Theory initiatives at IITR

P. Arumugam, R. Chatterjee, and A.K. Jain
Department of Physics,
Indian Institute of Technology - Roorkee

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Interaction Meeting on Theoretical Nuclear Physics

September 3 – 5, 2010

Department of Physics
Indian Institute of Technology Roorkee
India – 247667

IMTNP @ Roorkee

September 3-5, 2010

Sponsored by
Science and Engineering Research Council
Department of Science and Technology
Government of India

Participation will be by invitation

Planning Committee

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Prof. A.K. Jain (IITR), Convener

Aim

- To identify the topics in nuclear structure and reaction theory being pursued, or which could be pursued at different places in India,
- To identify the possibility of research collaborations between the different groups within the country and internationally,
- To identify areas where we can contribute to the experimental programmes being pursued at different laboratories in India and their upgrades, and finally
- To make recommendations for a national program of coordinated research and development for the next decade which may include formation of working groups, organization of a series of schools and collaborative meetings.

Topics

- *Ab-initio* and mean field models of nuclear structure and reactions and their future directions
- Shell Model for the 21st century
- Density functional methods in nuclei
- Effective Interactions in Nuclei
- Group theoretical approaches to nuclei
- Semi-classical methods and Random Matrix Theory
- Applications in nuclear astrophysics, reaction network calculations
- Advances in computational nuclear physics

Contact

Prof. A. K. Jain, (Convener)
Email: ajainfph@iitr.ernet.in; Tel: +91 1332 285753(O), 274144(R).
Dr. Rajdeep Chatterjee
Email: rcfphfph@iitr.ernet.in; Tel: +91 9997133789
Dr. P. Arumugam
Email: p.arumugam@gmail.com; Tel: +91 8979890366

Main Objectives of IMTNP

- Identify the topics in nuclear structure and reaction theory being pursued, or which could be pursued at different places in India

- Research collaborations between the different groups

- Identify areas where we can contribute to the experimental programs being pursued at different laboratories in India and abroad

IMTNP : Working Groups

1. Nuclear Shell Model

2. Reaction Mechanisms of loosely bound systems & Astrophysics

3. Mean Field Theories, DFT/RMF

4. Non Perturbative Theories/Semi Classical, Random Matrix Theory & Quantum Chaos

IMTNP : Working Groups

5. Hypernuclei

6. Many Body Theory & G Matrix

7. Double Beta Decay

8. Neutron induced Reactions as Applied to Nuclear energy Program

9. Fission & Fusion Reactions

10. Relativistic Heavy Ion Collisions

IMTNP : Centre for Nuclear Theory

1. The proposed Centre will coordinate the activities of the various working groups

2. Organize topical meetings, workshops and schools

3. Facility where generally theorists can come in for short term visits and interact among themselves

4. A web based virtual centre of nuclear theory would be the first step towards this goal

Nuclear Theory @ Roorkee

Spectroscopy

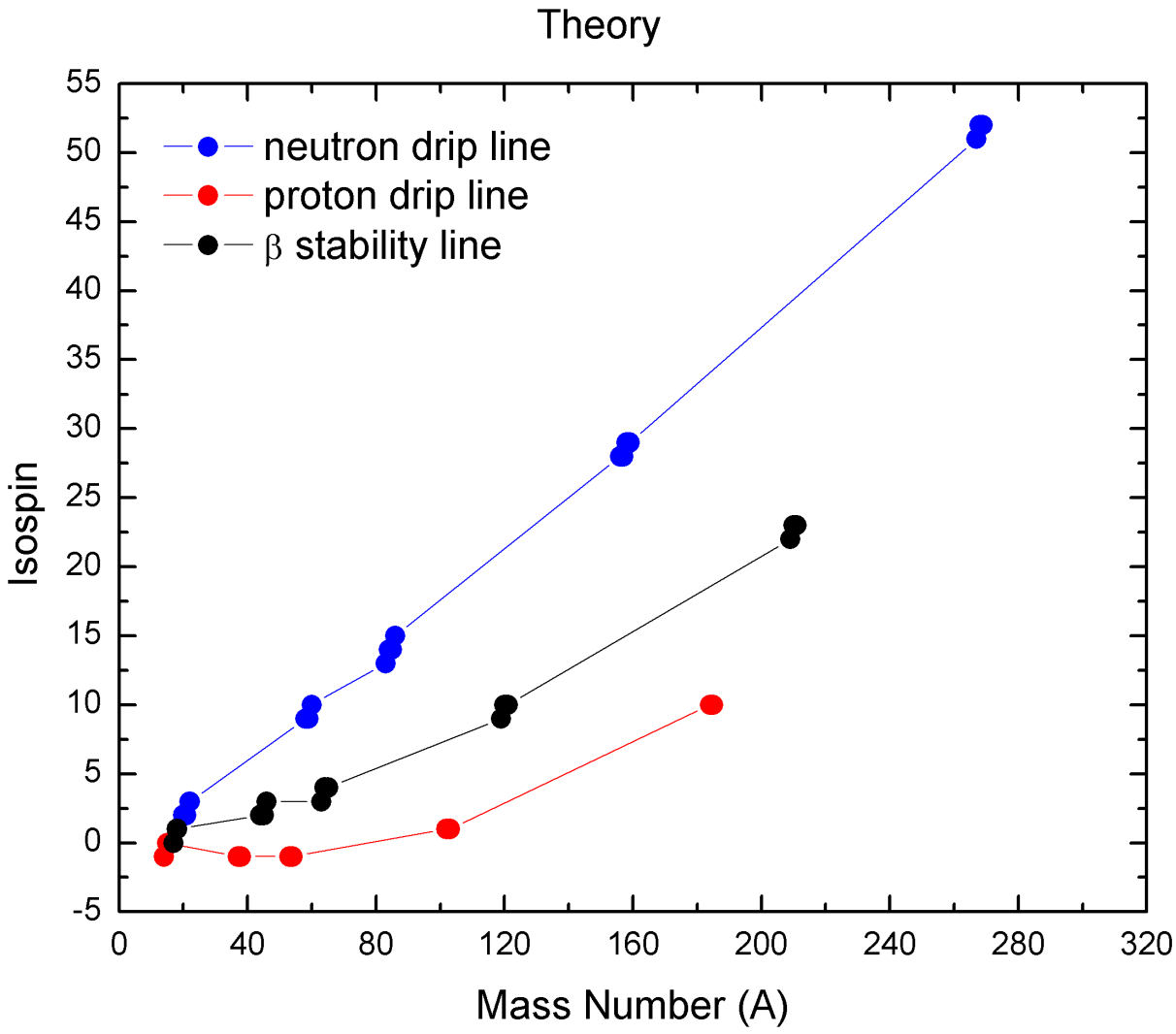
- High spin spectroscopy
- Large Isospin in Nuclei
- Symmetries
- Exotic Radioactivity

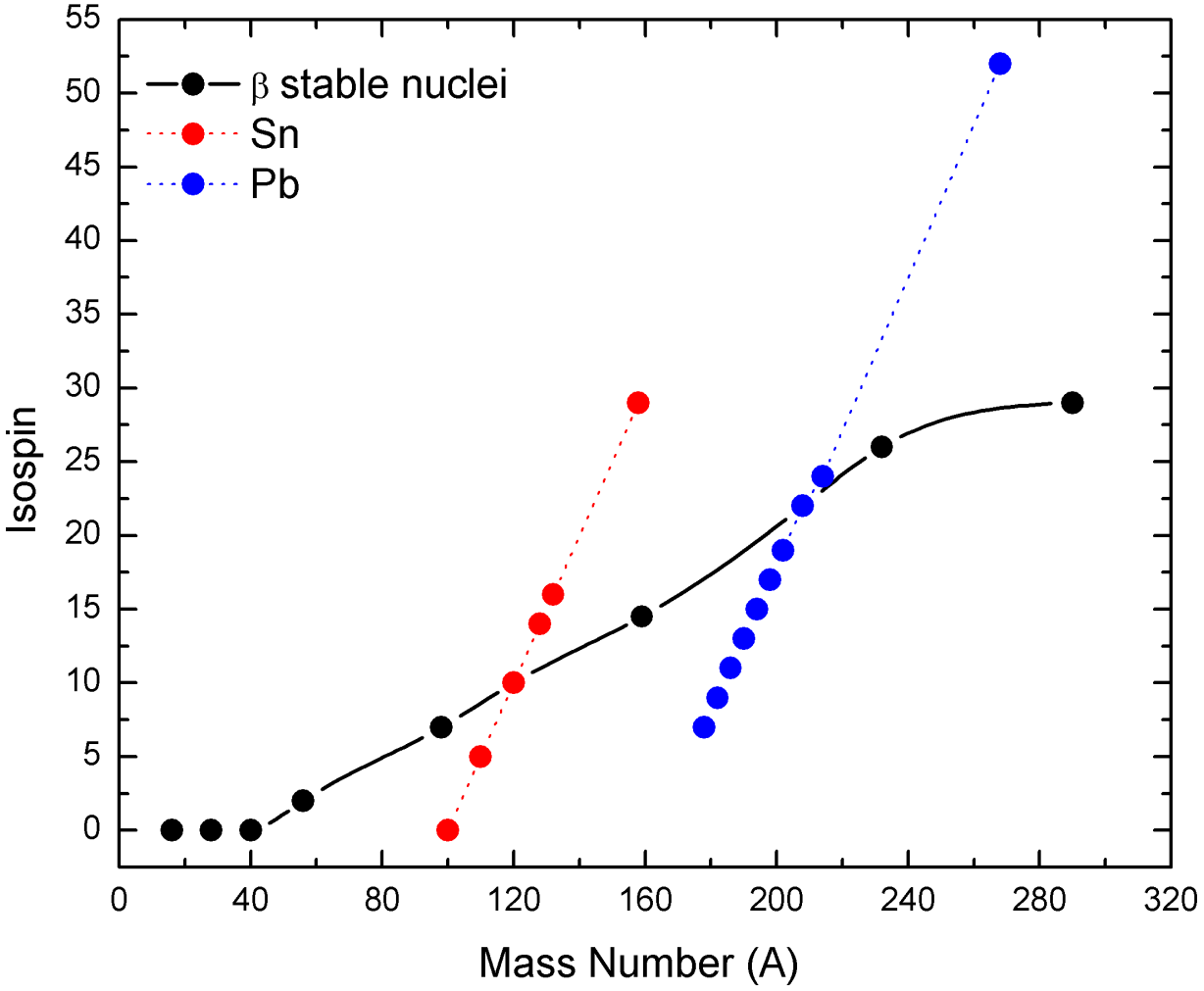
Reactions with RIB

- Reaction dynamics of exotic nuclei
- Open quantum systems

Nuclear Astrophysics

- Reaction rates (Direct and indirect methods)
- Neutron Stars


Theory
neutron drip line
proton drip line
β stability line
Isospin
Mass Number (A)
55
50
45
40
35
30
25
20
15
10
5
0
-5
0
40
80
120
160
200
240
280
320


β stable nuclei
Sn
Pb
Isospin
Mass Number (A)
0
5
10
15
20
25
30
35
40
45
50
55
0
40
80
120
160
200
240
280
320

First we consider HI fusion-fission reac. : $^{238}U(^{18}O, f)$

$$^{18}O + {}^{238}U \rightarrow {}^{256}Fm^* \rightarrow \underbrace{F_1 + F_2}_{\text{RCN}} + qn$$

- ***Sn-Sn***
- ***Cd-Te***
- ***Pd-Xe***
- ***Ru-Ba***
- ***Mo-Ce***
- ***Zr-Nd***
- ***Sr-Sm***

Sn-Sn *(Symmetric Fission)*

$$^{18}O + {}^{238}U \rightarrow {}^{256}Fm^* \rightarrow {}^{244}Fm^* + 12n$$

T_3 :	1	27	28	22	6
T :	1	27	28	22 *to* 34	6

$T'_{Sn} + T''_{Sn}$

$$\left|T, T_3\right\rangle_{RCN} = \sum \left\langle C.G.\ coeff.\right\rangle \left|T', T'_3\right\rangle_{Sn} \left|T'', T''_3\right\rangle_{Sn}$$

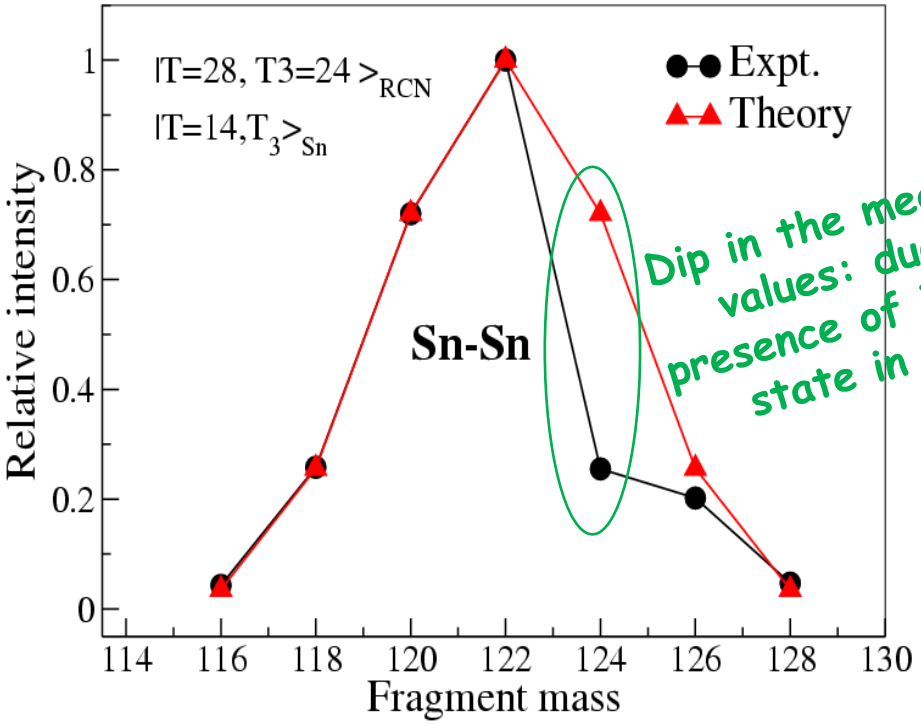
Intensity = (C.G. coeff.)^2

☆ ***The observed correlated pairs of Sn fragments have T_3 values ranging from 8 to 14 their sum always being 22.***

☆***Total isospin of Sn fragments should be at least 14 so that all the fragments can be generated as members of the T=14 multiplet.***

☆***For ^{122}Sn-^{122}Sn pairs of fragments : totally symmetric => must have identical isospins : |14,11>***

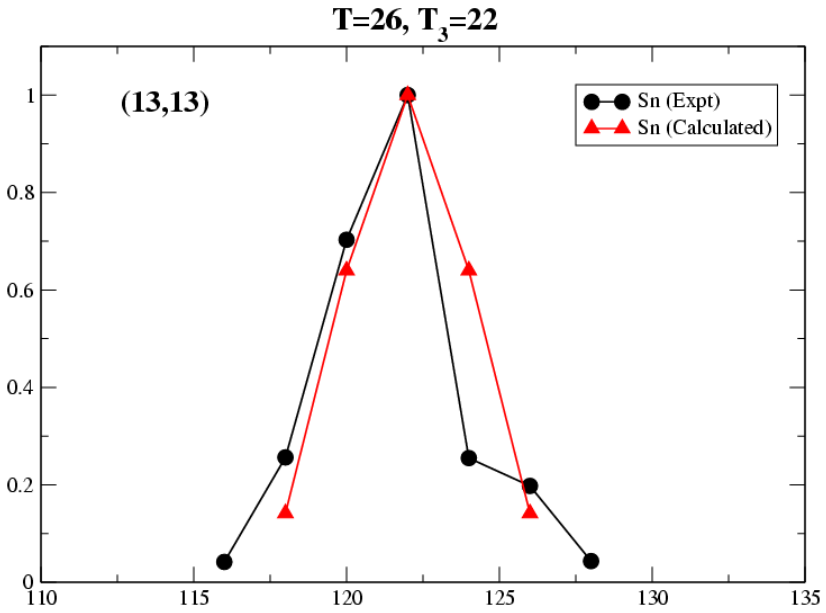
$$\left|28,22\right\rangle_{RCN} = \sum \left\langle 14,T',14,T'' \,|\, 28,22\right\rangle \left|14,T_3'\right\rangle_{Sn} \left|14,T_3''\right\rangle_{Sn}$$



Dip in the measured values: due to presence of isomeric state in ^{124}Sn

$$\left|28,22\right\rangle_{RCN} = 0.108\left|14,14\right\rangle_{^{128}Sn}\left|14,8\right\rangle_{^{116}Sn} + 0.291\left|14,13\right\rangle_{^{126}Sn}\left|14,9\right\rangle_{^{118}Sn} + 0.488\left|14,12\right\rangle_{^{124}Sn}\left|14,10\right\rangle_{^{120}Sn} + 0.575\left|14,11\right\rangle_{^{122}Sn}\left|14,11\right\rangle_{^{122}Sn} + 0.488\left|14,10\right\rangle_{^{120}Sn}\left|14,12\right\rangle_{^{124}Sn} + 0.291\left|14,9\right\rangle_{^{118}Sn}\left|14,13\right\rangle_{^{126}Sn} + 0.108\left|14,8\right\rangle_{^{116}Sn}\left|14,14\right\rangle_{^{128}Sn}$$

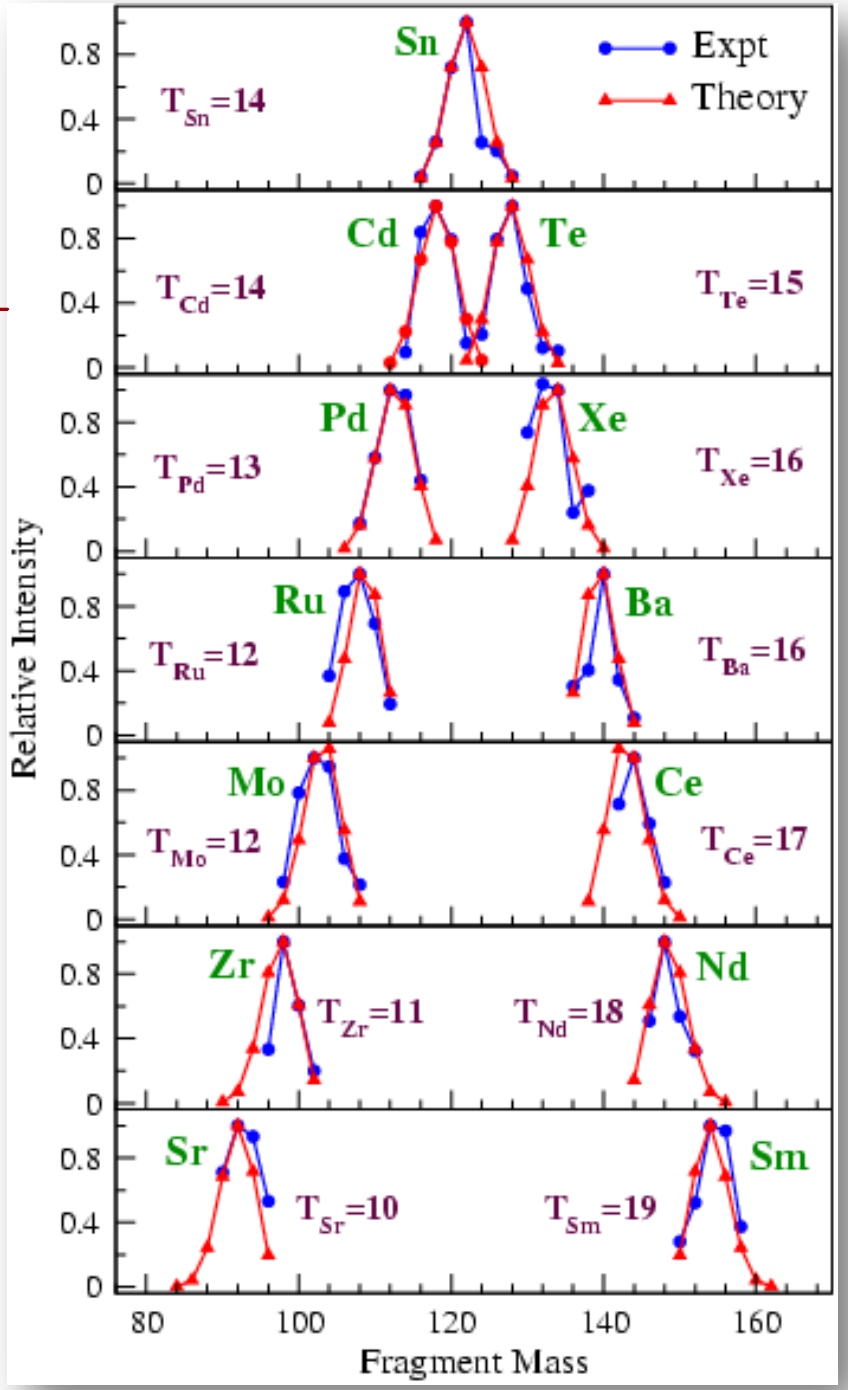
$$\left|26,22\right\rangle_{RCN} = +0.291\left|13,13\right\rangle_{^{126}Sn}\left|13,9\right\rangle_{^{118}Sn} + 0.488\left|13,12\right\rangle_{^{124}Sn}\left|13,10\right\rangle_{^{120}Sn} + 0.575\left|13,11\right\rangle_{^{122}Sn}\left|13,11\right\rangle_{^{122}Sn} + 0.488\left|13,10\right\rangle_{^{120}Sn}\left|13,12\right\rangle_{^{124}Sn} + 0.291\left|13,9\right\rangle_{^{118}Sn}\left|13,13\right\rangle_{^{126}Sn}$$



Comparison of the measured relative intensities of the correlated pairs of fission fragments [Danu et al. PRC 2010] with those calculated from isospin conservation

More asymmetric pair partitions can be explained by more asymmetric combinations of individual T values.

TR_{CN}=26,27,28 all appear to give a reasonable description in many of the channels but T=28,29 as assigned here leads to most consistent agreement with the experimental data.



Conclusions

- As the Project – X comes up, we can propose a set of experiments to test some of our ideas/predictions related to large isospin systems and test the validity of isospin symmetry.
- Intense beams of rare isotopes will provide opportunities to test/develop nuclear models
- Questions related to nuclear astrophysics and formation of heavier elements can be explored.