDF interaction based on the semi-classical extended Thomas Fermi density is carried out

with well established proximity interactions and the analysis is utilised further for understanding dynamical evolution of nuclear systems formed in heavy ion induced reactions. Various decay modes such as Evaporation Residue, fission and quasi etc. are duly addressed. Extensive analysis of different nuclear effects such as rotational energy, angular momentum, deformations (static and dynamic) and orientation degree of freedom etc. are investigated.

13. **Achievements from the project:** Twelve papers are published in reputed international journals (list attached). One Ph. D student is enrolled in this project. A variety of theoretical models are used in order to meet the communicated objectives. Some theoretical predictions are made which can further be useful for some future experiments.

14. **Summary of the findings:** A separate list is attached as annexure I.

15. **Contribution to the society:** The work carried out in this project deals with the fusion and decay of various nuclear systems. Comprehensive analysis of different nuclear structure properties relevant to excited state decays of nuclear systems is studied. The heavy ion dynamics is explored within collective clusterization approach and various aspects related to nuclear reaction dynamics and associated structure effects are worked out. This work is of extreme relevance and importance, as a number of related experiments are being performed in leading nuclear research centres of country and abroad. Our inputs and predictions may be of immense use for future experiments in the related area.

16. **Whether any PhD enrolled:** Yes

17. **No. of publications out of the project:** A separate list is attached

MShare
(PRINCIPAL INVESTIGATOR)

Registrar
Thapar University
Patiala-147 004
(PRINCIPAL)
(Seal)

Annexure I

Summary of the work done in the project

Problem 1: Reaction dynamics of Pt* isotopes formed using stable and radioactive Sn-beams [1].

The decay of various isotopes of Pt* formed using stable and neutron-rich radioactive beams of Sn is studied by using dynamical cluster-decay model (DCM). The entrance channel effect in ^{190}Pt* compound nucleus is investigated using different target and projectile. For both entrance channels i.e. ^{132}Sn+^{58}Ni and ^{126}Sn+^{64}Ni, the fragmentation potential and preformation probability of decaying fragments is almost identical at comparable center-of-mass energies ($E_{c.m.}$), enabling us to conclude that decay of ^{190}Pt* is independent of its formation effects. In order to check for the persistence of entrance channel independence in the decay of Pt* compound nucleus, various versions of nuclear proximity potentials and different values of level density parameter are employed in the calculations and result sustain. It is also observed that with inclusion of deformation effects up to quadrupole (β_2) within the optimum orientation approach, the structure of potential energy surfaces changes significantly. Beside this the fission mass distribution of Pt*isotopes is investigated and consequently the barrier modification is estimated to account for the phenomena of fusion hindrance. The ^{132}Sn+^{58}Ni reaction is also studied using four proximity potentials i.e. Prox 1977, Prox 1988, mod-Prox 1988 and Denisov 2002 within the framework of ℓ-summed extended-Wong model for addressing the fusion hindrance phenomena. We find that Prox 77 and Prox 88 fit the total fusion cross-section data only at above barrier energies whereas Denisov 2002 underestimate the data at all energies due to its least sensitiveness towards asymmetry and isospin. So a stronger nuclear interaction potential mod-Prox 1988 that accounts for isospin effect and asymmetry of the colliding nuclei is employed, which fits the data with smooth variation of ℓ_{max} (Ec.m.). Our calculations indicate that the isospin and asymmetry of colliding nuclei also plays an important role in the fusion dynamics particularly at below barrier region.

Problem 2: Theoretical study of odd-mass Fr* isotopes using the collective clusterization approach of the dynamical cluster-decay model [2].

The reaction dynamics of various odd-mass Fr* isotopes is studied over a wide range of incident energies, spread across the Coulomb barrier. The specific reactions analyzed are ^{18}O+^{197}Au and ^{19}F+^{192,194,196,198,200}Pt, forming odd-mass $^{211-219}$Fr* compound systems where some data are available for three of these isotopes: ^{213,215,217}Fr*. Based on the dynamical cluster-decay model (DCM), we have extended our calculations of the evaporation residue (ER) cross sections to the mainly fissioning ^{215}Fr*, using the systematics of ^{213,217}Fr* isotopes where the available ER cross sections (as well as fusion-fission cross sections) were studied earlier within the DCM. In order to obtain a clear picture of the dynamics involved, including entrance channel effects, the variations of fragmentation potential, preformation factor, and decay barrier height are analyzed. The relevance of barrier modification effects is also explored in the decay of ^{213,215,217}Fr* nuclei. In addition, fusion-fission (ff) cross sections are extended to ^{213,217}Fr* systems where some more data has recently become available. Also, the fission fragment anisotropies (so far measured and studied for ^{215}Fr* alone) are estimated for ^{213,217}Fr* using DCM for the use of non-sticking

moment of inertia, and relevant comparison with the sticking moment-of-inertia approach is analyzed. Furthermore, the shell closure effects of the decay fragments are investigated for odd-mass $^{211-219}$Fr* isotopes.

Problem 3: Possible decay mechanisms of ^{220}Ra formed in carbon induced reaction [3].
Using the dynamical cluster decay model (DCM), the decay of ^{220}Ra* compound nucleus formed in ^{13}C+^{207}Pb reaction is studied at various compound nucleus (E_{CN}) energies. The cross sections are calculated for various decay processes like neutron (n)-decay, evaporation residue (ER), fission and αxn channel, which find nice comparison with experimental data. The cross sections are calculated considering quadrupole (β_2) deformations with optimum orientation (θ_i^{opt}) by fitting the neck length (ΔR) parameter. The neck length parameter gives the measure of time scales of the respective decay channels. The potential energy surfaces corresponding to various decay channels are investigated over a wide range of incident energies above the Coulomb barrier. Finally, the competing incomplete fusion (ICF) contribution is analyzed for the above mentioned reaction channel.

Problem 4: Sticking versus non-sticking moment of inertia: Application to the ^{9}Be+^{232}Th reaction [4].
The aim of present study is to investigate the relative importance of sticking and non sticking limits of moment of inertia in the decay of ^{241}Pu* formed in ^{9}Be+^{232}Th reaction. The effects of nuclear deformations and orientations are duly incorporated and investigated for both static and dynamic choices in reference to decay path of ^{241}Pu* nucleus. The decay barrier height (V_B) increases as a function of angular momentum and is shown to get strongly influenced with the choice of I_S or I_{NS} limits of moment of inertia. We find that V_B decreases and hence the decay probability increases, with the inclusion of sticking moment of inertia. The exclusive role of deformations, orientations, and angular momentum dependence is also addressed in reference to centrifugal potential for the use of sticking and non-sticking limits of moment of inertia.

Problem 5: Effects of deformations and orientations in the fission of the actinide nuclear system ^{254}Fm* formed in the ^{11}B + ^{243}Am reaction [5].
We have studied the decay of actinide nuclear system ^{254}Fm* formed in ^{11}B + ^{243}Am reaction using the dynamical cluster decay model (DCM), with choices of spherical, quadrupole deformation β_2 alone and higher multipole deformations β_2–β_4. For β_2 deformations, the optimum orientations θ_i^{opt} are used whereas for higher multipole deformations the compact orientations θ_i^{c} of decaying fragments are taken in to account. Besides static-β_2 deformations, the effects of dynamical-β2 deformations are also explored. The calculated cross sections find excellent agreement with the available experimental data with spherical as well as deformed choices of fragmentations, enabling us to account for the role of important nuclear deformation effects in the ^{11}B-induced nuclear reaction. Spontaneous decay of ^{254}Fm* with cold elongated configuration and optimum orientation is also worked out. The mass distributions of excited fermium isotopes in the neighborhood of ^{254}Fm* are also explored. In addition, the roles of temperature, angular momentum, and fission fragment anisotropies are investigated in the context of the chosen reaction.

Problem 6: Fusion-evaporation residues and α-decay chains of the superheavy element Z = 115 formed in the ^{243}Am + ^{48}Ca reaction using the dynamical cluster-decay model [6].

The decay of the $Z = 115$ superheavy nuclear system, formed in the $^{243}Am + ^{48}Ca$ reaction, is studied by using the dynamical cluster-decay model. The calculated excitation functions of $2n$-, $3n$-, and $4n$-evaporation channels, for the excitation energy range $E^*_{CN} = 31–47$ MeV, are compared with the recent experimental data. The deformation effects are included up to β_2, within the hot optimum orientation approach, and a comparative analysis of spherical versus static and dynamic deformations is investigated explicitly for the $2n$ evaporation residue, as only $2n$ decay responds to spherical fragments. The $3n$ and $4n$ decay cross sections could be fitted only after the inclusion of deformation effects. The variation of preformation probability, barrier penetrability, and barrier modification is investigated in order to extract a better picture of the dynamics involved in the reaction under consideration. It is observed that, for the $3n$-evaporation channel, the barrier modification at $E^*_{CN} = 36.15$ MeV is the smallest and hence supports the experimental observation of maximum cross section (8.5 pb) at this energy. The role of isospin (N/Z ratio) is also investigated for the decay of various isotopes of $Z = 115$ formed in $^{48}Ca + ^{241,243,245}Am$ reactions. Furthermore, the evaporation cross sections of $2n$, $3n$, and $4n$ channels are also estimated at the Bass barrier by interpolating the neck-length parameters fixed in reference to available data at above-barrier energies. Finally, the α-decay chains are analyzed by using the preformed cluster model. It is shown that the present data of α-decay half-lives support "hot" optimum orientations of nuclei, rather than the usual "cold" ones, within a constant empirical factor in penetrability.

Problem 7: Effect of deformation and orientation on interaction barrier and fusion cross-sections using various proximity potentials [7].

The effect of deformation and orientation on barrier height and barrier position is studied using different types of proximity potentials for some 52 colliding nuclei with mass asymmetry parameter in range of 0 to 0.96.Various proximity potentials like Prox77, Prox88, Prox00, Bass80 and DenisovDP are used to extract barrier characteristics. These potentials cover a wide range of barrier and have different isospin and asymmetry dependence. With the inclusion of deformations, the barrier height and barrier position gets modified along with a significant change in the curvature. In order to study the possible effect of these deformation and orientation dependent proximity potentials, application is made in the frame work of Wong formula to O-,Ca- and Ni-based reactions in medium mass region in reference to available data on fusion cross-sections at around and above the Coulomb barrier energies. For ^{16}O- and ^{48}Ca-based reactions, Prox77 gives better comparison with experimental data as compared to other potentials around the Coulomb barrier energies whereas for ^{64}Ni-based reactions Prox88 seems close to the experimental data. At energies above the Coulomb barrier Bass80 and DenisovDP compete with each other. Angular dependence of cross-section is also studied. It is observed that deformation and orientation degree of freedom plays a significant role in reaction dynamics.

8. Dynamics of $^{58}Ni + ^{54}Fe \rightarrow ^{112}Xe$ reaction across the Coulomb barrier [8].

The dynamical cluster-decay model (DCM) has been applied to study the decay of the $^{112}Xe^*$ compound nucleus formed in the massive heavy-ion reaction $^{58}Ni + ^{54}Fe$ at energies across the Coulomb barrier with $E_{c.m.} \approx 85–110$MeV. The calculations are done for spherical fragmentation as well as by including deformation and orientation degrees of freedom of the decaying fragments. DCM-based cross sections give a nice description of the experimental fusion

excitation function σ_{ER}, within one parameter fitting, the neck length parameter (ΔR), whose value remains within the range of nuclear proximity interaction. The barrier height corresponding to the neck length parameter brings into the picture the barrier modification which enables us to address the data particularly at below barrier energies. The role of excitation energy (or temperature), deformations, orientations, angular momentum and diffuseness parameter is investigated to understand the dynamics of the $^{58}Ni + ^{54}Fe$ reaction. Finally the N/Z dependence of the fragmentation structure of different compound systems formed via ^{58}Ni beam (projectile) is explored.

Problem 9: Neutron-halo structure of light nuclei studied with effects of deformations and orientations included [9].

Based on the cluster-core model, the effects of nuclear deformations and orientations on the halo structure of the observed and proposed cases of neutron-halo nuclei is analyzed. The calculations are performed for the deformed structures using quadrupole (β_2) deformations with 'optimum' orientations as well as including higher multipole deformations (β_2-β_4) with the 'compact' (hot) orientations. The interesting result is that, although potential energy surfaces are modified with the inclusion of deformation effects up to β_2, but the 1n- and 2n-halo nature remains intact for almost all cases investigated here, except for ^{17}B and ^{22}C nuclei.However, in some cases (^{22}O, ^{26}F, ^{27}F), the choice of higher multipole deformations up to hexadecapole is shown to be rather sensitive. In addition, the relevance of the use of different nuclear proximity potentials is also explored in the context of the halo nature of neutron-rich light nuclei. The possible role of Q-value and angular momentum effects are also addressed.

Problem 10: Formation and decay of $^{200}Pb^*$ using different incoming channels [10].

Entrance channel effect is studied in the dynamics of $^{200}Pb^*$ formed in $^{16}O + ^{184}W$, $^{19}F + ^{181}Ta$, and $^{30}Si + ^{170}Er$ reactions over a wide range of excitation energies using the dynamical cluster-decay model (DCM) and Wong model. The effect of deformations up to β_2 along with optimum orientation is investigated in both formalisms. The fusion cross section is studied using the Wong model, which overestimates experimental data for $^{19}F + ^{181}Ta$, and $^{30}Si + ^{170}Er$ reactions and underestimates the data at few energies for $^{16}O + ^{184}W$. However with the use of the extended ℓ-summed Wong model, the overestimation is taken care and the cross sections are fitted nicely. The Wong-based calculations suggest that there might be some non compound nucleus contribution at few energies for the $^{16}O + ^{184}W$ channel, as the underestimation of the cross section persists even after the inclusion of deformation effects. This lead us to conclude that the formation of $^{200}Pb^*$ compound nucleus depends on the choice of the incoming channel. In addition to this, the decay path of $^{200}Pb^*$ is investigated using DCM. Although the overall decay pattern of compound nucleus $^{200}Pb^*$ seems similar for all the chosen reactions, some signatures of variation are observed in fission and in the intermediate mass fragment region for the deformed fragmentation process. It is to be noted that with the inclusion of deformation, the decay pattern changes from symmetric to asymmetric, thereby suggesting that the deformation and orientation of decaying fragment are equally important in the formation as well as in the decay process of proton magic nuclear system $^{200}Pb^*$. Prediction of the evaporation residue and fission cross sections at higher as well as at lower incident energies is also worked out. In addition to this, the dynamics of neighbouring nuclei $^{192}Pb^*$ and $^{202}Pb^*$ is also analyzed.

Problem 11: Fragment mass identification and related aspects in the decay of $^{40}Ca^*$ and $^{39}K^*$ nuclei [11].

The dynamics involved in the decay of light mass nuclei formed in asymmetric channels $^{12}C + ^{28}Si$, $^{11}B + ^{28}Si$ and $^{12}C + ^{27}Al$ have been investigated using the dynamical cluster-decay model (DCM). In reference to the experimentally measured charge particle cross-sections, the fragment masses contributing towards the decay of $^{40}Ca^*$ and $^{39}K^*$ nuclei have been identified using spherical choice of fragmentation. Also, the role of entrance channel has been investigated by studying the decay of $^{39}K^*$ nuclear system formed in two different reactions at same excitation energy. The behavior of fragmentation potential, preformation probability, penetrability and emission time, is analyzed to figure out the favorable mass fragments, their relative emergence and the entrance channel effects observed in the decay of light mass nuclei. In addition to this, the cross-sections for the light particles (LPs) and heavier charge fragments have been estimated for the compound nucleus (CN) decay. Besides this, one of the non-compound nucleus (nCN) process, deep inelastic collision (DIC) has been addressed in context of DCM approach for the first time. The cross-sections obtained in framework of DCM for both CN and nCN processes are found to have nice agreement with the available experimental data.

Problem 12: Decay of Zr isotopes and related nuclear structure effects using collective clusterization approach [12].

The reaction dynamics of various even-mass Zr isotopes is studied using collective clusterization approach of the dynamical cluster decay model (DCM). The role of iso-spin (N/Z ratio) and deformations is explored by analysing the decay pattern of various Zr-nuclei formed in ^{16}O induced reactions. Also, the entrance channel effect is investigated by studying the decay of $^{92}Zr^*$ nuclear system formed in two different reactions at comparable excitation energy. In order to obtain a clear picture of the dynamics involved in the reactions under consideration, the behaviour of fragmentation potential and preformation factor is analyzed. The DCM calculated cross-sections find nice agreement with available experimental data.

References:

1. D. Jain, R. Kumar, and M. K. Sharma, Phys Rev. C 87, 044612 (2013).
2. G. Sawhney, G. Kaur, M. K. Sharma, and R. K. Gupta Rev. C 88 034603 (2013).
3. M. Kaur and M. K. Sharma AIP Conf. Proc. 1524, 151 (2013).
4. G. Sawhney, R. Kumar, Rajni, and M. K. Sharma AIP Conf. Proc. 1524, 174 (2013).
5. M. Kaur, M. K. Sharma, and R. K. Gupta, Phys Rev. C 86, 064610 (2012).
6. R. Kumar, K. Sandhu, M. K. Sharma, and R. K. Gupta phys. Rev. C 87, 054610 (2013).
7. D. Jain, R. Kumar, M. K. Sharma Nucl. Phys. A 915. 106-124 (2013).
8. M. Kaur and M. K. Sharma Eur. Phys. J. A 50, 61 (2014).
9. G. Sawhney, M. K. Sharma, and R. K. Gupta J. Phys. G: Nucl. Part. Phys. 41 055101 (2014).
10. Rajni, R. Kumar, and M. K. Sharma, Phys Rev. C 90, 044604 (2014).
11. G. Kaur and M. K. Sharma Int. J. Mod. Phys. E 23, 1450063 (2014).
12. G. Kaur, Rajni and M. K. Sharma, Phys. Scr. (2015) (Accepted).

List of Publications in international journal

1. D. Jain, R. Kumar, and M. K. Sharma, Phys Rev. C 87, 044612 (2013).
2. G. Sawhney, G. Kaur, M. K. Sharma, and R. K. Gupta Rev. C 88 034603 (2013).
3. M. Kaur and M. K. Sharma AIP Conf. Proc. 1524, 151 (2013).
4. G. Sawhney, R. Kumar, Rajni, and M. K. Sharma AIP Conf. Proc. 1524, 174 (2013).
5. M. Kaur, M. K. Sharma, and R. K. Gupta, Phys Rev. C 86, 064610 (2012).
6. R. Kumar, K. Sandhu, M. K. Sharma, and R. K. Gupta phys. Rev. C 87, 054610 (2013).
7. D. Jain, R. Kumar, M. K. Sharma Nucl. Phys. A 915, 106-124 (2013).
8. M. Kaur and M. K. Sharma Eur. Phys. J. A 50, 61 (2014).
9. G. Sawhney, M. K. Sharma, and R. K. Gupta J. Phys. G: Nucl. Part. Phys. 41 055101 (2014).
10. Rajni, R. Kumar, and M. K. Sharma, Phys Rev. C 90, 044604 (2014).
11. G. Kaur and M. K. Sharma Int. J. Mod. Phys. E 23, 1450063 (2014).
12. G. Kaur, Rajni and M. K. Sharma, Phys. Scr. (2015) (Accepted).

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23235733, 23232317, 23236735, 23239437

विश्वविद्यालय अनुदान आयोग
बहादुरशाह जफर मार्ग
नई दिल्ली 110 002
UNIVERSITY GRANTS COMMISSION
BAHADURSHAH ZAFAR MARG
NEW DELHI-110 002

F. No. 41-978/2012 (SR)

The Under Secretary (FD-III)
University Grants Commission
New Delhi-110002

Sub:- UGC support for the Major Research Project in Physical Sciences, Bio-Sciences, Maths , Medical, Agricultural Sciences and Engineering & Chemistry to University/College Teachers - Project entitled,

"Formation and decay of exotic nuclear systems using energy density formalism"

Sir,

I am to refer to your letter forwarding the application of **Dr. Manoj Kumar Sharma** of your institution for financial assistance under the above scheme and to convey the Commission's approval & sanction an on account grant of **Rs. 9,10,300/- (Rupees: nine lakh ten thousand three hundred only)** to the Registrar, **Thaper Institute of Engineering and Technology, Pattiala-147004, Punjab** in r/o Major Research Project of **Dr. Manoj Kumar Sharma**, Department of **Physics** for the period of 3 years w.e.f. **1.7.2012** as detailed below:-

S.No	ITEMS	AMOUNT APPROVED	GRANT RELEASED AS Ist INSTALMENT	Categ ory
A.	**Non - Recurring**		4,90,000/-	GEN
1.	Books & Journals	40,000/-		
2.	Equipment (As per proposal)	4,50,000/-		
B.	**Recurring**		4,20,300/-	
1.	Honorarium to Retd. Teacher @ Rs. 12, 000/- p.m.	nil		
2.	Project Fellow @14,000/- p.m. for initial 2 years and Rs. 16,000/- p.m. from the third year onwards.	5,28,000/-		
3.	Chemical/ Glassware / Consumable	nil		
4.	Hiring Services	20,000/-		
5.	Contingency	90,000/-		
6.	Travel/Field Work	75,000/-		
7.	Special Need	nil		
8.	Overhead Charges @ Rs. 10% approved recurring Grant (Except Travel & Field Work)	63,800/-		
	Total (A + B)	12,66,800/-	9,10,300/-	

The acceptance Certificate in prescribed format (Annexure-I available on the UGC web-site) may be sent to the undersigned within one month from the issue of the award letter failing which the project may be treated as cancelled.

If the terms & conditions are acceptable, as per guideline which are available on UGC web-site www.ugc.ac.in the Demand Draft/ Cheque being sent may be retained. Otherwise the same may be returned in original to the UGC by Registered Post in variably with in 15 days from the receipt of the Demand Draft/Cheque in favour of Secretary, UGC, New Delhi.

Principal Investigators should ensure that the statement of expenditure & utilization Certificate to the effect that the grant has been utilized for the purpose for which it has been sanctioned shall be furnished to the University Grants Commission in time.

The first instalment of the grant shall comprise of 100% of the Non - Recurring including Over Head Charges, and 50% of the total Recurring grant.

23236351, 23232701, 23237721, 23234116
23235733, 23232317, 23236735, 23239437

विश्वविद्यालय अनुदान आयोग
बहादुरशाह जफर मार्ग
नई दिल्ली 110 002
UNIVERSITY GRANTS COMMISSION
BAHADURSHAH ZAFAR MARG
NEW DELHI-110 002

F. No. 41-978/2012 (SR)

The Under Secretary (FD-III)
University Grants Commission
New Delhi-110002

Sub:- UGC support for the Major Research Project in Physical Sciences, Bio-Sciences, Maths , Medical, Agricultural Sciences and Engineering & Chemistry to University/College Teachers - Project entitled,

"Formation and decay of exotic nuclear systems using energy density formalism"

Sir,

I am to refer to your letter forwarding the application of **Dr. Manoj Kumar Sharma** of your institution for financial assistance under the above scheme and to convey the Commission's approval & sanction an on account grant of **Rs. 9,10,300/- (Rupees: nine lakh ten thousand three hundred only)** to the Registrar, **Thaper Institute of Engineering and Technology, Pattiala-147004, Punjab** in r/o Major Research Project of **Dr. Manoj Kumar Sharma**, Department of **Physics** for the period of 3 years w.e.f. **1.7.2012** as detailed below:-

S.No	ITEMS	AMOUNT APPROVED	GRANT RELEASED AS Ist INSTALMENT	Category
A.	Non - Recurring		4,90,000/-	GEN
1.	Books & Journals	40,000/-		
2.	Equipment (As per proposal)	4,50,000/-		
B.	Recurring		4,20,300/-	
1.	Honorarium to Retd. Teacher @ Rs. 12, 000/- p.m.	nil		
2.	Project Fellow @14,000/- p.m. for initial 2 years and Rs. 16,000/- p.m. from the third year onwards.	5,28,000/-		
3.	Chemical/ Glassware / Consumable	nil		
4.	Hiring Services	20,000/-		
5.	Contingency	90,000/-		
6.	Travel/Field Work	75,000/-		
7.	Special Need	nil		
8.	Overhead Charges @ Rs. 10% approved recurring Grant (Except Travel & Field Work)	63,800/-		
	Total (A + B)	12,66,800/-	9,10,300/-	

The acceptance Certificate in prescribed format (Annexure-I available on the UGC web-site) may be sent to the undersigned within one month from the issue of the award letter failing which the project may be treated as cancelled.

If the terms & conditions are acceptable, as per guideline which are available on UGC web-site www.ugc.ac.in the Demand Draft/ Cheque being sent may be retained. Otherwise the same may be returned in original to the UGC by Registered Post in variably with in 15 days from the receipt of the Demand Draft/Cheque in favour of Secretary, UGC, New Delhi.

Principal Investigators should ensure that the statement of expenditure & utilization Certificate to the effect that the grant has been utilized for the purpose for which it has been sanctioned shall be furnished to the University Grants Commission in time.

The first instalment of the grant shall comprise of 100% of the Non - Recurring including Over Head Charges, and 50% of the total Recurring grant.

THAPAR UNIVERSITY
(Declared as Deemed-to-be-University u/s 3 of the UGC Act, 1956)
Thapar Technology Campus, Post Box No. 32
Patiala 147 004 Punjab India
Fax : +91-175-2364498, 2393005
URL : www.thapar.edu

NO:SPMS/UGC/ 202
Dated: 9.11.2012

Ms. Rajni
2905, Bagichi Mangal Dass
Patiala

Dear Ms. Rajni,

I have the pleasure to offer you a temporary appointment of Project Fellow in the UGC sponsored project entitled "Formation and decay of exotic nuclear systems using energy density formalism" initially for a period of one year at a salary of Rs. 14,000/- p.m. as per UGC rules effective from the date you actually join duty. However, in case your performance is observed to be unsatisfactory or in the event of misconduct on your part during the period of the temporary appointment, your services are liable to be terminated without any notice.

During the said period, the temporary appointment is liable to be terminated on either side on one-month notice or on payment of one-month salary in lieu thereof, without assigning any reason. This offer of appointment shall any case, be co-terminus with the project.

In the matter of leave and general conditions of service, you will be governed by the regulations of the project in which you are appointed and as specified by the University.

In case you accept the offer, please return the duplicate copy of the temporary appointment letter duly signed by you in token of your acceptance of the above terms. In case, we do not hear from you latest by November 9, 2012 or you fail to report by November 20, 2012 the offer of temporary appointment will be withdrawn.

Yours sincerely,

9.11.12
(MANOJ K. SHARMA)
Principal Investigator
Associate Professor
School of Physics & Materials Science
Thapar University-147004

I accept the offer of the above temporary appointment on the terms and conditions stated above and expect to join the University by 9 Nov, 2012

9/11/2012

Copy to: Dean, RSP
Head, SPMS
Finance Officer

Date:09-11-2012

Dr. Manoj K. Sharma
Principal investigator
Associate Professor
School of Physics & Material Science
Thapar University
Patiala

Subject : joining letter as project fellow in UGC project.

Respected Sir

I hereby accept the Project Fellow position under the UGC funded project entitled "**Formation and decay of exotic nuclear system using energy density formalism**" with reference No SPMS/UGC/202. I am joining my duty on November 09, 2012.

Yours Sincerely

Rajni

HSPMS
for inf. pl.
MSharma
9.11.12

Fule
19/11/12

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

SPMS/MKS/605

Dated: 19-04-2019
22

The Secretary
University Grants Commission
Bahadur Shah Zafar Marg
New Delhi- 110002

Subject: Regarding fellowship of project fellow in UGC project reference no. 41-**978/2012 (SR) dated 1-7-2012**

Dear Sir/Madam,

In reference to your letter dated 28 June 2018, in respect of UGC funded Major Research Project entitled **"Formation and decay of exotic nuclear system using energy density formalism"** sanctioned vide file no. **41-978/2012 (SR),** the letter of amount 3,21,851/- has been received. As per the letter, the tenure of the project from 01.07.2012 to 30.06.2015 is extended upto 31.12.2015, however, the fellowship received till 30 Sept 2015. Therefore, you are requested to kindly release the remaining fellowship on priority.

It may be noted that project fellow Ms. Rajni worked in this project from Nov. 11, 2012 to Dec 31, 2015 (36 months completed on Nov 8, 2015).

We are sending the following documents:

1. Revised Claim Form
2. Details of salary
3. Sanctioned letter
4. Bank detail of TIET

Thanking You

Yours sincerely

19.4.19

Dr. Manoj Kumar Sharma
(Principal Investigator)
School of Physics & Materials Science
Thapar Institute of Engineering and Technology (TIET),
Patiala (147004)

CLAIM BILL

Name of the Research Scholar : Ms. Rajni

Address : School of Physics & Materials Science, Thapar Institute of Engineering & Technology, Patiala, Punjab-147004.

UGC approval No. and Date: **41-978/2012(SR), 1-7-2012**

PARTICULARS	AMOUNT OF GRANT			
	Fellowship	HRA @10%	Total	Remarks
1. Amount to be Claim for the period from 01/10/2015 to 31/12/2015	48000/-	4800	52800/-	
2. Unspent balance from the grant of last year	Nil	Nil	Nil	
3. Total amount from the last year carry forwarded to the next year	Nil	Nil	Nil	
4. Net Amount to be released for the period of 01/10/2015 to 31/12/2015	48000/-	4800/-	52800/-	As per UGC letter dated 28 June 2018, Project has been extended upto 31.12.2015 and

				3 months' salary is pending

Certified that the amount claimed in this bill will be utilized for the purpose for which it has been sanctioned and the statement of expenditure will be furnished as per requirement.

Principal Investigator

Thapar Institute of Engineering and Technology Patiala

Head, SPMS

HEAD
School of Physics & Materials Science
Thapar Institute of Engineering & Technology
Patiala - 147004.

Registrar

Registrar
Thapar Institute of Engg. & Tech.,
PATIALA (PUNJAB) INDIA

Details of Salary in UGC project

09.11.2012-31.12.2015

Project F. N : 41-978/2012(SR) dated: 01-07-2012

Title of the project: Formation and decay of exotic nuclear system using energy density formalism

Sr. No.	Month (year) 14000/-p.m for initial two years then 16000/- third year onward	(A) Fellowship Sanctioned		(B) Fellowship Withdrawn		(C) Balance Claimed	
		Salary (in rupees)	HRA@10 % (in rupees)	Salary (in rupees)	HRA@10% (in rupees)	Salary (in rupees)	HRA@10 % (in rupees)
1	**09.11.2012-30.11.2012 (Nov 2012)**	10267/-	1026	10267/-	1026	Nil	Nil
2	**December 2012**	14000/-	1400	14000/-	1400	Nil	Nil
3	**January 2013**	14000/-	1400	14000/-	1400	Nil	Nil
4	**February 2013**	14000/-	1400	14000/-	1400	Nil	Nil
5	**March 2013**	14000/-	1400	14000/-	1400	Nil	Nil
6	**April 2013**	14000/-	1400	14000/-	1400	Nil	Nil
7	**May 2013**	14000/-	1400	14000/-	1400	Nil	Nil
8	**June 2013**	14000/-	1400	14000/-	1400	Nil	Nil
9	**July 2013**	14000/-	1400	14000/-	1400	Nil	Nil
10	**August 2013**	14000/-	1400	14000/-	1400	Nil	Nil
11	**September 2013**	14000/-	1400	14000/-	1400	Nil	Nil
12	**October 2013**	14000/-	1400	14000/-	1400	Nil	Nil
13	**November 2013**	14000/-	1400	14000/-	1400	Nil	Nil
14	**December 2013**	14000/-	1400	14000/-	1400	Nil	Nil
15	**January 2014**	14000/-	1400	14000/-	1400	Nil	Nil
16	**February 2014**	14000/-	1400	14000/-	1400	Nil	Nil
17	**March 2014**	14000/-	1400	14000/-	1400	Nil	Nil
18	**April 2014**	14000/-	1400	14000/-	1400	Nil	Nil
19	**May 2014**	14000/-	1400	14000/-	1400	Nil	Nil
20	**June 2014**	14000/-	1400	14000/-	1400	Nil	Nil
21	**July 2014**	14000/-	1400	14000/-	1400	Nil	Nil
22	**August 2014**	14000/-	1400	14000/-	1400	Nil	Nil
23	**September 2014**	14000/-	1400	14000/-	1400	Nil	Nil
24	**October 2014**	14000/-	1400	14000/-	1400	Nil	Nil

25	**November 2014**	3733/-(8 days @14000pm) 11,733/-(22 days @16000pm) T=15,466/-	1547	15,466/-	1547/-	Nil	Nil
26	**December 2014**	16000	1600	16000	1600	Nil	Nil
27	**January 2015**	16000	1600	16000	1600	Nil	Nil
28	**February 2015**	16000	1600	16000	1600	Nil	Nil
29	**March 2015**	16000	1600	16000	1600	Nil	Nil
30	**April 2015**	16000	1600	16000	1600	Nil	Nil
31	**May 2015**	16000	1600	16000	1600	Nil	Nil
32	**June 2015**	16000	1600	16000	1600	Nil	Nil
33	**July 2015**	16000	1600	16000	1600	Nil	Nil
34	**August 2015**	16000	1600	16000	1600	Nil	Nil
35	**September 2015**	16000	1600	16000	1600	Nil	Nil
36	**October 2015**	16000	1600	Nil	Nil	16000	1600
37	**November 2015**	16000	1600	Nil	Nil	16000	1600
38	**December 2015**	16000	1600	Nil	Nil	16000	1600
	Total Amount	5,55,733	55,573/-	5,07,733/-	50,773/-	48000/-	4800/-
	(A) 6,11,306/- = (B) 558506+ (C) 52800/-						

(Dr. Manoj K. Sharma)
Principal Investigator
SPMS
TIET Patiala

(Dr. O. P. Pandey)
Head of the Dept.
SPMS
TIET Patiala

HEAD
School of Physics & Materials Science
Thapar Institute of Engineering & Technology
Patiala - 147004.

(Dr. Gurbinder Singh)
Registrar
TIET Patiala

Registrar
Thapar Institute of Engg. & Tech.,
PATIALA (PUNJAB) INDIA