Zakopane Conference on Nuclear Physics

XLV in the series of Zakopane Schools of Physics

August 30 – September 5, 2010
http://zakopane2010.ifj.edu.pl

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Program

Monday, August 30

18:00	*Dinner*
19:30 – 20:00	**Opening**
20’	Adam Maj (Kraków) *Welcome*
10’	Reinhard Kulessa (Kraków) *Memories of Andrzej Bałanda*
20:00 – 21:20	**Key–note Lectures**
	Chair: Muhsin Harakeh (GSI/KVI)
lecture-40’	Walter Henning (ANL) *Nuclear physics experiments*
lecture-40’	James P. Vary (Iowa) *Ab initio nuclear theory – progress and prospects*
21:30 –	**Welcome reception**

Tuesday, August 31

7:30	*Breakfast*
8:25 – 10:30	**Computing Atomic Nuclei: Frontiers of Nuclear Structure Theory**
	Convener: Witek Nazarewicz (Tennessee/Warszawa)
lecture-30'	Achim Schwenk (TRIUMF/Darmstadt) *Neutron-rich matter and three-nucleon forces*
lecture-30'	Dario Vretenar (Zagreb) *Relativistic nuclear density functionals*
seminar-15'	Michał Warda (Lublin) *Theoretical description of cluster radioactivity in Ba isotopes*
lecture-30'	Wojtek Satuła (Warszawa) *Isospin mixing around N=Z*
seminar-15'	Kazunari Kaneko (Fukuoka) *Mirror energy difference at high spins in the mirror pair ^{67}Se and ^{67}As*
10:30–11:00	*Coffe break*
11:00–13:00	**Superheavy Nuclei**
	Convener: Matti Leino (Jyväskylä)
lecture-30'	Dieter Ackerman (GSI) *Superheavy elements at GSI – investigating exotic nuclear matter*
lecture-30'	Sergey Dmitriev (Dubna) *Radiochemical investigation of superheavy elements*
seminar-15'	Benoit Gall (Strasbourg) *Pushing the limits of spectroscopy of heavy elements with S^3*
lecture-30'	Paul Greenlees (Jyväskylä) *Gamma and electron spectroscopy of the heaviest elements*
seminar-15'	Trine Wiborg-Hagen (Oslo) *Spectroscopy of transfermium nuclei using the GABRIELA setup*

13:00	*Lunch*
	Free afternoon
18:00	*Dinner*
19:00–22:00	**Proton–rich Nuclei**
	Convener: Mike Bentley (York)
lecture-30'	Bob Wadsworth (York) *Spectroscopy of N ~ Z nuclei above mass 60*
lecture-30'	Tommi Eronen (Jyväskylä) *Mass measurements of proton rich-nuclei with JYFLTRAP*
lecture-30'	Bertram Blank (Bordeaux) *Two-proton radioactivity as a tool of nuclear structure*
seminar-15'	Leonid Grigorenko (Dubna) *Recent advances in theoretical studies of two-proton radioactivity*
20:45-21:00	*Coffe break*
lecture-30'	Dirk Rudolph (Lund) *Proton-rich nuclei studied with RISING*
seminar-10'	Timothy Brock (York) *Isomer spectroscopy of very neutron-deficient ^{94}Pd*
lecture-20'	Moshe Gai (Yale) *The structure of ^{12}C and stellar helium burning*
22:15 –	**Midnight school** **Symmetries in Nature - Symmetries in Nuclei**
	Tutor: Jerzy Dudek (Strasbourg)

Wednesday, September 1

7:30 *Breakfast*

8:25 – 13:00 **Neutron–rich Nuclei**

Convener: Faiçal Azaiez (Orsay)

lecture-30' Hiroyoshi Sakurai (RIKEN)
Recent results and future plans at RIKEN

lecture-30' Daniel Bazin (MSU)
Recent results from MSU on neutron-rich

lecture-30' Didier Beaumel (Orsay)
Shell structure evolution inferred from transfer reactions

seminar-10' Lucia Caceres (GANIL)
Shell and shapes in the ^{44}S nucleus

seminar-10' Megumi Niikura (Orsay)
Lifetime measurements of low-lying states in neutron-rich Zn isotopes by the plunger technique

seminar-10' Juho Rissanen (Jyväskylä)
Nuclear structure studies of neutron-rich nuclei performed by JYFLTRAP

10:30–11:00 *Coffe break*

lecture-30' Giacomo De Angelis (Legnaro)
The structure of neutron rich nuclei studied by deep inelastic reactions: recent results from LNL

lecture-30' Krzysztof Rykaczewski (ORNL)
Recent results from Oak Ridge

lecture-30' Reiner Krücken (München)
Recent Results from REX-ISOLDE

seminar-10' Miguel Madurga (Tennessee)
Beta decay spectroscopy of ^{81}Zn from an isotopically pure radioactive beam

seminar-10' Eda Sahin (Legnaro)
The evolution of the Z=28 shell gap towards ^{78}Ni: Neutron-rich Cu isotopes

seminar-10' Caterina Michelagnoli (Legnaro)
Lifetime measurements in the N=Z nucleus ^{44}Ti

13:00 *Lunch*

Free afternoon

18:00 *Dinner*

19:00–22:20 **Beyond Nuclear Physics**

Convener: Christoph Scheidenberger (GSI)

lecture-30' Joseph Pochodzalla (Mainz)
Hypernuclei

lecture-30' Jürgen Gerl (GSI)
Nuclear techniques for landmine detection

seminar-15' Christoph E. Düllmann (Mainz /GSI)
TASCA experiments with the reaction $^{244}Pu + {}^{48}Ca$ leading to element 114: high cross sections and the new nucleus ^{277}Hs

lecture-20' Andrzej Rybicki (Kraków)
What is the role of nuclear effects in ultrarelativistic reactions at 158 GeV/nucleon ?

lecture-20' Marek Kowalski (Kraków)
First results of charged particle production in the ALICE experiment at LHC

20:55-21:10 *Coffe break*

lecture-30' Peter Thirolf (München)
Laser particle acceleration: status and perspectives for nuclear physics

seminar-10' Alexander Pasternak (St. Petersburg)
Nuclear transitions and new standards of length and time

lecture-30' Ludwik Pieńkowski (Warszawa)
Nuclear cogeneration

Thursday, September 2

7:30 *Breakfast*

8:25 – 10:30 **Computing Atomic Nuclei: Frontiers of Nuclear Structure Theory**

Convener: Witold Nazarewicz (Tennessee/Warszawa)

lecture-30' Morten Hjorth–Jensen (Oslo)
Modern theory of effective interactions

lecture-30' Stuart Pittel (Delaware)
The density matrix renormalization group and the nuclear shell model

lecture-30' Frederic Nowacki (Strasbourg)
Large-scale shell model calculations and nuclear structure

seminar-10' Nobuo Hinohara (RIKEN)
Local QRPA vibrational and rotational inertial functions for large-amplitude quadrupole collective dynamics

seminar-10' Takahiro Mizusaki (Tokyo)
Filter diagonalization: a new method for large-scale shell-model calculations

seminar-10' Jacek Okołowicz (Kraków)
Impact of exceptional point threads on nuclear observables

11:00–18:00 *Excursion*

18:00 *Dinner*

19:00–20:30 **Nuclear Theory Models**

Chair: Jacek Dobaczewski (Warszawa/ Jyväskylä)

seminar-15’ Krzysztof Pomorski (Lublin)
On optimal in energy shapes of fissionning and rotating nuclei

seminar-15’ Andrzej Góźdź (Lublin)
Nuclear collective models and partial symmetries

seminar-10’ Leszek Próchniak (Lublin)
A symmetry of the CPHC model of odd-odd nuclei and its consequences for properties of M1 and E2 transitions

seminar-10’ Kamila Sieja (Strasbourg)
Shell evolution and core excitations in semi-magic nickel and tin isotopes

seminar-10’ Katarzyna Mazurek (Kraków/GANIL)
Poincare shape transitions in hot rotating nuclei

seminar-10’ Timur Shneidman (Dubna)
Cluster interpretation of reflection-asymmetric type bands structures in actinides

seminar-10’ Shuhrat Kalandarov (Dubna)
Angular momentum dependence of cluster emission from highly excited nuclei

seminar-10’ Yuri Anischenko (Omsk)
Fission rate and time of highly excited nuclei in multi-dimensional stochastic calculations

21:00- **Poster Session**

Chair: Marta Kicińska-Habior (Warszawa)

Friday, September 3

7:30	*Breakfast*
8:25 – 12:40	**Collective Modes**
	Convener: Angela Bracco (Milano)
lecture-30'	Takashi Nakatsukasa (RIKEN) *Self-consistent description of nuclear photoabsorption cross sections*
lecture-20'	Sunniva Siem (Oslo) *Soft dipole modes - overview and recent results*
lecture-30'	Franco Camera (Milano) *Prompt dipole gamma emission*
seminar-10'	Concetta Parascandolo (Napoli) *Dynamical dipole mode in fusion heavy-ion reactions by using stable and radioactive beams*
seminar-10'	Michał Ciemała (Kraków) *Search for Jacobi shape transition in hot rotating ^{88}Mo nuclei with the GDR γ-decay*
seminar-10'	Sandro Barlini (Firenze) *Fission fragment and light charged particles distribution for $^{48}Ti+^{40}Ca$ at 600 MeV: some preliminary results*
seminar-10'	Roberto Nicolini (Milano) *Inelastic scattering as a tool to search for highly excited states up to the region of the Giant Quadrupole Resonance*
10:30–11:00	*Coffe break*
lecture-30'	Umesh Garg (Notre Dame) *Nuclear incompressibility and symmetry energy from compression-mode Giant Resonances*
seminar-10'	László Stuhl (Debrecen) *High resolution study of the Gamow-Teller strength distribution in Sc isotopes*
lecture-20'	Indranil Mazumdar (Mumbai) *Search for GQR and rare shape transition in hot rotating nuclei*
lecture-30'	Walter Reviol (St. Louis) *Tidal waves and onset of collectivity above N = 126*
seminar-10'	Katarzyna Hadyńska-Klęk (Warszawa) *Coulomb excitation of the presumably super-deformed*

band in ^{42}Ca - preliminary results from the first AGATA Demonstrator experiment

12:40 **Conference photo**

13:00 *Lunch*

Free afternoon

18:00 *Dinner*

19:00 – 22:00 **Nuclear Reactions and Spectroscopy with Novel Techniques**

Convener: Marek Lewitowicz (GANIL)

lecture-30’ Silvia Leoni (Milano)
Reaction dynamics and nuclear structure studies of neutron rich nuclei

lecture-25’ Wojciech Królas (Kraków)
Neutron-rich nuclei populated in deep-inelastic collisions: reaction mechanism features important for spectroscopy

lecture-30’ Navin Alahari (GANIL)
Accessing the neutron rich frontier at VAMOS: from gentle rearrangement to equilibration

seminar-10’ Katarzyna Wrzosek-Lipska (Warszawa)
Coulomb excitation of ^{100}Mo

seminar-10’ Joann Borgensztajn (Zielona Góra)
A novel method of automatic particles identification for large CsI(Tl) detection systems

20:45-21:00 *Coffe break*

lecture-30’ Hans–Jürgen Wollersheim (GSI)
Coulomb excitation of exotic nuclei

seminar-10’ Ivano Lombardo (Catania)
The strong role of N/Z degree of freedom in ^{48}Ca+^{48}Ca reactions at 25 MeV/nucleon

seminar-10’ Nihal Buyukcizmeci (Selçuk)
Investigating the isotopic effects in nuclear fragmentation

seminar-10’ Yuriy Stepanenko (Kyiv)
^{7}Li(^{18}O, ^{17}N)^{8}Be reaction mechanism and ^{17}N + ^{8}Be potential; ^{16}N + ^{9}Be optical potential from ^{7}Li(^{18}O, ^{16}N)^{9}Be reaction analyses

Saturday, September 4

7:30	*Breakfast*
8:25–12:30	**Structure of Light Nuclei and Astrophysics**
	Convener: Tohru Motobayashi (RIKEN)
lecture-30'	Hisashi Horiuchi (Osaka) *Overview on the cluster structure and the alpha-condensation*
lecture-30'	Christian Beck (Strasbourg) *Clusters in light nuclei*
lecture-30'	David Jenkins (York) *Nuclear clustering studied by gamma-ray spectroscopy*
seminar-10'	Sandrine Courtin (Strasbourg) *Radiative capture in the ^{12}C+^{16}O system: structural vs statistical aspects of the decay*
seminar-10'	Vivek Parkar (Huelva) *Dipole polarizability of weakly bound nuclei*
seminar-10'	Takamasa Kuboki (Saitama) *Measurement of interaction cross sections for neutron rich Na isotopes*
10:30–11:00	*Coffe break*
lecture-30'	Michael Hass (Rehovot) *Astrophysical reactions with radioactive beams – present and future*
lecture-30'	Silvio Cherubini (Catania) *The Trojan Horse method in nuclear astrophysics*
seminar-10'	Chiara Mazzocchi (Milano) *Nuclear astrophysics deep underground: the LUNA experiment*
seminar-10'	Natalia Targosz-Ślęczka (Szczecin) *Enhanced pycnonuclear reactions in metallic environments*
seminar-10'	Adam Kozela (Kraków) *First measurement of R-correlation in free neutron decay*

12:45–13:30 **Special Lecture**

Chair: Marek Jeżabek (Kraków)

Michał Heller (Kraków)
Lemaitre's Primeval Atom and contemporary standard world model

13:30 *Lunch*

15:00–17:30 **Nuclear Lifetimes and Collectivity**

Chair: Hans Geissel (GSI)

lecture-30’ Wolfram Korten (Saclay)
Recent experimental advances for measuring nuclear collectivity

seminar-15’ Paul Garrett (Guelph)
Using beta-decay to map the E2 strength in the Cd isotopes and the downfall of vibrational motion

seminar-10’ Vasiliki-Anastasia Anagnostatou (Guildford)
Measurements of picosecond lifetimes in the transitional nucleus ^{100}Pd using the RDDM in inverse kinematics

seminar-10’ Farheen Naqvi (Köln/GSI)
Isomer spectroscopy of ^{125}Cd and ^{127}Cd

seminar-10’ Rakesh Kumar (New Delhi)
Enhanced E2 transition strength in $^{112,114}Sn$

seminar-10’ Aurore Dijon (GANIL)
Lifetime measurement in neutron rich Fe and Co isotopes applying the recoil distance Doppler Shift Method to Deep Inelastic Reactions

seminar-10’ Dan Gabriel Ghita (Bucharest)
In beam experiments for measuring sub-nanosecond lifetimes using fast $LaBr_3$: Ce detectors at the Bucharest FN Tandem accelerator

seminar-10’ Mustafa Rajabali (Leuven)
Nuclear structure systematics in odd-odd neutron-rich gallium isotopes

seminar-10’ Mehdi Nasri Nasrabadi (Isfahan)
Relative even and odd parity levels within the nuclei in the iron region

seminar-15’ Oliver Roberts (York)
Novel detector development for the PARIS project

19:30 **Closing and Conference Banquet**

Sunday, September 5

7:30	*Breakfast*
6:30 9:00 10:30	***Bus Departures to Kraków***

Midnight - School Lectures

"Symmetries in Nature - Symmetries in Nuclei"

Jerzy Dudek (Strasbourg)

Midnight-School initiative has its roots, on the one hand, in the long tradition of the Zakopane SCHOOLS [organised during nearly half-a-century by the Niewodniczanski Institute of Nuclear Physics and the Jagiellonian University, Krakow, Poland] and on the other hand, in the growing need for lecture-type presentations addressing first of all the younger generation of research persons.

The format of the Midnight School - Zakopane 2010 this year is a bit special. There are only two hours of the lecture-type foreseen this year and they are scheduled rather unusually - literally approaching Midnight. This second aspect is not going to be ignored - OH NO! - it will certainly be taken into account!

The first lecture is of general character and format and is therefore oriented towards general audiences so that not only the participants but also the *accompanying persons* are cordially invited. The program contains surprises but we can say that among others, the magic numbers of nature, the Fibonacci numbers, and related observations of symmetries in plants and (unexpectedly?) in humans will be discussed and illustrated. [To give you another example: We are not 100% sure at this time whether the technical arrangements at the hotel will allow to present this theory - but we have the intention to prove mathematically that the female's beauty is superior to that of the other half of the population - the thought that may come as a surprise to some].

The second presentation, after a small pause, is a bit longer then the first one and will address the problem of symmetries in both the nuclear interactions and the nuclear many-body systems. Again we hope to hide a surprise or two for everyone - but the main lines of the discussion follow the two most fundamental symmetries of micro-nature: the relativity principle and the unitarity in the many-body systems. This time some mathematics will be in the game - yet, taking into account the Midnight's character of the adventure the format should allow all physicists to easily follow.

Don't go to bed too early! Don't follow (even though generally good) the British (?) habit of Pubs, Lassies & Glassies!

Join for the adventure with symmetries, beauty (and beer as far as we can tell).

List of Posters

The Poster Session - Antałówka Conference House

E1	Guilain Ademard	*Persistence of structure effects in the asymmetric fission of medium mass compound nuclei*
E2	Thamer Alharbi	*Beta-Decay of ^{104,106}Y; the structure of ^{104,106}Zr*
I1	Marzena Bakoniak	*The Monte Carlo calculations of energy spectra of the 6 MV X-ray beams from medical linac*
E3	Mili Biswas	*Study of transfer reaction channel produced in the system ^{12}C+^{27}Al at 73 MeV*
E4	Debasmita Bondyopadhaya nee Kanjilal	*Observation of excited states and isomeric decays in doubly odd ^{208,210}Fr*
E5	Mouna Bouhelal	*Negative parity states in the P isotopes with N= 15 to 20: a 1$\hbar\omega$ shell model description*
E6	Michael Bowry	*Investigating isomers in heavy neutron-rich nuclei populated in relativistic projectile fragmentation of ^{238}U*
E7	Michael Bunce	*Identifying neutron rich nuclei using projectile fragmentation at GSI*
I2	Stefano Carboni	*FAZIA: a new detector for nuclear physics*
E8	Natalia Cieplicka	*New, high-lying isomers in the proton-particle three-neutron-hole nucleus ^{206}Bi*
E9	Margit Csatlós	*High resolution study of fission resonance structure in ^{233}Th*
E10	Nikit Deshmukh	*The breakup threshold anomaly of the ^{6}Li + ^{116}Sn system from the elastic scattering measurements*
T1	Artur Dobrowolski	*Puzzle of tetrahedrality in ^{156}Gd and ^{156}Dy nuclei*
T2	Prasad Edayillam	*Deformation and quasifission*
E11	Maria Esther Estevez Aguado	*Study of shape effects in ^{190}Pb using the total absorption technique*
T3	Alexandr Gegechkori	*Orientation degree of freedom as an essential collective coordinate in fission dynamics*
E12	Dmitry Gin	*Study of the ^{9}Be(α, nγ)^{12}C reaction for the high temperature plasma diagnostics*
T4	Alain Goasduff	*Coexistence of 0 $\hbar\omega$ and 1 $\hbar\omega$ excitations at low energy in Ne neutron rich isotopes*
E13	Thomas Gorbinet	*Study of the spallation of ^{136}Xe in collisions with hydrogen at 1 GeV per nucleon*
T5	Yannen Jaganathen	*A unified framework for nuclear structure and reactions within the GSM formalism*
E14	Ulrika Jakobsson	*Isomeric states in ^{197,199}At and ^{203,205}Fr*
I3	Grzegorz Jaworski	*Optimizing the neutron detection capabilities of NEDA - the NEutron Detector Array for spectroscopy studies*
E15	Dragana Jordanov	*New method of mesurement of temperature in spallation reaction*
T6	Kazunari Kaneko	*Puzzling E2 transition and a new island of inversion in the neutron-rich Ti isotopes*

E16	Ryan Kempley	*Neutron-rich nuclei in the vicinity of* ^{208}Pb *studied with the AGATA demonstrator*
E17	Ali ihsan Kilic	*Branching ratio of the d+d reactions in metallic environments at very low energies*
T7	Mariola Kłusek-Gawenda	*Exclusive production of* $\rho^0\rho^0$ *and* $\mu^+ \mu^-$ *pairs in ultrarelativistic heavy ion collisions*
T8	Michal Kowal	*Low-energy shape oscillations of negative parity around the main and shape-isomeric minima in actinides*
T9	Asli Kusoglu	*The effect of valence neutrons on spin-orbit splitting*
I4	Dorothée Lebhertz	*Performances of the future multidetector PARIS illustrated on the radiative capture physics case*
E18	Tomasz Malkiewicz	*Recent results of prompt and delayed* γ*-ray and conversion-electrons spectroscopy of neutron-rich lanthanide nuclei*
E19	Enrique Minaya Ramírez	*Direct mass measurements above uranium*
T10	Hamidreza Moshfegh	*Critical behaviour of baryonic matter*
E20	Mohamad Moukaddam	*Search for the neutron* $d_{5/2}$ *level in neutron-rich nuclei*
I5	Farheen Naqvi	*Development of slowed down beams at GSI/FAIR*
I6	Mehdi Nasri Nasrabadi	*Shielding design for an Am-Be neutron source considering different sites to achieve maximum thermal and fast neutron flux using MCNPX code*
T11	Bożena Nerlo-Pomorska	*Rotational bands in Fm isotopes within LSD and Yukawa-folded models*
I7	Paivi Nieminen	*Characterising isomeric states - complementary instrumentation*
E21	Vivek Parkar	*Fusion of* ^{9}Be *with* ^{124}Sn
E22	Dieter Pauwels	*Beta-decay studies of neutron-rich manganese isotopes*
E23	Pauli Peura	*Recoil decay tagging studies of* ^{173}Pt, ^{175}Pt
I8	Daniel A. Piętak	*An application of genetic algorithm to the COULEX data analysis*
I9	Mustafa Rajabali	*The CRIS beam line at ISOLDE and associated spectroscopy station*
E24	Łukasz Standyło	*Elastic scattering of the halo nucleus* ^{6}He *from* ^{206}Pb *below the Coulomb barrier*
E25	Iulian Stefan	*Deep-inelastic reactions at untypical energies*
I10	Jerzy Szerypo	*Target Laboratory at the University of Munich (LMU)*
I11	Tayebeh Taherkhani	*Simulation of dose distribution in electron irradiation system in water phantom using MCNP code*
E26	Aurélie Vancraeyenest	*Search for feeding transitions of isomeric states in* ^{138}Nd, ^{139}Nd *and* ^{140}Nd
I12	Marzena Wolińska-Cichocka	*New modular total absorption spectrometer at the HRIBF (ORNL, Oak Ridge)*

E- experiment, I-Instrumentation, T-theory

Abstracts

Dieter Ackermann (GSI) **LECTURE**

Superheavy elements at GSI – investigating exotic nuclear matter

The search for the next closed proton and neutron shells beyond ^{208}Pb has yielded a number of exciting results in terms of the synthesis of new elements [1,2,3] at the upper end of the charts of nuclides, in a region of exotic high-Z nuclear matter. In particular, the results obtained at the Flerov Laboratory of Nuclear Reactions (FLNR) for a rich number of decay patterns for ^{48}Ca induced reactions on actinide targets [2] have by now been confirmed for reactions on ^{238}U and ^{244}Pu at GSI [4,5], and on ^{242}Pu at LBNL [6].

These superheavy elements (SHE), however, are a nuclear structure phenomenon. They owe their existence to shell effects, an energy contribution of quantum mechanical origin to the nuclear potential, without which they would not be bound. Experimental activities in this field, apart from the synthesis of new elements, have to investigate reaction mechanism studies and, in particular, they have to pursue nuclear structure investigations to study the development of single particle levels towards the expected gap for the proton and neutron shell closure in the region of the spherical SHE.

In recent years the development of efficient experimental set-ups, including separators and advanced particle and photon detector arrays, allowed for more detailed nuclear structure studies for nuclei at and beyond Z=100. A recent review is given in ref. [7]. Among the most interesting features is the observation of K-isomeric states. Experimentally about 14 cases have been identified in the region of Z>96. K-isomers or indications of their existence have been found for almost all even-Z elements in the region Z=100 to 110. We could recently establish and/or confirm such states in the even-even isotopes ^{252,254}No [8]. The heaviest nucleus where such a state was found is ^{270}Ds with Z=110 as we reported in 2001 [9]. Precision mass measurements with the SHITRAP set-up are important new source of valuable information. In particular, the successful mass measurements for ^{252,253,254}No performed in 2009 [10] establish together with α-decay chains the connection up to Ds isotopes. So we are able to lay the grounds for a detailed understanding of these heavy and high-Z nuclei, and contribute at the same time valuable information to the preparation of strategies to successfully continue the hunt for the localisation of the next spherical proton and neutron shells beyond ^{208}Pb.

[1] S. Hofmann and G. Münzenberg, Rev. Mod. Phys. 72, 733 (2000).
[2] Yu.Ts. Oganessian, J. Phys. G 34, R165 (2007).
[3] K. Morita et al., J. Phys. Soc. Jpn. 73, 2593 (2004).
[4] S. Hofmann et al., EPJ A 32, 251 (2007).
[5] C.E. Düllman et al, to be published.
[6] L. Stavstera, PRL 103, 132502 (2009).
[7] R.-D. Herzberg and P.T. Greenlees, Prog. Part. Nuc. Phys. 61, 674 (2008).
[8] B. Sulignano et al., EPJ. A 33, 327 (2007).
[9] S. Hofmann et al., EPJ. A 10, 5 (2001).
[10] M. Block et al., Nature 463, 785 (2010).

Navin Alahari (GANIL) LECTURE

Accessing the neutron rich frontier at VAMOS: From gentle rearrangement to equilibration

Recent advances in measuring various signals in nuclei far from the valley of stability have strengthened the quest for finding and understanding signatures of simple patterns in nuclei. Among the diverse available paths, we will focus on the exploitation various reactions, ranging from grazing collisions to fusion reactions, at energies around the Coulomb barrier. In this talk we discuss recent results obtained using high intensity stable beams in inverse kinematics combined with highly efficient detection systems comprising of the EXOGAM gamma array and VAMOS spectrometer at GANIL. An overview of the evolution of this program towards the characterization of neutron rich nuclei, will be presented. In particular the opening of new avenues and results from measurements of prompt γ-ray spectroscopy of isotopically identified fission fragments will be discussed. Status of the advances of the VAMOS spectrometer for exploiting beams from the present facility and SPIRAL2 will also be presented.

Vasiliki-Anastasia Anagnostatou (Guildford/Yale) SEMINAR

Measurements of picosecond lifetimes in the transitional nucleus ^{100}Pd using the RDDM in inverse kinematics

V. Anagnostatou[1,2] , P.H.Regan[1] , V. Werner[2] , E. Williams[2] , A. Heinz[2]
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An experiment to determine the electromagnetic transition rates in the yrast sequence of the transitional nucleus, ^{100}Pd was performed at the WNSL Nuclear Structure Laboratory, Yale University using the Doppler Recoil Distance Method in inverse kinematics. A ^{80}Se beam, accelerated by the ESTU-1 Tandem Van de Graff Accelerator to 268 MeV impinged on a stretched, thin ^{24}Mg foil. The nucleus ^{100}Pd was produced in this reaction via the 4n evaporation reaction, with an initial recoil velocity in the laboratory frame of about 6% the speed of light. The emitted gamma-rays were measured using the SPEEDY gamma-ray array consisting of eight compton suppressed germanium clover detectors. The target-stopper distances were detemined using the New Yale Plunger Device (NYPD). Electromagnetic transition probability measurements of states of the ground state band of ^{100}Pd and the corresponding B(E2) transition strengths are being determined following the analysis of these data and compared with the predictions of IBM and Cranked Nilsson-Strutinsky calculations.

Giacomo de Angelis (Legnaro) **LECTURE**

The structure of neutron rich nuclei studied by deep inelastic reactions: recent results from LNL

Magic numbers are a key feature in finite Fermion systems since they are strongly related to the underlying mean field. The evolution of the shells far from stability can be linked to the shape and symmetry of the nuclear mean field and allows to probe the density dependence of the effective interaction. Changes of the nuclear density and size in nuclei with increasing N/Z ratios are expected to lead to different nuclear symmetries and excitations. Recently it has also been shown that the tensor force play an important role in breaking and creating magic numbers being a key element of the shell evolution along the nuclear chart.

The study of nuclear structure far from stability, mainly linked to the availability of radioactive nuclear beams, can be complementary addressed by means of high intensity beams of stable ions. Deep-inelastic and multi-nucleon transfer reactions are a powerful tool to populate yrast and non yrast states in neutron-rich nuclei. Particularly successful is here the combination of large acceptance spectrometers with highly segmented γ-detector arrays. Recent results from the CLARA and AGATA γ-ray detector arrays coupled with the PRISMA spectrometer at the Legnaro National Laboratories (LNL) will be presented.

Yuri Anischenko (Omsk) **SEMINAR**

Fission rate and time of highly excited nuclei in multi-dimensional stochastic calculations

The impact of dimensionality of the dynamical model in use on the fission rate and time is studied within the stochastic approach to fission dynamics. The evolution of the system was described by multidimensional Langevin equation for the elongation and orientation degrees of freedom[1]. One-, two- and three-dimensional cases were considered on the basis of the {c, h, α}-parametrization of the nuclear surface shape.

It was shown in [2] that it’s very important to take into account orientation (K state) degree of freedom to correctly calculate fission lifetimes. K state, which is the angular moment onto the elongation axis, was incorporated into our Langevin calculations and treated as the fourth overdamped coordinate. It was demonstrated that the inclusion of K state leads to the decrease in the stationary fission rate and increase in the mean fission time. Such observations based on the fact that K state can give a significant rise to the fission barrier height. The increase in the mean fission time is about 1.5 – 2 times for the reactions with compound nuclei with excitation energy 200 MeV.

The influence of the dissipation mechanism on the transient time is studied for multi-dimensional systems. It was shown that the ratios of the stationary fission rates obtained in the calculations with the different dimensionalities remain almost the same for different dissipation mechanisms. Thus we conclude that the fission rate is mostly determined by the structure of the potential energy surface of the system [3].

Calculations were performed for the large number of compound nuclei with Z^2/A parameter in the range $20 < Z^2/A < 40$. A considerable increase of the stationary fission rate in the transition from one-dimensional to three-dimensional case was revealed. This increase is particularly substantial for the light fissile nuclei near the Businaro–Gallone point. Comparison of the dynamically calculated stationary fission rate and Kramers rate was also made. Fission time was calculated for considered reactions, where particle evaporation was taken into account. The tremendous influence of the dimensionality of the dynamical model on the fission rate and time led us to note about the importance of the inclusion of the many coordinates into the statistical calculations of fission widths.

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Sandro Barlini (Firenze) **SEMINAR**

Fission fragment and light charged particles distribution for ^{48}Ti + ^{40}Ca at 600 MeV: some preliminary results

In the spring 2009, an experimental campaign has been performed by the Nuclex-Hector collaboration at the Laboratori Nazionali di Legnaro in order to study different reaction channels by detecting, in coincidence, Evaporation Residue (ER), Charged Particles and Fragments and high energy gamma rays from Giant Dipole Resonance (GDR). The studied system was ^{48}Ti+^{40}Ca at 600, 450 and 300 MeV using a composite apparatus formed by 48 triple-phoswich detectors for ER and other ejectiles at the forward angles (about 6-13 deg), the GARFIELD ΔE-E forward drift chamber for the charged particles between 30 and 85° and the HECTOR apparatus at the backward angles for γ-rays. The aim of the campaign was the study of the GDR as a function of the excitation energy of the Compound Nucleus (CN) and of its spin. For a rather precise evaluation of these quantities, it is important to measure the amount of charge, mass and energy removed from the nuclear system by pre-equilibrium particles and to select the different decay channels (fission and/or alpha chain) in order to disentangle the different angular momentum associated to the CN.

Some preliminary results about Light Charged Particles and Fission Fragment mainly from the 600 MeV reaction will be shown in the talk.

Daniel Bazin (MSU) **LECTURE**

Recent results from MSU on neutron-rich

The study of the nuclear landscape on the neutron-rich side of the valley of stability has seen recent developments in the past few years at the NSCL. Progress have been made using a wide variety of methods and reaction probes, all based on the availability of fast radioactive beams produced via the projectile fragmentation technique. I will discuss the evolution of shell structure in neutron-rich nuclei located across the sd and fp shells, based on various results obtained, ranging from the discovery of the most neutron-rich nuclei in that region, to in-beam gamma-ray spectroscopy studies using various reactions such as knockout of one or two nucleons, as well as inelastic scattering. The experimental techniques used to achieve these measurements will also be presented.

Didier Beaumel (Orsay) **LECTURE**

Shell structure evolution inferred from transfer reactions

Recent results on shell evolution in light exotic nuclei obtained through several experiments performed at GANIL using the MUST2 particle array will be presented. MUST2 has been built for the optimal study of direct reactions experiments in which light recoiling charged particles are detected. In the first serie of experiments reported here, MUST2 was coupled to the TIARA particle array and EXOGAM detectors for gamma-rays, in order to provide a powerful detection system. The one-nucleon transfer reactions ^{20}O(d,p)(d,t) and ^{26}Ne(d,p)(d,t) could be investigated using this setup. Results on the populated states as well as comparison with calculated spectroscopic factors will be presented. In a second study, the Z=8 shell closure was investigated by means of the two-neutron transfer reaction ^{14}O(p,t) using a set of MUST2 telescopes. A newly observed state at low excitation energy in the unbound ^{12}O points to the Z=8 shell quenching, analogously to the established case at N=8 in the neutron-rich mirror nucleus.

Christian Beck (Strasbourg) **LECTURE**

Clusters in light nuclei

A great deal of research work has been performed in the field of alpha clustering since the pioneering discovery, by Bromley and his collaborators half a century ago, of molecular resonances in the excitation functions for ^{12}C+^{12}C scattering [1]. Our knowledge of this field of nuclear molecular physics has increased considerably [2] and nuclear clustering remains one of the most fruitful domains of nuclear physics [3-4], facing some of the greatest challenges and opportunities in the years ahead.

The question whether quasimolecular resonances always represent true cluster states in the compound systems, or whether they may also simply reflect scattering states in the ion-ion potential is still unresolved [1-3,5]. Inmany cases, these resonant structures have been associated with strongly-deformed shapes and with clustering phenomena, predicted from the Nilsson-Strutinsky approach, the cranked α-cluster model, or other mean-field calculations (see for instance Ref.[6] and references therein). Of particular interest is the relationship between superdeformation (SD) and nuclear molecules, since nuclear shapes with major-to-minor axis ratios of 2:1 have the typical ellipsoidal elongation (with quadrupole deformation parameter $\beta_2 \approx 0.6$) for light nuclei. Furthermore, the structure of possible octupole-unstable 3:1 nuclear shapes (with $\beta_2 \approx 1.0$) - hyperdeformation (HD) - for actinide nuclei has also been widely discussed in terms of clustering phenomena. Typical examples of the possible link between quasimolecular bands and extremely deformed (SD/HD) shapes have been widely discussed in the literature for N=Z nuclei such as ^{28}Si [7], ^{32}S [8], ^{36}Ar [9-11], ^{40}Ca [12] and ^{48}Cr [13].

Large quadrupole deformations and α-clustering in light N = Z nuclei are known to be general phenomena at low excitation energy. For high angular momenta and higher excitation energies, very elongated shapes are expected to occur in a-like nuclei for ACN = 20-60. In fact, highly deformed shapes and SD rotational bands have been recently discovered in several such N = Z nuclei, in particular, ^{36}Ar using γ-ray spectroscopy techniques [14]. Extremely deformed rotational bands in ^{36}Ar are observed as quasimolecular bands in both ^{12}C+^{24}Mg and ^{16}O+^{20}Ne reactions [9-11], and their related ternary clusterizations are also predicted theoretically [11]. The most recent results obatiend on ternary fission in light N=Z reactions [9,15] will also be discussed in terms of predicted hyperdeformed structure of cluster states.

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Bertram Blank (Bordeaux) **LECTURE**

Two-proton radioactivity as a tool of nuclear structure

Two-proton radioactivity is the latest nuclear decay mode discovered. It consists of the emission of a pair of protons from a nuclear ground state. According to the definition by V. Goldanskii who was the first to discuss this new type of radioactivity extensively, one-proton radioactivity is not allowed to be an open decay channel for two-proton radioactivity (2p) candidates.

In pioneering experiments at GANIL and GSI, this new radioactivity was discovered in 2002 and meanwhile ^{45}Fe and ^{54}Zn are established 2p emitters, with a possible third nucleus, ^{48}Ni, for which one event was most likely observed. These results allowed a detailed comparison with the theoretical models available and showed that, at the level of precision of the experimental data and of the predictive power of the models, nice agreement was obtained.

The latest step in the investigation of 2p radioactivity was the use of time-projection chambers to study the decay dynamics via measurements of the individual proton energies and the relative proton-proton emission angle. A first experiment at GANIL and a high-statistics experiment performed at MSU on ^{45}Fe allowed to gain first insides into the decay characteristics by comparison with a three-body model. Meanwhile ^{54}Zn has also been studied with a TPC at GANIL.

The present talk will review the experimental results on ground-state two-proton radioactivity and compare these results with theoretical predictions. Future studies and the possible discovery of new 2p emitters will be discussed.

Joanna Borgensztajn (Zielona Góra) **SEMINAR**

A novel method of automatic particles identification for large CsI(Tl) detection systems

CsI(Tl) scintillators are often used in nuclear and high energy physics as charged particles detectors. Optical properties of CsI(Tl) allow simultaneous measurement of different types of particles and quite good discrimination between them. The last possibility is related to the fact that duration of the light pulse emitted by some materials is determined by two time constants. The first of them corresponds to so-called fast component of emitted light and varies very strongly with particle mass, charge and energy. The second corresponds to so-called slow component and is regarded as independent on particle type.

By recording the pulse shape and applying Pulse Shape Discrimination Method [1] it is possible to find for each event two digital variables proportional respectively to the fast and slow component. Data analysis is usually done by displaying these variables on two-dimensional fast-slow plot (see examples in [1-3]) and by putting graphical cuts or masks separating isotopic branches.

The idea of this method is very simple but it should be noted that for two or more identically fabricated detectors we never obtain identical fast-slow plots. Moreover plots obtained for one detector vary with temperature. Ageing effects of scintillators are also present so the procedure of putting masks should be repeated many times, according to the current conditions. Especially for devices consisting of several hundred detectors as CHIMERA [1] or INDRA [3] the method is very time consuming process.

To overcome this difficulty a modification of the commonly used method is proposed. The modification is based on the concept that all fast-slow plots obtained for one or more detectors could be standardized to one pattern. The method seems to be very promising in automatic particles identification, crucial for nuclear experiments on multifragmentation inwhich huge number of fragments have to be detected and identified. In present work the basis of the method and some important results are described and discussed.

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Timothy Brock (York) **SEMINAR**

Isomer spectroscopy of very neutron-deficient ^{94}Pd

The region of neutron-deficient nuclei close to ^{100}Sn is remarkable for an abundance of isomeric states. Recent discoveries in this respect include high-spin states in ^{98}Cd [1], ^{95}Ag [2] and ^{94}Ag [3]. Much discussion has focused on the decay modes of the latter, a (21^+) state at an excitation energy of around 7 MeV with a half-life of 0.47 ± 0.08 s [4].

The apparent observation of a two-proton decay channel [5] for the state is especially interesting, but has been the subject of some debate [6]. Much of our understanding of this “unique” isomer comes from studies of its β-decay to ^{94}Pd [3,4]. However, the ordering of states above 5 MeV that are fed by the β-decay of the 0.47 s isomer, together with their spins and parities, remains tentative.

In a recent RISING experiment at GSI, fragmentation of an 850 MeV/u ^{124}Xe beam on a ^{9}Be target was used to produce neutron-deficient nuclei near ^{100}Sn. After separation and identification via the FRS and detectors at its central and final foci, nuclides of interest were implanted in a nine-DSSSD active stopper at the centre of the RISING array of germanium detectors in its stopped beam configuration [7]. The set-up allowed for both sub-millisecond-isomer and beta-delayed gamma-ray spectroscopy of the implants. New results from this data, focusing on isomeric decays in implanted ^{94}Pd ions, will be presented showing a new isomeric state and shedding further light on the high spin states populated in the β-decay of the (21^+) isomer in ^{94}Ag.

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Nihal Buyukcizmeci (Selçuk) **SEMINAR**

Investigating the isotopic effects in nuclear fragmentation

In collaboration with A.S. Botvina and R. Ogul

Isotopic effects in nuclear multi-fragmentation are also important for astrophysical processes such as supernova simulations and neutron star models. Modifications for symmetry and surface energy coefficients of nuclear matter at freze-out density are investigated theoretically by means of isoscaling. In order to compare our predictions with MSU experimental data we consider the fragmentation of the projectiles ^{124}Sn and ^{112}Sn which were also used for the MSU experiments. It is seen that while the isoscaling parameters as predicted by statistical multifragmentation model calculations for the single sources ^{124}Sn and ^{112}Sn are very sensitive to the symmetry term, the surface energy variation slightly affects the isoscaling parameters. Comparing our results with MSU experimental data, it is confirmed that a significant reduction of the symmetry term coefficient is found necessary to reproduce the isoscaling parameters.

Lucia Caceres (GANIL) **SEMINAR**

Shell and shapes in the ^{44}S nucleus

It is known that the ``magic numbers'' valid in the valley of β-stability may evolve or even disappear when approaching the limits of the nuclear chard. In particular, the N=28 isotones are of special interest due to the rapid structural changes with the removal of few protons. $^{48}_{20}$Ca is known to be a spherical nucleus while the combined action of proton-neutron tensor forces causes the development of oblate deformation in $^{42}_{14}$Si. Spectroscopy information in $^{44}_{16}$S is of outstanding importance to understand how the deformation evolves from Z=20 to Z=14 in the N=28 isotones. In order to shed light on the underlying structure in ^{44}S nucleus, two experiments aiming complementary information were performed and will be reported. The first measurement concentrate in the study of the decay pattern of the 0^+_2 isomeric state in ^{44}S. The isomeric state was populated in the fragmentation of ^{48}Ca beam into a ^{9}Be target. The reaction products were separated by means of the Bρ–ΔE-Bρ method in the LISE spectrometer at GANIL. The half-life analysis in conjunction to the measured branching ration depopulating the isomeric state allowed to extract the mixing between the ground state and the 0^+_2 level assuming two state configuration mixing. The second experiment focus on in-beam spectroscopy in ^{44}S produced by a two step-reaction. The fragmentation of a ^{48}Ca beam into a ^{12}C target produced ^{45}Cl separated in the alpha spectrometer. Following, the ^{45}Cl undergo π-knockout in a secondary target to form ^{44}S which was separated from other ions in the SPEG spectrometer at GANIL and identified unambiguously in an even-by-event basis. The secondary target was surrounded in close geometry by 74 BaF_2 detectors allowing to measured in coincidence prompt gamma-radiation and detected ions. Additionally, the large statistics allowed to perform gamma gamma-coincidences analysis crucial to construct the level scheme of ^{44}S. Moreover, the preliminary analysis evidences the existence of a transition above the isomeric state observed for the first time in this type of experiments. By combining the experimental outcome of both measurement, the deformation in ^{44}S has been inferred yielding spherical-prolate shape coexistence. The experimental results will be discussed in terms of Large Scale Shell Model calculations.

Franco Camera (Milano) **LECTURE**

Prompt dipole gamma emission

The study of the collective properties of the nucleus is a powerful tool to understand the structure which lays inside the nucleus. A successful technique which has been used in this field is the measurement of the gamma decay of the highly collective state Giant Dipole Resonance (GDR). In fact, GDR can be used as a probe for the internal structure of hot nuclei and, in addition, constitutes a clock for the thermalization process.

Using the fusion-evaporation reaction, it has been recently possible to study i) the yield of the high energy gamma ray emission of the dynamic dipole which takes place during the fusion process and ii) the degree of isospin mixing at high temperature in the decay of ^{80}Zr. In the first case it is important to stress the fact that the prediction of the theoretical models differs depending on the type of nuclear equation of state (EOS) used in the calculations while in the second physics case the data are relative to the heaviest nucleus N=Z which has been possible to populate in the channel I=0 using fusion-evaporation reaction.

In both experiments, the data have been acquired at the Laboratori Nazionali di Legnaro using the HECTOR-GARFIELD array. The high energy gamma-rays have been measured in 8 large volume BaF_2 detectors in coincidence with light charged particle (measured in ~ 100 E-ΔE telescopes) and reaction residues (measured with an array of phoswich detectors).

Silvio Cherubini (Catania) **LECTURE**

The Trojan Horse method in nuclear astrophysics

The Trojan Horse method (THM) is an indirect method based on quasi-free reactions (QFR) for studying nuclear reactions of interest for nuclear astrophysics.

Recently we applied this method to the study of nuclear reactions that involve radioactive species, namely to the study of the $^{18}F+p \rightarrow ^{15}O+\alpha$ process at temperatures corresponding to the energies available in the classical novae scenario. The experiment was performed in two runs at the CRIB apparatus of the Center for Nuclear Study of the University of Tokyo and results of the data analysis will be presented.

A method closely related to THM has also been implemented to study processes induced by neutrons. We recently applied this technique to the study of the reaction $^{6}Li+n \rightarrow ^{3}H+^{4}He$ as a test case and other reactions are presently being considered. This technique is particularly interesting when applied to reaction induced by neutrons on unstable short-lived nuclei. In this case, direct measurements are practically impossible. Such processes are very important in the nucleosynthesis of elements in the s- and r-processes scenarios and this technique can give hints for solving key questions in nuclear astrophysics.

Michał Ciemała (Kraków) **SEMINAR**

Search for Jacobi shape transition in hot rotating ^{88}Mo nuclei with the GDR gamma-decay

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The study of the properties of the giant dipole resonance (GDR) at high temperature and angular momentum is one of the central topics in nuclear structure as it provides insight into the behavior of nuclei under extreme conditions. The wealth of experimental data on this subject covers in most cases an interval of temperatures up to 2.5 MeV and is mainly based on the study of the GDR gamma-decay from fusion-evaporation reactions. These data have been shown to provide evidence of relevant physical effects such as damping and shapes, the latter in the liquid drop regime. Of special interest are shape changes induced by temperature and angular momentum, particularly the predicted Jacobi shape transition, seen up to mass 50 and to be confirmed by exclusive experimental data also in heavier nuclei. This phenomenon is predicted as an abrupt change from an oblate to a more elongated triaxial shape occurring at the so called critical value of spin above which the nucleus undergoes scission.

An experiment focussing on the ^{88}Mo nucleus was performed in LNL Legnaro using ^{48}Ti beam at 300, 450 and 600 MeV on ^{40}Ca target and producing by fusion evaporation compound nuclei at temperatures of 3, 3.8 and 4.5 MeV. High-energy gamma-rays were measured in coincidence with residues and alpha particles and the data were analysed with the statistical model (CASCADE). The data have allowed to extract the spin and temperature evolution of the GDR width in ^{88}Mo up to at high temperature values, region where information are scarce. A change of the GDR width with angular momentum and temperature was found and this reflects the role played by quantal and thermal fluctuations in the damping of the giant vibrations. In addition, preliminary results deduced from the fit of the measured GDR line-shapes seem to suggest existence of Jacobi shape transition in ^{88}Mo.

Sandrine Courtin (Strasbourg) **SEMINAR**

Radiative capture in the ^{12}C+^{16}O system: structural vs statistical aspects of the decay

The radiative capture process is the complete fusion of target and projectile to form a compound nucleus which deexcitates solely by γ-ray emissions. This mechanism is a powerful tool to investigate the interplay between reaction mechanisms and the structure of the populated compound nucleus (CN). Such informations result from an overlap not only between the entrance channel and the CN states but also between these states and lower lying states. From the connecting γ transitions, information can be obtained on spins, isospins and deformations of the populated CN states [1]. Heavy ion radiative capture is nonetheless a rare process compared to dominant fusion-evaporation channels. From the experimental point of view, measuring the CN at 0° and the coincident γ-rays accurately can be very challenging.

We have instigated the light heavy-ion ^{12}C(^{16}O,γ)^{28}Si resonant reaction at Triumf using the Dragon spectrometer to identify the ^{28}Si recoiling nuclei at 0° and measure the complete ^{28}Si decay spectrum in the associated BGO array [2]. Our first data, taken at Ecm= 8.5, 8.8 and 9 MeV revealed a previously unobserved large feeding of intermediate energy doorway states (around 11 MeV) in ^{28}Si. This decay branch represents 60% of the total γ width. A question arises about these doorway states: are they the result of structural or statistical aspects of the decay? For instance, we have observed in this system an important flux to ^{28}Si deformed states such as the octupole 3^- and members of the prolate band of this oblate ground state nucleus. A discussion will be presented about this selective feeding: this could highlight the long debated link between resonances in the ^{12}C+^{16}O collisions and molecular ^{12}C-^{16}O configurations in ^{28}Si which is a key nucleus for the occurrence of clusters in the sd shell.

Moreover these results have large consequences on the cross-section of the capture process itself.

The very recent focus of our experimental programme is to explore ^{12}C+^{16}O resonances below the Coulomb barrier (CB) where the reduction of the phase space may reveal new structural features of the resonance decay. We have thus performed recently a new Dragon ^{12}C(^{16}O,γ)^{28}Si capture experiment at resonant energies Ecm= 6.6 MeV and 7.2 MeV, below CB (ECB~ 7.8 MeV) well below CB to deepen our understanding of the statistical s structural part of the decay. First results will be presented, which could be important for our understanding of fusion not only at CB but also at lower energies, down to the astrophysics region where unexpected resonances are observed close to the Gamow energy in the similar ^{12}C+^{12}C system [3].

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Aurore DIJON (GANIL) **SEMINAR**

Lifetime measurement in neutron rich Fe and Co isotopes applying the recoil distance Doppler Shift Method to Deep Inelastic Reactions

A.Dijon, J.Ljungvall, E.Clément, G. de France, A.Görgen, A.Obertelli, W.Korten, A.Bürger, JP.Delaroche, A.Dewald , A.Gadea, L.Gaudefroy, M.Girod, M.Hackstein, J. Libert, D.Mengoni, F.Nowacki, T.Pissula, A.Poves, F.Recchia, M.Rejmund, W.Rother, E.Sahin, C.Schmitt, A.Shrivastava, K.Sieja, JJ.Valiente-Dobon, KO.Zell, M.Zielinska

GANIL, Caen, France; CSNSM, Orsay,France; Department of Physics, Univ. of Oslo, Norway; CEA Saclay, IRFU, France; CEA, DAM, France; Institüt für Kernphysik, Köln, Germany; Instituto de Fisica Corpuscular, CSIC, Valencia, Spain; IPNO, Orsay, France; INFN-Padova, Italy; IPHC, Strasbourg, France; Departamento de Fisica Teorica, Madrid, Spain; INFN-Legnaro, Italy; HIL, Warsaw, Poland

Excited states in a wide range of neutron rich nuclei around ^{68}Ni has been studied in multi nucleon transfer reactions in inverse kinematics between ^{238}U at 6.5 A MeV and a ^{64}Ni target using the large acceptance spectrometer VAMOS and the segmented germanium clover detectors EXOGAM at GANIL.

The lifetimes of the first excited 2^+ states in ^{62}Fe and ^{64}Fe have been measured for the first time using the recoil-distance Doppler shift method. A sudden increase of collectivity from ^{62}Fe to ^{64}Fe has been observed and probe the weakness of the N=40 subshell gap. This observation is confirmed by the onset of a collective character in the neutron rich zinc and germanium isotopes. Moreover, collective $7/2^-$ states observed in the structure of copper isotopes above nickel can be interpreted as a one proton in the $p_{3/2}$ orbital coupled to the first 2^+ state in nickel isotones. Similarly, a one proton hole in the $f_{7/2}$ orbital coupled to the first 2^+ state in nickel isotones would induce some collectivity in the cobalt isotopes as suggested by D. Pauwels et al. To demonstrate this, the lifetime of the first excited $9/2^-$ state in $^{63\text{-}65}$Co has been measured and the B(E2) transition probability extracted.

The data extracted from this experiment have been compared with large scale shell model calculations performed with ANTOINE code in the fp model space leading to a better understanding of the mechanism at the origin of the onset of collectivity around ^{68}Ni.

Sergey Dmitriev (Dubna) **LECTURE**

Radiochemical investigation of superheavy elements

The experiments, performed during the last few years, have lead to the discovery of six new (113-118) superheavy elements (SHE) in the Periodic Table of D.I. Mendeleev and 45 new most neutron-rich (among the presently known) isotopes of elements 104-118.

The new nuclides were synthesized in the fusion reactions between accelerated ^{48}Ca ions and nuclear targets ^{238}U, ^{237}Np, ^{242,244}Pu, ^{243}Am, ^{245,248}Cm, ^{249}Cf [1] and

^{249}Bk [2]. Their half-lives vary from 0.5 ms to 30 h depending on the proton and neutron numbers in the synthesized nuclei. The relatively long lifetimes of the new nuclides allowed the conduction of the first experiments devoted to their chemical identification and study of their properties. The identification of the decay chain of element 115, synthesized in the reaction ^{243}Am(^{48}Ca, 3n), was performed by the final decay product, i.e., the element 105 isotope (^{268}Db, $T_{1/2}$ = 29 hr), which is a homologue of Ta and Nb [3]. The chemical identification of elements 112 and 114, produced in the reactions ^{242}Pu(^{48}Ca,3n)^{287}114 (α) → ^{283}112 and ^{244}Pu(^{48}Ca,4n)^{288}114 (α) → ^{284}112, was performed in experiments, in which the volatility and adsorption on Au surface were studied [4,5]. It was shown that element 112 is close in its properties to Hg (instead of Rn). Element 114 differs greatly from Pb (volatile, adsorption on the Au surface was observed at temperatures close to –1000 C). On the whole, the data from the chemical experiments are in full agreement with the results of the physical experiments and are an independent evidence of the synthesis of elements 112 and 114 in the reactions ^{48}Ca+^{242,244}Pu and the synthesis of elements 113 and 115 in the reaction ^{48}Ca+^{243}Am. The first experiments devoted to the properties of element 113 (volatility) were carried out using the reactions ^{243}Am(^{48}Ca,3n) and ^{249}Bk(^{48}Ca,4n).

Taking into account the above results, the search for long-lived isotopes of superheavy elements in nature is reconsidered. Presently the experiment SHIN in the underground low radioactivity laboratory in Modane (LSM), using a neutron multi-detector, is going on with 550g ^{nat}Os , 100 g ^{nat}Xe and 100 g ^{136}Xe samples [6].

The program of further research for the synthesis and chemistry of SHE includes:

Chemistry of elements 112-114 in the reactions of ^{242,244}Pu and ^{243}Am with ^{48}Ca;

Carrying out experiments on the determination of the masses of isotopes of elements 114 and 112, produced in the reaction of ^{244}Pu and ^{48}Ca, using the newly created at the FLNR Mass Analyzer of Super Heavy Atoms (MASHA).

The work has been performed with the financial support of the Russian Foundation for Fundamental Research (project code 09-03-12029).

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Christoph E. Düllmann (Mainz/GSI) **SEMINAR**

TASCA experiments with the reaction ^{244}Pu + ^{48}Ca leading to element 114: high cross sections and the new nucleus ^{277}Hs

In the past few years, the new gas-filled TransActinide Separator and Chemistry Apparatus TASCA was installed and commissioned at the GSI Helmholtz Center for Heavy Ion Research in Darmstadt. As a first highlight experiment in the region of the superheavy elements, the reaction ^{244}Pu+^{48}Ca leading to element 114 was studied.

In a one month long experiment, performed in the summer of 2009 at TASCA, thirteen atoms of the two most neutron-rich known isotopes of the superheavy element 114 with mass numbers 288 and 289 were observed. The high statistics allowed a reliable measurement of the cross section. The measured value of about 10 picobarns represents the largest cross section measured for any reaction leading to the presumably spherical superheavy elements. This opens up fascinating possibilities for more detailed studies of, e.g., the chemical behavior or atomic and nuclear structure of this superheavy element. Overall, the measured data, including the half-lives, which are of the order of one second, are in agreement with those reported from the DGFRS collaboration.

In one decay chain, the new isotope ^{277}Hs was observed. It decayed by spontaneous fission after a lifetime of 4.5 ms. With its neutron number N = 169 it is situated in the region of minimum stability, in between the last experimentally established deformed neutron shell at neutron number N=162 and the predicted spherical shell closure at N=184. The measured decay properties confirm the trends predicted by theoretical calculations.

Tommi Eronen (Jyväskylä) **LECTURE**

Mass measurements of proton rich nuclei with JYFLTRAP

In this talk an overview of atomic mass measurements of proton rich nuclei with the JYFLTRAP Penning trap setup located in University of Jyväskylä, Finland will be given. The proton rich nuclei of interest were produced with light and heavy ion fusion evaporation reactions at the IGISOL facility.

An extensive measurement program has been carried out to confirm and improve the decay energies associated with superallowed beta emitters. These decays contribute significantly to testing the Standard Model because the most precise value of V_{ud} of the Cabibbo-Kobayashi-Maskawa (CKM) quark-mixing matrix is currently derived from superallowed beta decays. These decays occur between nuclear analog states having the spin-parity 0^+ and isospin T=1. There are about 15 transitions that are precisely enough known to contribute to the "world average" V_{ud} value. JYFLTRAP has contributed by providing high-precision Q-value data to nearly all relevant cases.

Another areas of interest have been the role of isospin symmetry in nuclear binding and mass measurements for the astrophysical rp-process. To test the isospin multiplet mass equation (IMME) the atomic mass of ^{23}Al was measured to a sub-keV accuracy. Also, mass measurements in the vicinity of the doubly-magic nucleus ^{56}Ni have been performed and decay energy values of several $T_z = 1/2$ nuclei have been determined. Furthermore, mass measurements for the astrophysical rp-process path have been carried out for neutron-deficient nuclei between yttrium and iodine. With the new data it appears that the SnSbTe Cycle in the rp process is quenched.

Moshe Gai (Yale) **LECTURE**

The structure of carbon and carbon formation in stellar helium burning, studied with an optical readout TPC

The observation of the second 2^+ state in ^{12}C, predicted to be between 9-10 MeV, is a subject of continuing interest and debate. Such a state may reveal the structure of the Hoyle 0^+ state at 7.6542 MeV in ^{12}C [1]. On one hand there has been a long standing search for the proposed 2^+ member of the rotational band built on the (deformed) Hoyle state and on the other hand within the context of the small N limit of Bose-Einstein alpha-condensate [2] such a band is not predicted. An inclusion of the predicted 2^+_2 at 9.11 MeV with a Gamma Width = 0.2 eV increase (by up to a factor of 15) the production of ^{12}C during stellar helium burning at high temperatures (above 3 GK) [3]. Such a dramatic deviation (at high temperatures) will be the first hint of a significant deviation from the prediction of carbon formation based on the Hoyle state alone.

The search for the 2^+_2 via the beta decay of ^{12}B and ^{12}N yielded null result [4] with a significantly small upper limit on the non-observed bete-deacy branching-ratio to a 2^+ state between 9.0 and 10.0 MeV (with very large log ft value). Alpha scattering, ^{12}C(α,α′) experiment [5] and more recently proton scattering ^{12}C(p,p′) data [6], reveal a broad 2^+ state (Width = 600 keV) at 9.6 MeV.

We have used an Optical Readout Time Projection Chamber (O-TPC) detector [7] placed at the gamma beam at the HIγS facility of the TUNL at Duke University [8] to study the ^{12}C(γ,3α) reaction. The detector system and the HIγS facility will be discussed. Data taken at E = 9.363, 9.556 and 9.771 MeV reveal direct evidence for the 2^+_2 in ^{12}C with angular distributions of a pure E2 transition. Our data also allow us to measure the gamma-width of this state. Data analysis is in progress and up to date results will be discussed.

* Work Supported by the Yale-Weizmann Collaboration of the ACWIS, N.Y., and USDOE Grant No DE-FG02-94ER40870, and DE-FG02-97ER41033.

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Benoit Gall (Strasbourg) **SEMINAR**

Pushing the limits of spectroscopy of heavy elements wiht S^3

Spectroscopy of heavy elements is a very delicate task due to the extreme low production cross sections. We recently pushed the limits of prompt spectroscopy down to the order of 10 nb with the study of ^{246}Fm using JUROGAM2/RITU setup in Jyväskylä University. The S^3 project operated in the framework of the SPIRAL2 project will enable us to go to the spectroscopy of superheavies elements. Based on the existing expertise, the S^3 collaboration is preparing the best possible focal planes for spectroscopy of VHE/SHE elements and spectroscopy around ^{100}Sn. After an introduction of the suject based on our recent ^{246}Fm experiment, the developments done for S^3 will be presented.

Umesh Garg (Notre Dame) **LECTURE**

Nuclear incompressibility and symmetry energy from compression-mode Giant Resonances

We have measured the compression-mode giant resonances—the giant monopole resonance (GMR) and the isoscalar giant dipole resonance (ISGDR—in a number of Sn (A=112-124) and Cd (A=106-116) isotopes. From the excitation energies of the GMR, we have obtained an experimental value for the asymmetry term of the nuclear incompressibility, $K_\tau = -550 \pm 100$ MeV. Combined with the value for the incompressibility of infinite nuclear matter, $K_\infty = 240 \pm 20$ MeV, this provides significant constraints on the interactions employed in nuclear structure and equation of state calculations. We find that the GMR centroid energies of the in both Sn and Cd isotopes are significantly lower than the theoretical predictions, pointing to the role of superfluidity in the off-shell nuclei.

Paul Garrett (Guelph) **SEMINAR**

Using beta-decay to map the E2 strength in the Cd isotopes and the downfall of vibrational motion

The nuclear structures of the even-even Cd isotopes near stability, especially $^{110\text{-}116}Cd$, were long thought to be prime examples of low-lying vibrational motion. Their level schemes display a nearly harmonic spacing of one, two, and three-phonon levels. Due to their importance as paradigms of vibrational motion, their structures were previously investigated by a variety of reactions. While these reactions were essential for establishing the location of levels and their main decay branches, and in most cases their lifetimes, they did not have the sensitivity to probe the weak low-energy branches that are necessary to assess the degree of collectivity that the states possess.

In order to complement the data used to test the collectivity present in the Cd isotopes, we have initiated a programme of extensive beta-decay experiments using the 8π spectrometer at the TRIUMF-ISAC radioactive-beam facility. The goal of these experiments is to achieve a sufficient sensitivity to weak, low-energy branches amongst the multi-phonon levels so that the collective branches would either be observed, or very stringent upper limits set. Thus far, we have examined the decay of ^{110}In to ^{110}Cd, and ^{112}In/^{112}Ag to ^{112}Cd. These experiments have revealed that the individual low-spin multi-phonon states do not decay in the expected manner. Further, and much more surprising, the missing E2 strength is not due to fragmentation (i.e., mixing) amongst the levels below ~ 3 MeV. This lack of the E2 strength has forced a re-evaluation of the structure, suggesting a more rotational picture rather than vibrational. This also raises the issue that if our long-standing paradigms of vibrations can no longer be considered as vibrational nuclei, are there any spherical vibrational nuclei?

Jürgen Gerl (GSI) **LECTURE**

Nuclear techniques for landmine detection

It is estimated that more than 110 million active mines are a permanent threat in some 70 countries, resulting in about 2000 casualties per month, most of them being civilians. The anti-personnel mines (APM) and anti-tank mines (ATM) found in several affected countries are mostly buried, non-metallic or with minimum metal content.

Using the classical technologies (metal detector, dogs, prodding) finding, localizing and identifying the landmines is a time consuming, expensive and extremely dangerous procedure. In addition, it will take a long time to de-mine the affected countries, mainly because the same tedious procedure has to be applied to all areas suspected to be contaminated with landmines. Mined areas are generally close to the battlefields, being consequently heavily infested by metal pieces from the explosions of different ordnances (explosion of an ordnance can result in more than 1000 small metal fragments). The presence of metal clutter produces a large number of false alarms in the metal detectors (MD) commonly used in de-mining. As a consequence, there is a need for a technological breakthrough in this field to solve definitively the land-mine problem.

X-ray or gamma-ray based imaging is the only technique which enables a direct view of objects embedded or buried in soil. State of the art systems can give good precision density measurements with high-resolution three-dimensional images. The observed shapes and mechanical structure of detected objects may help to identify a particular mine type or at least to distinguish a mine from other buried objects such as metal scrap. Metal can be distinguished further by the available gross information about the elemental content of the inspected item (low Z vs. high Z discrimination). Recent examples of systems under investigation will be discussed as well as emerging ideas of combining gamma and neutron detection to further increase the sensitivity and selectivity of such systems.

Dan Gabriel Ghita (Bucharest) **SEMINAR**

In beam experiments for measuring sub-nanosecond lifetimes using fast $LaBr_3$:Ce detectors at the Bucharest FN Tandem accelerator

An in-beam method to determine lifetimes of nuclear states in the sub-nanosecond range domain with triple coincidences using an array of eight HPGe and five $LaBr_3$:Ce detectors will be presented. The good resolution of the HPGe detectors allowed to select the decay cascades feeding the levels with lifetimes to be determined with the fast $LaBr_3$:Ce detectors. Two measurements were performed at the Bucharest FN Tandem accelerator in order to demonstrate the capabilities of this method: a test measurement of the $7/2^+$ level at 205 keV in ^{107}Cd having the known half-life of $T_{1/2}$ = 0.7 ns and the determination of the $3/2^+$ state at 367 keV half-life of $T_{1/2}$ = 47 ps in ^{199}Tl.

Andrzej Góźdź (Lublin) **SEMINAR**

Nuclear collective models and partial symmetries

Nuclear collective states are usually grouped into sequences of energy levels called bands. However, the definition of a such band is not unique and model dependent because of different inter-band transitions which does not allow to order the energy levels sequentially. On the other hand, collective models allow for approximate determination of physical nature of considered excitations, e.g. vibrational excitations, rotational motion and so on.

Nowadays, there is considered a possibility of existence of nuclei with exotic,e.g. tetrahedral or octahedral, symmetries. This hypothesis opens up a new possibility of classification of nuclear energy bands. It turns out that, in principle, the energy levels can be grouped into bands of levels generated by sub-Hamiltonians having different symmetries. In this case the global Hamiltonian has the symmetry which is a common symmetry of allsub-Hamiltonians.

This idea allows to explain a puzzle of coexistence of energy bands with different symmetries. For example, it is expected that, in many nuclei, the g.s. rotational band has axial or D_{2h} symmetry (for gamma unstable nuclei), but other bands can have either higher, e.g. tetrahedral, or lower symmetry than the ground state band.

The gadolinium and dysprosium nuclei are considered as examples.

Paul Greenlees (Jyväskylä) **LECTURE**

Gamma and electron spectroscopy of the heaviest elements

The production and spectroscopic study of the heaviest elements has always been a central theme of nuclear physics. In recent years, a wealth of new data has been produced, both in terms of new elements (up to Z=118 [1]) and in detailed spectroscopic studies of nuclei with masses above 240 [2]. Such studies provide data concerning nuclear parameters such as masses, decay modes, half-lives, moments of inertia, single-particle properties, etc., in systems with the highest possible number of protons. The main focus of current experiments is the search for the next closed proton- and neutron- shells beyond the doubly magic ^{208}Pb. This search can be made directly, by producing nuclei in the region of interest (Z>112 and N>176), or indirectly through the study of lighter deformed nuclei where the orbitals of interest at sphericity are active at the Fermi surface.

In the latter case, the production cross section is large enough to permit detailed in-beam spectroscopic studies. These studies employ state-of-the art spectrometers such as the JUROGAM array of germanium detectors or the newly-commissioned SAGE combined conversion electron and gamma-ray spectrometer.

Examples of recent highlights in heavy element studies with stable beams, along with the opportunities provided by current and future facilities to extend these studies will be presented.

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Leonid Grigorenko (Dubna) **SEMINAR**

Recent advances in theoretical studies of two-proton radioactivity

Two-proton radioactivity is the most recently discovered radioactive decay mode of nuclei and it is a very actively developing field. The modern trend of this research lies in the studies of the correlations for the decay fragments. With correlation information becoming available, the 2p-decay studies are now turning into a field of research where precise information about structure and continuum dynamics can be obtained. A consistent three-cluster quantum-mechanical theory of two-proton radioactivity and "democratic" three-body decays of the coulombic nuclear systems has been developed in our works. This model have demonstrated significant predictive power, especially for "light" 2p emitters (say, up to ^{19}Mg). For heavier 2p-emitters our model required improvements which became evident with availability of the precise experimental data. We are reporting the following new developments of our model. (i) Development of the methods for classical trajectory treatment of the remote (1000-100000 fm) WF region. This allows to achieve complete radial convergence of the momentum distributions for the decay fragments for heavy 2p emitters. (ii) Development of the methods to incorporate the nuclear structure information obtained within the relativistic mean-field approach into the three-body cluster model of 2p radioactivity. This allows to narrow drastically the lifetime range predicted by the three-cluster model and provide much more certain information about correlations. (iii) We also discuss the prospects of studies of the two-proton radioactivity including the ongoing experimental search for ^{26}S isotope.

Katarzyna Hadyńska-Klęk (Warszawa) **SEMINAR**

Coulomb excitation of the presumably super-deformed band in ^{42}Ca - preliminary results from the first AGATA Demonstrator experiment

The Coulomb excitation experiment to study the presumably super-deformed band in ^{42}Ca was performed in February 2010 at LNL Legnaro using the gamma-ray spectrometer AGATA Demonstrator coupled to the charged particle detection set-up DANTE [1]. Gamma-rays from Coulomb excited ^{42}Ca nuclei were measured in coincidence with calcium projectiles back-scattered on the ^{208}Pb target and detected by three position-sensitive MCP detectors forming the DANTE array. The AGATA Demonstrator spectrometer consisting of three clusters was used for the first time in a nuclear physics experiment. The performance of the novel experimental set-up will be presented.

The motivation for the study was the observation of a rotational structure in ^{42}Ca which is similar to the previously identified super-deformed bands in several A~40 nuclei such as ^{40}Ca [2], $^{36,38}Ar$ [3-5]. Lifetime measurements in ^{42}Ca using the Doppler-shift attenuation method [6], suggest a smaller deformation of the band built on the second 0^+ state (1837 keV) than in the case of ^{40}Ca. On the other hand, the moment of inertia of this band was found to be very similar to the one of the super-deformed band in ^{40}Ca [7]. Another argument for the highly-deformed character of this band was the observation of its preferential feeding by the low energy component of the highly split GDR decaying from ^{46}Ti [8].

In order to resolve the existing ambiguities concerning the deformation of the presumably super-deformed band, an attempt has been made to measure directly the B(E2) values in ^{42}Ca using the Coulomb excitation technique.

In the present experiment the transitions deexciting the presumably super-deformed band were observed for the first time following the Coulomb excitation. Low lying states in the yrast band were also populated via multiple Coulex. Preliminary results of the measurement will be reported and the further analysis aiming at describing the collective structure of ^{42}Ca will be discussed.

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Michael Hass (Rehovot) **LECTURE**

Astrophysical reactions with radioactive beams – present and future

Explosive nucleo-synthesis is one of the fore-front topics in nuclear astrophysics research, especially in present and future large-scale "rare-isotopes" facilities. The study of the underlying nuclear reactions that govern astrophysical phenomena such as x-ray bursts and super-novae is essential for illuminating the nature and mechanism that trigger and power such objects. For example, the source of the observed x-ray radiation in the astrophysical objects of "x-ray bursters" stems from nuclear reactions taking place on the surface of the neutron star that are periodically ignited by the accreting mass from the larger companion. The ignition of such reactions, at a typical temperature of ~ 0.4 GK, produces a rapid increase in power and leads to breakout from the "hot-CNO cycle" into the "rp" (rapid proton capture) process with the production of medium mass proton-rich nuclei. Of this chain of reactions, $^{14}O(\alpha,p)^{17}F$ and $^{15}O(\alpha,\gamma)^{19}Ne$ are one of the most important reactions that determine the x-ray burst scenario. These nuclear astrophysics studies are closely linked to state-of-the-art telescopes that provide astronomical observations of x rays (CHANDRA) and γ rays (INTEGRAL).

In this talk we concentrate on two complementary directions:

- Experiments using the existing radioactive beams at relatively low intensity that are available at present facilities. Recent examples include collaborative efforts with the University of Edinburgh group to study “inverse-kinematics” reactions of $^{1}H(^{17}F, ^{17}F^{*})^{1}H$ at ISOLDE (CREN) and the $^{14}O(\alpha,p)^{17}F$ reaction at GANIL (France). The advances on the experimental side in detector technology and related efforts are an integral part in this research. be an important input to better understand the scenario at the relevant astrophysical site via modeling and simulated network calculations.

• Concurrent to the activity above, considerable efforts are devoted to produce orders-of-magnitude higher intensities of the radioactive beams listed above, using the emerging possibilities of the target setup for production of light radioisotopes in the SPIRAL II LINAC, as well as at the new SARAF LINAC at the Soreq Research Center, Israel.

Michał Heller (Kraków) **LECTURE**

Lemaître’s primeval atom and the present standard cosmological model

Georeges Lemaître is one of the founders of relativistic cosmology. To him we owe the first ever paper (1927) comparing predictions of a cosmological model, being a solution to Einstein’s equations, with red shifts of distant galaxies, and a daring idea called by him the Primeval Atom Hypothesis that was a predecessor of the present Big Bang model. Basing on this hypothesis he predicted that the early universe was filled with radiation, the remnants of which should now be detectable. Erroneously, however, he tried to identify it with cosmic rays. In his discussions with Einstein he defended the necessity of introducing cosmological constant and favoured a cosmological solution (with a positive cosmological constant) starting with the initial singularity and having a quasi-static period in the middle part of its evolution. It is exactly this solution that seems to be in the best agreement with the present observational data of the Ia type of supernovae. Lemaître’s Primeval Atom Hypothesis can also be regarded as an early attempt to include quantum effects into the physics of the superdense state in the beginning.

Walter F. Henning (ANL) **LECTURE**

Nuclear physics experiments

Research into the structure of the nuclear many body system continues to provide new insights and surprises to both, our understanding of the strong force and effective nuclear interaction and our ability to handle the many-body aspects of the nuclear system.

From an experimental point of view, much of the new information arises from the advanced abilities to reach new regions of unstable nuclei in reaction studies, employing inverse reactions with rare-isotope beams. This has also considerable impact on nuclear astrophysics where reactions between unstable isotopes are the key to our understanding of explosive nucleosynthesis.

The talk will provide an overview of the current status of both, recent experimental progress and results and the current international efforts towards new facilities to substantially expand rare-isotope beam capabilities in the future.

Nobuo Hinohara (RIKEN) **SEMINAR**

Local QRPA vibrational and rotational inertial functions for large-amplitude quadrupole collective dynamics

On the basis of a microscopic theory of large-amplitude collective motion, called the adiabatic self-consistent collective coordinate method, we have developed a local quasiparticle RPA (QRPA) to determine microscopically the vibrational and rotational inertial functions appearing in the five-dimensional (5D) quadrupole collective Hamiltonian of the Bohr-Mottelson type.

The local QRPA is a natural extension of the QRPA for small-amplitude vibrations to large-amplitude vibrations, and provides an efficient way of evaluating the inertial functions taking into account the contributions from the time-odd terms that arise in the moving mean field. These contributions are ignored in the widely used Inglis-Belyaev cranking inertial functions. We apply the newly developed microscopic approach to a wide variety of low-frequency quadrupole collective motions including anharmonic vibrations, quantum phase transitions and oblate-prolate shape coexistence/mixing phenomena. Some typical results will be presented including proton-rich Se and Kr isotopes, neutron-rich Mg, Cr isotopes and Gd and Sm isotopes.

Morten Hjorth-Jensen (Oslo) **LECTURE**

Modern theory of effective interactions

We compare several methods to perform ab-initio calculations for open-shell nuclei. In particular we focus on coupled-cluster theory and how to derive improved effective interactions for the nuclear shell model. A critical assessment of methods like many-body perturbation theory and Green's function methods to derive effective interactions will also be discussed.

Hisashi Horiuchi (Osaka) **LECTURE**

Overview on the cluster structure and the alpha condensation

Recent trends in nuclear cluster physics are discussed. Three major subjects of discussions are (1) clustering in neutron-rich nuclei., (2) alpha-condensate-like states, and (3) coexistence of cluster and mea-field-type states. The subject (1) includes molecular-orbital and atomic-orbital structures in Be and F isotopes and also dineutron correlation in halo nuclei. The subject (2) is discussed by using the investigations of ^{12}C and ^{16}O. The subject (3) are discussed on the basis of AMD studies of mean-field-type and cluster states in many nuclei and also by using the studies of electric transitions between cluster states and the ground state having mean-field-type structure.

David Jenkins (York) LECTURE

Superdeformation and clustering in ^{24}Mg and ^{28}Si

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Taniguchi et al. have recently performed antisymmetrized molecular dynamics (AMD) calculations for ^{28}Si and delineate a range of excited, highly-deformed configurations based on ^{12}C+^{16}O and ^{24}Mg+^{4}He clustering [1]. The latter configuration is associated with the superdeformed band predicted for ^{28}Si. Similar structures are also expected in ^{24}Mg based on ^{12}C+^{12}C clustering. The increasing sophistication of these calculations, which predict both the parentage of these different configurations as well as the strength of in-band transitions, prompts a renewed experimental search for possible candidate states. A review of possible candidates for cluster states in ^{28}Si found in the literature will be given. We will also present new information on gamma-decaying, excited states in ^{28}Si taken from a study of the ^{12}C(^{20}Ne,α)^{28}Si reaction using the Gammasphere array at Argonne National Laboratory (ANL).The predicted structure of the cluster states in ^{24}Mg and ^{28}Si suggests that alpha- or heavy-ion radiative capture may be a promising strategy in attempting to locate cluster configurations experimentally. Comparatively little is known about the latter process of heavy-ion radiative capture (HIRC), which is difficult to study due to the large positive Q-values and the overwhelming competition from particle emission. Sandorfi found a series of narrow resonances on and around the Coulomb barrier in the ^{12}C(^{12}C,γ) and ^{12}C(^{16}O,γ) reactions in the late 1980s [2]. We have revisited the topic of heavy ion radiative capture, by searching for a doorway mechanism whereby the capture decay would favorably populate high-lying states with a larger structural overlap with the entry resonance. In this manner, it might be possible to locate the superdeformed band in ^{24}Mg, whose band-head is predicted to lie around 10 MeV, by feeding it from above. Three known resonances in the ^{12}C(^{12}C,γ) reaction at $E_{c.m}$=6.0, 6.7 and 8.0 MeV have been studied using the combination of the DRAGON recoil separator and BGO array at TRIUMF [3]. This has allowed firm spin assignments to be made to the resonances and for the general character of the HIRC process to be understood. We have recently carried out a more detailed study of the ^{12}C(^{12}C,γ) reaction at $E_{c.m}$=8.0 MeV using the Gammasphere array and Fragment Mass Analyser at ANL. This shows many interesting aspects relating to non-statistical decay branching including a strong decay to a K=0^{-} band and a number of states around 10 MeV in ^{24}Mg. Preliminary results from this experiment will be presented. We acknowledge the contribution of many other colleagues to the successful running of the Gammasphere and DRAGON experiments.

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Shuhrat Kalandarov (Dubna) **SEMINAR**

Angular momentum dependence of cluster emission from highly excited nuclei

Cluster emission from highly excited nuclei which are formed in heavy ion collisions is investigated within di-nuclear system model(DNS). Depending on entrance channel mass asymmetry and on energy of projectile, one can form highly excited compound nucleus(CN) with different angular momentums. Competition of different channels such as light particle emission (neutrons, protons and etc), complex fragment(cluster) emission and fission, depend on the angular momentum of the intermediate system. Here we present the results for cluster emission cross sections and isotopic distribution of these clusters for different reactions with different angular momentum and excitation energy.

Kazunari Kaneko (Fukuoka) **SEMINAR**

Mirror energy difference at high spins in the mirror pair ^{67}Se and ^{67}As

Recent experimental data have revealed large mirror energy differences (MED) between high-spin states in the mirror nuclei ^{67}Se [1] and ^{67}As [2], the heaviest pair where the MED has been observed so far. This corresponds generally to the isospin symmetry breaking caused by the Coulomb force and the nucleon-nucleon interactions [3], with the details yet to be explored. By employing large-scale shell model calculations [4], we show that the electromagnetic spin-orbit interaction and the Coulomb monopole radial term are important for the observed large MED in this mirror pair. Differing from what has been suggested for lighter nuclei, this large MED is attributed to the proton pair excitations from the $p_{3/2}$ and $f_{7/2}$ orbits to the $g_{9/2}$ orbit and the spin alignment of the $g_{9/2}$ protons at high spins. The relation of the MED to deformation is discussed.

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Wolfram Korten (Saclay) **LECTURE**

Recent experimental advances for measuring nuclear collectivity

Collective excitations play a prominent role in nuclei away from closed shells. The onset of collectivity can therefore signal shell changes in exotic nuclei far from stability. Detailed investigations of collective excitations also allow stringent tests of state-of-the-art nuclear structure models, and in particular those bases on the mean-field approach.

Nuclear collectivity is measured by the (reduced) transition probability of the collective mode of interest, which is in most cases the quadrupole (E2) degree of freedom. Lifetime measurements are one of the "classical" methods to determine B(E2) values often used in conjunction with other spectroscopic information, such as branching or mixing ratios of the state of interest. Recent advances of methods based on the Doppler effect of the emitted gamma-radiation will be discussed, in particular their application to new energy regimes and reaction types. Coulomb excitation is an alternative yet even more powerful tool to determine nuclear collectivity as it allows in principal also to measure static moments of short lived states. While for a long time limited to stable nuclei, the availability of low-energy beams of exotic nuclei has lead to a renaissance of Coulomb excitation as means to perform detailed studies also of exotic nuclei. The lecture will show that the combination of both types of experiments allows to completely disentangle the low-energy structure of exotic nuclei and put stringent tests on their modelling using calculations beyond the mean field approach.

Marek Kowalski (Kraków) **LECTURE**

First results of charged particle production in the ALICE experiment at LHC

The ALICE experiment is the only dedicated heavy-ion experiment at the CERN LHC, but its physics program also covers the pp physics. ALICE, since its start, collected the pp data at 3 different center-of-mass energies - 900 GeV, 2.36 TeV, and the highest available 7 TeV. energies. Multiplicities and particle spectra will be presented and compared with the existing data from lower energies, as well as with Monte Calo predictions. Also, a brief introduction to the experiment will be given.

Adam Kozela (Kraków) **SEMINAR**

First measurement of R-correlation in free neutron decay

Both components of the transverse electron polarization emitted in the beta decay of polarized, free neutron have been measured at cold neutron spallation source SINQ (PSI, Villigen) in a search for a new source of T- or (via CPT theorem equivalent) CP-symmetry violation.

The T-odd, P-odd correlation coefficient associated with polarization component perpendicular to the neutron polarization and electron momentum, was found to be R= 0.008+/-0.015.

This value is consistent with time reversal invariance, and significantly improves limits on the relative strength of imaginary scalar couplings in the weak interaction.

The value obtained for the T-even correlation coefficient connected with the second polarization component, N=0.056 +/- 0.011, agrees with the Standard Model expectation, providing an important sensitivity test of the experimental setup.

This is the first determination of the R correlation coefficient in neutron decay and first determination of the coefficient N in nuclear decay.

Presented will be perspectives for significant improvement (almost by a factor of two) of the achieved accuracy of the correlation coefficient, resulting from the analysis of a new class of events and the application of a new method of the analysis which, taking advantage from the symmetry of the detector, decouples the determination of R and N coefficients.

Wojciech Królas (Kraków) **LECTURE**

Neutron-rich nuclei populated in deep-inelastic collisions: reaction mechanism features important for spectroscopy

Deep-inelastic heavy ion reactions are nowadays used in gamma spectroscopy studies of nuclei that cannot be populated in fusion–evaporation reactions. The planning of these spectroscopic experiments was initially guided by general understanding of the reaction mechanism of deep-inelastic heavy ion collisions acquired in earlier investigations which employed fragment detection techniques. However, it was early recognized that the knowledge of kinematics and dynamics of the colliding systems was not satisfactory for practical application of deep-inelastic reactions to nuclear spectroscopy. In particular, it was not straightforward to predict yields of populated fragments in order to select optimal experimental conditions such as the target-projectile combination and the collision energy.

I will review results of detailed product yield analysis for a few deep-inelatic collision experiments used for gamma spectroscopy. The most important feature determining the access to exotic neutron-rich nuclei is the neutron to proton (N/Z) ratio equilibration. Experimentally determined N/Z values for DIC products will be compared with expectations based on potential energy minimization and on Heavy-Ion Phase-Space Exploration (HIPSE) phenomenological model dedicated to heavy-ion reactions around Fermi energy. Conclusions drawn from the studied N/Z equilibration process show some limitations in reaching very exotic neutron-rich nuclei via this reaction mechanism.

Reiner Krücken (München) **LECTURE**

Recent results from REX-ISOLDE

The investigation of collectivity and single-particle structure in neutron-rich nuclei is at the center of many studies, in particular in view of experimental and theoretical evidence for modification of the shell structure in exotic nuclei.

In this contribution the recent experimental program at the REX-ISOLDE accelerator at ISOLDE/CERN will be presented with a particular focus on the newly initiated program of light-ion transfer reactions in inverse kinematics using the T-REX charged particle detectors in conjunction with the MINIBALL gamma-ray spectrometer. Recent results will be presented on the Island of Inversion, including the first (t,p) experiment with a radioactive ion beam, and the investigation of single-particle structure in neutron-rich Ni.

Takamasa Kuboki (Saitama) **SEMINAR**

Measurement of interaction cross sections for neutron rich Na isotopes

Measurements of interaction cross sections (σ_I) at relativistic energies allow us to determine nuclear matter radii for unstable nuclei via Glauber model analysis.

Since nuclear matter radii are directly related to the nuclear matter density distribution, the measurement of σI is a good tool to search for unusual nuclear structures, such as skins and halos.

Nuclear matter radii and neutron skin thicknesses of Na isotopes have been determined by T. Suzuki et al. via measurements of σI in the mass range from A = 20 to 32 at GSI. They found the existence of neutron skin in the neutron rich Na isotopes for the first time.

Recently, intensive efforts have been devoted to nuclei around the 'island of inversion', in both experimentally and theoretically, where the neutron fp shell is known to contributes significantly to the ground-state structure. However, beyond A = 32 of Na isotopes, no measurement of σI has been done because of their very low production rate.

Now the combination of high intensity ^{48}Ca beam and the next generation fragment separator (BigRIPS) at the RIKEN RIBF facility has opened to access such drip-line nuclei.

In order to investigate the nuclear structure around island of inversion, we measured σI of neutron rich sodium isotopes $^{29\text{-}35}$Na at 250MeV/nucleon by a transmission method using BigRIPS and determined the nuclear matter radii of those nuclei. Experimental setup is essentially the same as our previous experiment at GSI. A primary beam of 345MeV/nucleon ^{48}Ca with a typical intensity of 100 pnA was bombarded a Be production target. The produced fragments were pre-separated at the 1st stage of BigRIPS. The carbon reaction target with 3.6g/cm^2 thickness was placed at the middle focus point of the 2nd stage of BigRIPS. The first and second half's of the 2nd stage of BigRIPS were used to separate and identify the incident and outgoing secondary beam with a Bρ ΔE TOF method, respectively. In the case of $^{30\text{-}32}$Na, we accumulated more than 10^5 events, which corresponds to the accuracy in around 1 %.

The experimental results and discussion on their nuclear structure will be presented.

Rakesh Kumar (New Delhi) **SEMINAR**

Enhanced E2 transition strength in ^{112,114}Sn

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In recent years the region of tin isotopes has been intensively investigated both from experimental and theoretical perspectives. In particular, the excitation energies and the reduced transition probabilities across the Z=50 chain has been examined in detail. This constitutes the longest shell-to-shell chain of semi-magic nuclei investigated in nuclear structure to date. Radioactive ion beams yield new experimental results close to the doubly-magic ^{100}Sn and ^{132}Sn, but very accurate data of the stable mid-shell nuclei are also of great relevance for our understanding of nuclear structure.

The experimental B(E2; $0^+ \rightarrow 2^+$) values, on the neutron-rich side of the Sn chain drop considerably with increasing neutron number and are well described by the seniority scheme. On the proton-rich side an almost constant plateau of high B(E2) values emerges. These unexpected high B(E2↑) values caused a persistent discrepancy between the results of the new large-scale shell model (LSSM) calculations and experiment findings.

The less known B(E2↑) values in ^{112}Sn and ^{114}Sn motivated two Coulomb excitation experiments to improve these crucial data points and to firmly establish the location along the Sn isotope chain where the B(E2↑) value is increased. At GSI [1] we performed two consecutive measurements using 114Sn and ^{116}Sn beams on a ^{58}Ni target. In the experiment carried out at IUAC [2], targets of ^{112}Sn and ^{116}Sn were bombarded with a ^{58}Ni beam. The precise determination of the reduced transition probability, B(E2; $0^+\rightarrow 2^+$), of ^{112}Sn and ^{114}Sn relative to well known E2 excitation strength in ^{116}Sn was achieved by comparing the relative projectile to target $2^+\rightarrow 0^+$ decay intensities. The obtained B(E2↑) values of 0.242(8) e^2b^2 and 0.232(8) e^2b^2 for ^{112}Sn and ^{114}Sn , respectively, confirms the tendency of large B(E2↑) values for light tin isotopes below the mid-shell ^{116}Sn, that has been observed recently in various radioactive ion beam experiments.

A comparison with LSSM and relativistic quasiparticle random-phase approximation RQRPA [3] calculations will be presented.

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Silvia Leoni (Milano) **LECTURE**

Reaction dynamics and nuclear structure studies of neutron rich nuclei around ^{48}Ca with PRISMA-CLARA experiments

The population and gamma decay of neutron rich nuclei around ^{48}Ca has been measured at LNL with the PRISMA-CLARA setup, using deep-inelastic collisions (DIC) on ^{64}Ni, at an energy ~2.5 times above the Coulomb barrier. The reaction properties of the main products have been investigated, focusing on total cross sections and angular distributions energy integrated and associated to the population of specific excited states. This study provides information on basic physical quantities, such as potentials and pair transfer mechanism. Gamma spectroscopy studies based for the first time on angular distributions and polarization measurements will be also shown, allowing a rather firm spin and parity assignments for a number of excited states of one and two nucleons transfer channels. Special emphasis will be given to candidates for particle-vibration coupling in ^{49}Ca, for which lifetimes measurements are also performed. The excitation of these states provides a further test to the role of low lying collective states in the reaction dynamics. Both reaction and gamma spectroscopy studies therefore demonstrate the relevance of DIC with heavy ions for the investigation of neutron rich systems.

Ivano Lombardo (Catania) **SEMINAR**

The strong role of N/Z degree of freedom in $^{48}Ca+^{48}Ca$ reactions at 25 MeV/nucleon

We will show some preliminary data, recently obtained by studying the nuclear reaction $^{48}Ca+^{48}Ca$ at 25 MeV/nucleon with the 4p detection system CHIMERA installed at LNS. The measurements is a part of a larger experimental project aimed to probe isospin degree of freedom in neutron rich and neutron poor systems at or below the saturation density [F. Amorini et al, Phys. Re. Lett. 102 (2009)]. Inclusive data relative to well reconstructed events will be shown. In particular, charged particle multiplicity distributions, relative yields of Lithium and Beryllium isotopes and invariant cross section will be discussed.

We selected incomplete fusion phenomena in semi-central collisions by means of severe constraints on the observed charged particle multiplicity and on the experimental velocity of the largest detected fragments. For this class of events we performed mass and velocity distributions, in order to learn more about the mechanism of heavy residue production as well about the competition with other dissipative reactions (binary, ternary). The comparison of these preliminary data with previous distributions obtained for the reactions $^{40}Ca+^{40,48}Ca,^{46}Ti$, at the same bombarding energy of this report, confirms the strong influence of the N/Z degree of freedom on the fate of hot compound nuclei formed by means of incomplete fusion mechanisms at bombarding energies just at the threshold of the multi-fragmentation mechanism.

Miguel Madurga (Knoxville) **SEMINAR**

Beta decay spectroscopy of ^{81}Zn from an isotopically pure radiactive beam

The beta decay of the neutron rich N=51 nucleus ^{81}Zn was investigated in order to establish the ground state configuration of ^{81}Zn and the excited states in the N=50 isotone ^{81}Ga. The high detection efficiency digital beta/gamma spectroscopy setup at the HRIBF (Oak Ridge) was used. The isotopically pure radioactive beam of ^{81}Zn obtained by means of high resolution isobar separator was critical for the success of this measurement.

The selectivity of beta decay allowed us to investigate the spin assignment of ^{81}Zn ground state. The systematics observed in the first $1/2^+$ state in N=51 istotones suggested some scenarios were the ^{81}Zn ground state spin is $1/2^+$ instead of conventionally expected $5/2^+$ [1], an effect observed in Hartree-Fock calculations [2]. The beta decay branching ratio observed in our work strongly suggests a $5/2^+$ assignment for the ^{81}Zn g.s. This result is supported by our shell model calculation of the ^{81}Zn excited states. Our predicted $5/2^+$ g.s. for N=50 isotones implies large g.s. branching ratio and thus short half-lifes for these important r-process nuclei.

In this work we present the first observation of high energy states in ^{81}Ga, strongly populated in the beta decay of ^{81}Zn, indicating allowed Gammow-Teller transitions. Similar Gamow-Teller transitions have been previously observed in the decay of ^{83}Ge into the N=50 isotone ^{83}As, explained as exciations of the N=40 core [3]. The evolution of core excitations in N=50 isotones indicates a strengthening of the N=40 subshell closure in neutron rich nuclei. This result, combined with the observed weakening of the N=50 shell closure [4], suggests a preponderance of the N=40 over the N=50 shell closure in the ^{78}Ni region.

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Indranil Mazumdar (Mumbai) **LECTURE**

Search for GQR and rare shape transition in hot rotating nuclei

An overview of our programme to search for rare shape-phase transition in heavy nuclei and the Giant Quadrupole Resonance (GQR) based on excited states will be presented. The presentation will include new experimental data, instrumental details and theoretical calculations. The measurements have been carried out using large array of NaI(Tl) detectors and more recently a large $LaBr_3$:Ce detector for several heavy nuclei, namely, ^{188}Os, ^{192}Pt and ^{196}Hg. The angular momentum gating have been carried out using a sum-spin spectrometer in soccer-ball configuration covering nearly 4π solid angle. Details of the 4π spin spectrometer including measurements and simulations will be presented. The very recent results of our testingss and simulations for $LaBr_3$:Ce detectors used in our measurements will also be presented. The talk will endeavour to provide a comparative study of our programme with global efforts, the general paradigms and emerging trends.

Katarzyna Mazurek (Kraków/GANIL) **SEMINAR**

Poincare shape transitions in hot rotating nuclei

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The leading features of hot, fast rotating nuclei have been investigated using a realistic, the so-called Lublin-Strasbourg Drop model [1-2] that simulates the rotational nuclear behaviour using the rigid-body rotational-energy expression.

The total energy has been minimized in a multidimensional space of deformation parameters and the equilibrium nuclear shapes for each given spin have been found through the total energy minimization. For low and generally not too high spins the equilibrium shape evolves from spherical to more and more oblate configurations. At high angular momenta, however, shape-transitions occur that precede rotation-induced fission.

One of them, studied already for some time in the nuclear physics context is the so-called Jacobi shape transition, introduced long ago by Jacobi and known in the history of physics from the theory of rotating stellar objects [3].

The existence of the nuclear Jacobi shape transition was demonstrated experimentally through the change of the GDR strength function with increasing angular momentum [5].

But, there exists yet another type of transitions (also known in astrophysics under the name of Poincare transitions [4]) that can appear in competition with the previous one [5]. While the Jacobi shape transitions preserve the left-right symmetry the transitions of the Poincare-type break this type of symmetry leading to the new type of instabilities involving the octupole- and higher order left-right asymmetric shapes.

In this contribution we discuss the sensitivity of the method to predict such Poincare shape transitions. We report on the regions in the nuclear chart where the Poincare transitions are expected to take place. We discuss in some details as an illustration the chain of Barium isotopes. The possible observables which can experimentally verify our predictions for Poincare transitions, as for example the evolution of the GDR line shape, or mass and charge asymmetry of the fission fragments.

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Chiara Mazzocchi (Milano) **SEMINAR**

Nuclear astrophysics deep underground: the LUNA experiment

Nuclear reactions that generate energy and synthesize elements take place inside the stars in a relatively narrow energy window: the Gamow peak. In this region, which is in most cases below 100 keV, far below the Coulomb energy, the reaction cross-section drops almost exponentially with decreasing energy. The extremely low value, from pico- to femto-barn and even smaller, has always prevented its measurement in a laboratory at the Earth's surface, where the signal-to-background ratio would be too small because of the background generated by cosmic-ray interactions. Therefore, the observed energy dependence of the cross section at high energies is usually extrapolated to the low-energy region, leading to substantial uncertainties. In particular, a possible resonance in the unmeasured region is not accounted for by the extrapolation, but it could completely dominate the reaction rate at the Gamow peak.

The LUNA (Laboratory for Underground Nuclear Astrophysics) collaboration has exploited the low-background environment of the Gran Sasso National Laboratories in Italy to measure nuclear reactions that take place in stars at astrophysically relevant energies, at or close to the Gamow peak. The most recent reults obtained at LUNA will be presented and an outlook on ongoing and future projects will be given.

Caterina Michelagnoli (Padova) **SEMINAR**

Lifetime measurements in the N=Z nucleus ^{44}Ti

The structure of N~Z nuclei filling the $1f_{7/2}$ shell is a challenging ground for both collective and single particle nuclear models. Large scale shell-model calculations in the full pf shell give an accurate description of the nuclei in the middle of the shell but as one moves towards the shell-closures some discrepancies arise.

More experimental data are needed to understand the origin of these disagreements. The structure of the N=Z ^{44}Ti nucleus determined from high-spin gamma-ray spectroscopy presents many interesting features that deserve a special attention. Being an N=Z nucleus E1-type transition are forbidden but experimentally many such gamma-rays connecting the negative parity band to the ground state band we identified . The odd-spin branch of the negative parity band build on the 3^- state has a strong resemblance with the ground state band up to spin 8^+. Such experimental evidences might be associated to the contribution of some octupole-type correlations to the structure of this band. To clarify the underlying structure of the negative parity states, we performed a lifetime measurement using the IFIN Plunger device.

We report here on the lifetime measurement of the 3^- state, obtained from the RDDS data by means of the Differential Decay Curve Method.

The preliminary results suggest an enhanced B(E3) strength for the gamma-ray transition from 3^- to the ground state, that might be associated to the presence of octupole-type correlations, as mentioned before.

An small array of 5 2"x2" $LaBr_3$:Ce detectors was also used during the measurement to allow for the determination of the lifetime for long-lived states. From the preliminary analysis of the data it results that the 4^- state has a much longer lifetime than previously reported.

The new experimental results add important informations that new shell-model calculations has to take into account when explaining the structure of ^{44}Ti.

Takahiro Mizusaki (Tokyo) **SEMINAR**

Filter diagonalization: a new method for large-scale shell-model calculations

Shell model calculation has a long history over half century. Many advanced approaches have been developed while exact diagonalization is most basic and is still of primary importance. As exact diagonalization, the Lanczos method [1] is widely used and has been refined, combining with M-scheme shell model calculations. There was, however, no great progress for exact diagonalization except the Lanczos and its similar methods.

In this contribution, we present a new diagonalization method for large-scale M-scheme shell model calculations; filter diagonalization [2]. This is based on the Sakurai and Sugiura (SS) method [3] with shift algorithm for linear equations and is alternative for the Lanczos method which has been used over half century.

In the SS method, by considering a moment defined by the energy eigenvalues, large-scale shell model problem is reduced into small-scale one. By the Cauchy's contour integral, we can solve energy eigenvalues and wave functions in a given energy interval, which is quite unique compared to the Lanczos method. The SS method demands, however, heavy computations because it converts one diagonalization problem to solve a large number of linear equations. To overcome this difficulty, we combine the SS method with shift algorithm of linear equations, which is very recently used in all-to-all propagators in lattice quantum chromodynamics (QCD) [4].

In this contribution, we present an algorithm of filter diagonalization in the M-scheme shell model calculations and demonstrate how it works in the large-scale problem.

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Takashi Nakatsukasa (RIKEN) **LECTURE**

Self-consistent description of nuclear photoabsorption cross sections

We have developed several approaches to nuclear response functions based on the time-dependent density functional theory; real-time methods, finite-amplitude methods, QRPA for axially deformed nuclei, etc. We are aiming at systematic calculations from the proton- to neutron-drip lines. Thus, treatment of the continuum, self-consistent treatment of the deformation and pairing are important ingredients in our approaches. In this talk, we will show our recent developments and applications to nuclear photoabsorption cross sections and discuss properties of pygmy resonances in neutron-rich nuclei.

Farheen Naqvi (Köln/GSI) **SEMINAR**

Isomer spectroscopy of ^{125}Cd and ^{127}Cd

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The isomeric decays in ^{127}Cd and ^{125}Cd having two proton holes and three and five neutron holes respectively in the doubly magic ^{132}Sn core have been studied. To date even mass heavy Cd isotopes have been investigated in detail. The obtained systematics exhibit evolution of single particle energies and addresses the onset of deformation when removing particles from the core nucleus. The experiment was performed at GSI, Darmstadt to investigate the structure of excited states in odd mass neutron rich Cd isotopes. Isomeric decays of the nuclei were observed in the fragmentation reaction of ^{136}Xe beam at energy 750MeV/u on a ^{9}Be target of 4g/cm^2 thickness. The Cd ions were selected using standard Bρ-ΔE-Bρ method in the FRagment Separator (FRS). Event by event identification of the particles in terms of their A(mass) and Z(charge) was provided by the standard FRS detectors. Isomers populated in the reaction were implanted in a plastic catcher surrounded by 15 Ge cluster detectors from RISING array to detect the γ decays. In ^{127}Cd ,excited states with pure neutron $\nu h^{-2}_{11/2}\ d^{-1}_{\ 3/2}$ character analogous to ^{129}Sn have been observed, whereas in^{125}Cd apart from the previously observed $(19/2)^+$ isomer, a new isomer has been detected. Level schemes based on the intensity balance and life time information were constructed for these nuclei. The obtained experimental information provides vital inputs for the shell model description of the evolution of neutron hole energies in neutron-rich nuclei in the N=82, Z=50 region. Comparison of the experimental results with shell model calculations will be discussed.

Mehdi Nasri Nasrabadi (Isfahan) **SEMINAR**

Relative even and odd parity levels within the nuclei in the iron region

Shell Model Monte-Carlo Method (SMMC) has been used in the recent years for nuclear level density (NLD) calculations. This method is not only able to calculate NLD as a function of energy, spin and isospin but also as a function of parity although the calculations are time consuming and complicated. In the current study, we used a new method for the calculation of relative even and odd parity levels in which nucleons were considered as statically independent particles. Using this method for ^{58}Fe revealed that the NLDs of even and odd parities for the even-even nuclei are not equal at low energy levels. Therefore this method allows description of transformation from low excitation energies where there is only a single parity to high excitation energies where the probabilities for the two parities are the same. Using our method for ^{56}Fe and ^{60}Ni, was shown that the extracted results were comparable with those of the SMMC method. Then it convinced us that our method is correct and is applicable for other even-even nuclei such as ^{58}Fe.

Roberto Nicolini (Milano) **SEMINAR**

Inelastic scattering as a tool to search for highly excited states up to the region of the Giant Quadrupole Resonance

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An AGATA-Demonstrator (AD) experiment to study the gamma decay from giant resonances at zero temperature has been performed in June 2010 at LNL. The giant resonance modes have been excited by inelastic scattering of ^{17}O at 20 MeV/A (the highest energy available at LNL) on a series of targets, such as ^{208}Pb, ^{90}Zr and ^{140}Ce. The scattered ions have been detected by two E-ΔE Si telescopes of the TRACE project, while the gamma-decay have been measured by the AD coupled to an array of large volume scintillator detectors (BaF_2 and $LaBr_3$).

The experiment aimed at the measurement of a known case first, ^{208}Pb, but with improved experimental conditions, in particular concerning the energy resolution of the gamma detections. In contrast to the existing measurement concentrating mainly on the gamma decay of the giant quadrupole resonance (GQR) in the 10-13 MeV range, the experiment aimed also at the measurement of the lower excitation energy region between 5 to 10 MeV, where pygmy dipole structures exist but not all of them are yet well identified. Preliminary results of the analysis will be shown.

Megumi Niikura (Orsay) **SEMINAR**

Lifetime measurements of low-lying states in neutron-rich Zn isotopes by the plunger technique

One of the most critical ingredients in determining the disappearance or appearance of magicity in nuclei far from stability is the eolution of single-particle energies with increasing neutron or proton numbers when moving away from the alley of stability. The three known cases of disappearance of shell effects at N=8, 20 and 28 in neutron-rich nuclei are understood as due to the effect of the tensor part of the nucleon-nucleon interaction. The tensor force is held responsible for the strong attraction between a proton and a neutron in spin-flip partner orbits. A recent generalization of such mechanism foresees a similar behavior also for orbitals with non-identical orbital angular momenta. It is expected that orbitals with anti-parallel angular momenta attract each other and orbitals with parallel angular momenta repulse each other.

In this context neutron-rich nuclei in the vicinity of ^{78}Ni are particularly interesting since they allow to search for anomalies when compared with shell-model predictions. It is predicted, for example, that the Z=28 gap for protons in the pf-shell becomes smaller when moving from N=40 to 50 as a consequence of the attraction between the proton $f_{5/2}$ and neutron $g_{9/2}$ orbits and the repulsion between the proton $f_{7/2}$ and the neutron $g_{9/2}$ states. The same argument would also predict a weakening of the N=50 shell gap when depleting the proton $f_{5/2}$ state upon approaching the ^{78}Ni nucleus, due to the diminished attraction between the neutron $f_{9/2}$ and the proton $f_{5/2}$ orbits and the reduced repulsion between the neutron $g_{9/2}$ and the proton $f_{5/2}$ states.

In order to investigate the shell evolution in the vicinity of ^{78}Ni we have performed lifetime measurements for low-lying states in $^{72\text{-}74}$Zn by the differential plunger technique. A cocktail beam of ^{73,74}Zn was produced by the projectile-fragmentation reaction of ^{76}Ge on a ^{9}Be target and separated by the first half of the LISE spectrometer at GANIL. The secondary beam with the energy of 34 MeV/nucleon was bombarding on a secondary CD2 target to induce inelastic and transfer reactions, and outgoing particles were selected and identified by the second half of LISE. Gamma rays emitted from the reaction products were detected by 8 EXOGAM detectors, which were surrounding secondary target at 45 and 135 degrees relative to the beam direction. The differential plunger technique with ^{9}Be degrader was applied to measure lifetimes of excited states.

The first results of the lifetime measurement in low-lying states in ^{72,73,74}Zn will be reported together with the comparison to results from Coulomb excitation experiments at REX-ISOLDE and GANIL. A picture of the low-energy structure in these isotopes towards the middle of the $\nu g_{9/2}$ orbital will be given ia: i) identification of the levels populated with inelastic scattering reaction and ii) determination, in a model-independent way, of the transition probabilities of those levels towards the ground state.

Frederic Nowacki (Strasburg) **LECTURE**

Large-scale shell model calculations and nuclear structure

After an overview of actual possibilities of standard Shell Model calculations, we will focus on correlations and cross shell excitations in the isotopic chains of Silicon, Nickel and Tin.

Emphasis will be put on E2 response, for the description of the most exotic isotopes in the vicinity of ^{42}Si, ^{78}Ni and ^{132}Sn.

Shell evolution far from stability at N=28, N=50 and N=82, as well as connections with tensor components of the effective interaction will be discussed.

In particular, we will report on the results of a quantitive analysis of the role played by different components of the in-medium NN interaction in the shell evolution.

Based on the analysis of a well-fitted realistic interaction in sdpf shell model space, we reveal the role played by the different terms in the variation of the N=16, N=20 and N=28 shell gaps in neutron-rich nuclei. We will discuss some other regions of the nuclear chart and compare with available data. Finally, comparison of the spin-tensor content of the microscopically derived effective interaction and a well-adjusted one can shed light on the renormalization procedure and the effect expected from the three-nucleon interaction.

Jacek Okołowicz (Kraków) SEMINAR

Impact of exceptional point threads on nuclear observables

Jacek Okołowicz, IFJ PAN
Marek Płoszajczak, GANIL, Caen, France

Recently exceptional points (EP) have been observed in several open resonance cavity experiments. In nuclear physics we do not have a tuning parameter to approach the EP at our disposal. Therefore, we cannot approach it arbitrarily close, but some conclusions can be drawn already if we are in its vicinity. As the EPs are generic for any parameter dependent Hamiltonian, we should be able to find conducive conditions in some exotic nuclei.

We shall discuss different behaviour of some nuclear observables when the EP is being approached. Namely the conduct of a given observable depends on whether related operator commutes with the nuclear Hamiltonian. Apparently non-commuting observables exhibit a singularity at the EP and, consequently, loose their physical meaning. On the other hand those commuting observables, even though regular, can provide some hints of the EP closeness.

We shall present for some model loosely bound (unbound) nucleus ^{16}Ne the impact of EP on nuclear cross section and phase shifts, including unusual 2π change of the latter. The idea of EP threads in connection of scattering continuum and their influence on near threshold behavior of many body states mixing and eigenvectors rigidity will be discussed in detail.

Concetta Parascandolo (Napoli) SEMINAR

Dynamical dipole mode in fusion heavy-ion reactions by using stable and radioactive beams

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An experimental overview [1-6] on an interesting feature of dipole excitation in heavy-ion collisions, the dynamical dipole mode, predicted to occur between interacting ions with a large charge asymmetry will be presented. In a campaign of experiments where the same compound nucleus in the ^{132}Ce region was probed through different charge asymmetry entrance channels, a larger gamma-ray emission from the more charge asymmetric channel was evidenced, in the Giant Dipole Resonance energy range. The beam energy dependence of this extra gamma yield was extracted by comparing the results obtained at different beam energies [2-5]. The first angular distribution data taken at Elab= 16 MeV/nucleon support its prompt dynamical nature [2,3]. Our data [2-5] are compared with theoretical calculations performed within a BNV transport model and based on a collective bremsstrahlung analysis of the entrance channel reaction dynamics [7] and with recent data [6] obtained for compound nuclei in the same mass region but formed from entrance channel with a lower charge asymmetry.

Using the prompt dipole radiation as a probe and employing radioactive beams, new possibilities for the investigation of the symmetry energy at sub-saturation density are foreseen and will be discussed [5].

As a fast cooling mechanism on the fusion path, the prompt dipole radiation could be of interest for the synthesis of superheavy elements through hot fusion reactions. The entrance channel charge asymmetry could provide a way to cool down the hot fusion paths, so ending up with a larger survival probability. To shed light in this direction and to study if pre-equilibrium effects survive in heavier systems, we extended our study to the ^{192}Pb compound nucleus, formed at an excitation energy of 232 MeV, by using the ^{40}Ca + ^{152}Sm and ^{48}Ca +^{144}Sm reactions at Elab= 440 MeV and 485 MeV, respectively. Preliminary results of this measurement, done with the aim to search for the dynamical dipole mode in both fusion-evaporation and fusion-fission events for the first time in this mass region, will be presented.

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Vivek Parkar (Huelva) **SEMINAR**

Dipole polarizability of weakly bound nuclei

Dipole polarizability is one of the fundamental properties of a nucleus, and can be studied in elastic scattering experiments performed at energies below the Coulomb barrier. For strongly bound nuclei the effect of dipole polarizabilty is usually negligible. However, for weakly bound nuclei, where the dipole strength extend to low excitation energies, it does play a major role.

This effect has already been examined in the scattering of the lightest weakly-bound stable nuclei, viz., d, ^{3}He, and ^{7}Li. At present work, we study the possibility to extract information on the coulomb dipole strength for weakly bound unstable ^{6}He nucleus, using the elastic scattering data obtained in low energy collisions with a ^{208}Pb target. Three scattering energies have been used for this purpose. Continuum Discretized Coupled Channel (CDCC) calculations can reproduce the angular distribution of the data, and from this study we are able to gather information on the B(E1) distribution.

This technique can be further extended for the weakly bound unstable nuclei close to the drip lines.

Alexander Pasternak (St. Petersburg) **SEMINAR**

Nuclear transitions and new standards of length and time

The definition of the meter based on fundamental constant – speed of light c and the fundamental ratio c = λν. So, now wavelength of any light source, if its frequency is measured, becomes a standard of length with adequate accuracy. This accuracy is defined by the frequency stability of metrological lasers. The best stability and reproducibility was achieved due to sub Doppler spectroscopy of molecular or atom transitions; typical value for relative reproducibility now is 10-11 ÷ 10-13. It looks that this direction is close to limit. But a lot of expected achievements of 21 century in the fields of nanotechnologies, computers, GPS, astrophysics, metrology etc. are connected with an increasing of the accuracy of time and length measurements. The cardinal way of the improvement the laser frequency reproducibility is to find nuclear transitions of extremely low energies coincident with any laser line or its harmonic, because nuclear transitions almost absolute independence from temperature.

Nowadays significant efforts are devoted to the investigation of $3/2^+$ - $5/2^+$ transition of ^{229}Th (last reported value is 7.6 ± 0.5 eV [1]). In principle the transition could be tested by comb-generator, but this way looks very difficult due to extremely narrow line widths (~10-4 Hz). In spite of this there are some projects for resolving this problem, in particular, using intensity synchrotron beams [2]. But in any case ^{229}Th is very hard-to-reach and inconvenient material; so alternative nuclear transitions in optical range have to be found and studied. One possibility is the nuclear transition of 73 eV in ^{235}U. Proposal of J.L. Hall [3] regarding the pumping of ^{181}Tl (6 keV) and ^{57}Fe (14 keV) by comb-generator and lasers with non-linear crystals for generating high harmonics shows the availability of these efforts. Important to emphasize that transitions-candidate can populate not only ground levels but also isomeric excited nuclear states, especially in heavy odd-odd nuclei. We propose to make efforts in further investigation of ^{229}Th and for searching of new nuclear transitions.

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Ludwik Pieńkowski (Warszawa) **LECTURE**

Nuclear cogeneration

Nuclear Cogeneration refers to the simultaneous production of useful thermal energy and electrical energy using nuclear reactor as a heat source. Typical modern water-cooled reactor produces heat at a relatively low temperature, slightly in excess of 300°C. This limits the possibility of using today available nuclear reactors for electricity generation and low-temperature applications, for example as a heat source for district heating systems. Some of the new types of reactor like High Temperature Reactors (HTR) will open the possibilities to provide useful heat for many industrial processes. The industrial process heat market today is at least of the same size as the electricity market and almost entirely based on combustion of fossil. New, emission-free heat source not only will reduce CO_2 emissions, consumption of natural gas and crude oil in refineries, fertilizer plants, but also will open an option of the chemical coal processing with strongly limited CO_2 emission.

Stuart Pittel (Delaware) **LECTURE**

The density matrix renormalization group and the nuclear shell model

In this presentation, I will review our recent efforts to develop the Density Matrix Renormalization Group method into a practical approach for carrying out large-scale shell model calculations of atomic nuclei. I will begin with an overview of the essential features of the method [1] and will then turn to some of the issues specific to its use in atomic nuclei.

I will then summarize the principal results we have obtained to date [2-3].

Our primary applications have been to nuclei in the 2p-1f shell, where our focus has been to test the method by comparison with the results of exact shell-model diagonalization.

We have carried out calculations for both even-even and odd-mass nuclei, ranging from A=48-56.

We find that the method converges rapidly to the exact results for all nuclei considered. Most importantly, the fraction of the full space required for a high level of accuracy goes down rapidly with the size of the full shell-model space, suggesting that the method may prove useful for heavier nuclei where exact diagonalization is not feasible.

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Josef Pochodzalla (Mainz) **LECTURE**

Hypernuclei

The study of hypernuclei can illuminate features that are obscured in conventional nuclear systems and may thus help to understand how nuclear structures - nuclei on small as well as large scales – emerge in a rigorous way from QCD. On one hand hyperons embedded in a nuclear system may serve as a sensitive probe for the nuclear structure and its possible modification due to the presence of a hyperon. On the other hand, hypernuclei may unravel the strength of the hyperon-nucleon and even the hyperon-hyperon strong interaction and their different spin-dependent contributions. Furthermore, hypernuclei present a one-of-a-kind laboratory for the four-baryon, strangeness non-conserving weak interaction.

Electro-production of hypernuclei at JLAB and MAMI offers the unique possibility to probe the Λ wave function. Extremely neutron-rich hypernuclei will be investigated by nuclear collision with stable heavy ion beams and rare isotope beams at GSI and FAIR; copious production of double lambda-hypernuclei by antiproton beams will enable high precision gamma-spectroscopy with the PANDA experiment for the first time.

Leszek Próchniak (Lublin) SEMINAR

A symmetry of the CPHC model of odd-odd nuclei and its consequences for properties of M1 and E2 transitions

We studied energies and electromagnetic properties of odd-odd nuclei in the frame of the Core Particle Hole Coupling (CPHC) model[1,2]. In the version of the CPHC model used in the present work a core and unpaired nucleons interact via separable quadrupole-quadrupole forces. Proton particle and neutron hole occupy the same j level while the dynamics of the core is described by the general Bohr Hamiltonian depending on the beta and gamma deformation variables. Most calculations were done for the case of j=11/2 which is relevant for nuclei around A=130. We analysed several types of the potential and kinetic energy entering the Hamiltonian of the core, including completely gamma independent ones and compare the results for the odd-odd nuclei with those obtained with the rigid rotor of the Davydov-Filippov model.

We focused our investigations on these properties of odd-odd nuclei which are often treated as a manifestation of the chiral symmetry [3], that is a presence of nearly degenerate partner bands with characteristic staggering seen in the M1 and E2 transitions between states with the total spin I and I-1. We found that such staggering can be explained by selections rules following a new, not discussed as yet, symmetry of the model. This symmetry is a combination of the parity operation in the five dimensional space of deformation of the core (we stress that it is not the parity in the ordinary space) and an exchange of states of the unpaired particles.

All eigenstates of the core Hamiltonian which is invariant against the parity have mean value of the gamma deformation equal to 30 degs.

The considered symmetry is not fully preserved in the realistic cases, but as our calculations show, small breaking of this symmetry does not destroy staggering patterns in the M1 and E2 transition probabilities.

The present work was done in collaboration with Ch. Droste and S.G. Rohozinski (University of Warsaw) and K. Starosta (Simon Fraser University, Vancouver).

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Mustafa Rajabali (Leuven) SEMINAR

Nuclear structure systematics in odd-odd neutron-rich gallium isotopes

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The neutron rich odd mass Gallium isotopes have recently received much attention as they were examined by various experimental techniques with the aim of systematically studying the nuclear structure from the spin and parity of the ground state (gs) and excited states (see for example [1]). From collinear laser spectroscopy experiments conducted at ISOLDE, an increased occupancy of the proton $f_{5/2}$ level was observed starting from N=42 onwards and leading to shape changes as well as an unexpected collective ground state with spin I=1/2 for ^{73}Ga and I=5/2 for ^{81}Ga [2]. This reordering of the proton $f_{5/2}$ and $p_{3/2}$ orbits as the neutron $g_{9/2}$ orbital is being filled, was previously observed in the Cu isotopes to occur in ^{75}Cu with a gs dominated by a proton in $f_{5/2}$ [3].

In this submission we will present the systematics of neutron rich odd-odd Ga isotopes from ^{72}Ga to ^{80}Ga. Currently known spectroscopic information and recent spin and moment measurements allow us to study the effect of the odd $g_{9/2}$ neutron coupling to an odd number of protons in the $f_{5/2}$ or $p_{3/2}$ orbits.

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Walter Reviol (St. Louis) **LECTURE**

Tidal waves and onset of collectivity above N = 126

Recent experiments in the actinide region, using Gammasphere and the evaporation residue detector Hercules, have covered the territory between N = 126 and the center of static octupole deformation at N = 134. The ^{220}Th nucleus, its lighter N = 130 isotones, and the neighboring ^{219}Th isotope show a peculiar behavior: the octupole bands are vibrational-like i.e. E_γ(E2) ≈ const.], and their B(E1)/B(E2) ratios exhibit a spin-dependent staggering. The behavior has been described, based on a phonon picture developed by Frauendorf, as a constant-frequency tidal-wave mode for a reflection-asymmetric nuclear surface. The ^{219}Th level scheme deserves also attention in a different context, namely that of parity doublets. The discussion will conclude with a brief mentioning of observed and predicted cases for reflection-symmetric tidal waves in other mass regions.

Juho Rissanen (Jyväskylä) **SEMINAR**

Nuclear structure studies of neutron-rich nuclei performed by JYFLTRAP

Nuclear structure studies of neutron-rich nuclei becomes difficult at conventional ISOL facilities when going far from beta-stability due to high background generated by the nuclei within the same isobaric chain. Therefore, when studying the properties of the most exotic nuclei, the background level can be significantly reduced by using the Penning trap as a high-resolution mass filter to separate the nuclei of interest from the isobaric contaminants.

The unique possibilities of the IGISOL mass separator coupled to the JYFLTRAP double Penning trap setup have been used for nuclear spectroscopic studies at the University of Jyväskylä. The fission products have been isobarically purified with the Penning trap and sent forward to subsequent beta and gamma decay spectroscopy studies. By looking the gamma radiation emitted by the studied nuclei, one can build decay schemes to see a structure of the excited states fed by the beta-decaying parent nucleus.

The mass of the nucleus is an important ground state property having close connection for example to the shape of the nucleus. The JYFLTRAP Penning trap setup allows to measure atomic masses very precisely with a typical relative uncertainty of the order of 10-8. By looking systematically the properties extracted from the mass values, the nuclear structure effects, such as shell and sub-shell closures as well as the deformation effects become visible. In this contribution, highlights of the latest nuclear structure studies, including mass measurements and spectroscopic studies of neutron-rich nuclei in A = 110 region, will be presented.

Oliver Roberts (York) **SEMINAR**

Novel detector development for the PARIS project

$LaBr_3$:Ce scintillators are a novel scintillator with high timing and energy resolutions, making them attractive for future projects involving gamma-ray spectroscopy. The PARIS collaboration hopes to utilise these superior timing and energy properties from this scintillator in the construction of a new 4π detector array, with two hemispheres of scintillators.

Different types of detector methods have been tested and analysed, with the most favourable being the highly efficient "Phoswich" design. Various experiments analysing the basic properties of this method will be discussed and analysed in depth. These include pile-up and timing resolution tests. Initial timing resolutions for both the $LaBr_3$:Ce and CsI:Na were found to be ~600 ps and 24 ns respectively via a timing coincidence test with a BaF_2 scintillator.

Tests with a 10.5GBq AmBe neutron source were also conducted, and subsequent radioactive activation was found due to large thermal neutron cross-sections in Lanthanum and Bromine. Pulse shape analysis was done to determine whether pulse shape discimrination between neutrons and gamma rays were possible. Analysis showed that this is not the case, as one would expect.

Preliminary analysis of a high energy calibration experiment will also be discussed. Calibrations of the energy spectrum will be shown along with which states were populated in the $^{27}Al(p,\gamma)^{28}Si$ reaction.

Dirk Rudolph (Lund) **LECTURE**

Proton-rich nuclei studied with RISING

In the years 2006-2009 the pan-European programme “Rare Isotope Spectroscopic INvestigations at GSI” (RISING) applied the concept of high-resolution gamma-ray spectroscopy based on Ge-detector technology on implanted, exotic relativistic radioactive ion beams.

In the course of this so-called “Stopped-Beam Campaign”, nuclear spectroscopy studies of these radioactive beams have been performed by isotope selected isomeric gamma decays and beta-gamma correlations. Hereby, several experiments aimed at medium mass proton-rich nuclei at and beyond the N=Z line, yielding new and profound information on isospin symmetry and isospin symmetry breaking.

The presentation will highlight some physics results from these experiments.

Andrzej Rybicki (Kraków) **LECTURE**

What is the role of nuclear effects in ultrarelativistic reactions at 158 GeV/nucleon ?

In this talk I shall present a few simple examples on how the nuclear structure, nuclear density, isospin content, and finally the electric charge of the nucleus influence multiparticle production in ultrarelativistic nuclear reactions.

After a brief introduction to the phenomenology of nuclear collisions in the energy regime of a few or more GeV per incoming nucleon, I shall discuss the following physics items:

(1) The relation between the nuclear density profile and the fragmentation of the proton projectile in proton-nucleus reactions at 158 GeV/nucleon;

(2) The influence of the isospin content of the Pb nucleus on ratios of particles produced in ultrarelativistic Pb+Pb collisions;

(3) The final state electromagnetic interaction between charged pi mesons produced in the heavy ion reaction and the two nuclear remnants ("spectator systems") surviving this reaction.

If time permits, I shall also address the issue of ``neutron halo" studies in peripheral Pb+Pb collisions at high energies.

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Krzysztof Rykaczewski (Oak Ridge) **LECTURE**

Recent results from Oak Ridge

The nuclear spectroscopy studies at the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory concentrate on nuclei far from beta stability. The recent results include the information on the structure of nuclei next to three doubly-magic nuclei ^{100}Sn [1], ^{132}Sn [2] and ^{78}Ni [3,4,5]. The observed single particle levels and decay processes help to analyze the evolution of nuclear structure in these exotic regions of nuclei. The large beta-delayed neutron branching ratios observed for precursors near ^{78}Ni are also important for the analysis of the processes occurring in nuclear fuels and during the rapid neutron capture process in hot stars. The construction of new detectors improving our discovery potential at the HRIBF will be presented as well as Oak Ridge recent contribution [6] and planned detector upgrades for the studies of new super heavy nuclei.

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Eda Sahin (Legnaro) **SEMINAR**

The evolution of the Z=28 shell gap towards ^{78}Ni: Neutron-rich Cu isotopes

Neutron-rich Cu isotopes, having one proton outside the Z=28 shell, are also good probes of the single particle structure in the region of ^{78}Ni. The characterization of their excited states allows searching for possible shell modifications due to the tensor mechanism which is predicted to cause modifications into the known shell gaps with their possible weakening or disappearance [1, 2, 3]. Shell model calculations including the effect of the tensor force predict a lowering of the $\pi f_{5/2}$ state causing an inversion of the $\pi f_{5/2}$-$\pi p_{3/2}$ effective single particle states around ^{75}Cu which has been recently confirmed by nuclear spin and magnetic moment measurements performed at the ISOLDE facility [4].

From the comparison with the S.M. predictions, three different configurations can give rise to the I $7/2^-$ states appeared in the tentative experimental level scheme picture:

• either a coupling of the single-particle configuration of $\pi p_{3/2}$ to the 2^+ core excitation leading to the $7/2^-$ [$\pi p_{3/2}$ 2^+] levels,

• or similarly, a coupling of the single-particle configuration of $\pi f_{5/2}$ to the 2^+ core excitation leading to the $7/2-$ and $9/2^-$ [$\pi f_{5/2}$ 2^+] levels,

• or finally, the excitation of one proton hole into the $\pi f_{7/2}$ orbit, which results with the $7/2^-$ [$\pi f_{7/2}^{-}$] levels.

The aim of the present work is, therefore, to determine the collective or singleparticle character of those states, which would result in different lifetimes. The characterization of such states and in particular the identification of the $\pi f_{7/2}^{-}$ particle-hole excitations across the Z=28 shell will provide essential information on the shell gap size and therefore on the evolution of the Z=28 energy gap afore mentioned. The knowledge of the electromagnetic transition matrix elements deexciting such states, obtained through lifetime measurements, combined with the information coming from the Coulomb excitation measurement [5], will provide this characterization. The experiment has been performed at the Laboratory Nazionali di Legnaro (LNL, Italy), using the AGATA Demonstrator coupled to the PRISMA magnetic spectrometer. The neutron-rich Cu nuclei have been populated as products of multi-nucleon transfer reactions following the collision of a ^{76}Ge beam with an energy of 540 MeV onto a 1.5 mg/cm^2 thick ^{238}U target.

The lifetime of excited states in ^{71,73}Cu the has been studied recoil-distance Doppler shift (RDDS) technique [6] in which a 4 mg/cm^2 thick ^{24}Mg degrader was placed to degrade the ions produced in the reaction. The projectile-like reaction products will be detected and identified in the magnetic spectrometer PRISMA positioned at 55° with respect to the beam axis, close to the grazing angle for the proposed reaction. The γ rays emitted from the reaction products were detected with the AGATA Demonstrator, which was placed at sensitive backward angles with a total absorption efficiency of 5%. In the present work, the preliminary results on the first AGATA Demonstrator-PRISMA experiment as well as our previous experimental work on N=50 nuclei around ^{78}Ni [7] will be demonstrated.

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Hiroyoshi Sakurai (RIKEN) **LECTURE**

Recent results and future plans at RIKEN

I will show new results with fast radioactive isotope beams available at the RIKEN RIBF facility. Speial emphasis is given to spectroscopy on neutron-rich nuclei at the BigRIPS and RIPS inflight separators. Present status and future plans of RIBF are also presented.

Wojciech Satuła (Warszawa) **LECTURE**

Isospin mixing around N=Z

Isospin symmetry violation in atomic nuclei is caused primarily by the Coulomb force. Within mean-field approximation, there is another source of the isospin symmetry violation as the product states are generally not eigenstates of isospin [1,2,3]. In this talk, we shall report on a development of a new theoretical tool which allows for the isospin projection after variation from symmetry-unrestricted Slater determinants and subsequent rediagonalization of the total nuclear Hamiltonian including Coulomb interaction in order to incorporate only physical isospin-mixing effects [4]. Short overview of main theoretical building blocks of the formalism will be followed by specific applications pertaining to the isospin-mixing effects: (i) in ground states of N=Z and N≠Z nuclei, (ii) in particle-hole excitations and odd-odd N=Z nuclei, (iv) in superdeformed rotational bands in ^{56}Ni (v) at band termination in N=Z, A~44 nuclei. We shall focus on calculation of the isospin mixing correction Δ_C to the Fermi matrix element for the set of nuclei undergoing the superallowed $0^+ \rightarrow 0^+$ beta decay [5,6] presenting, for the first time, systematic results on Δ_C stemming from the isospin and angular-momentum projected Hartree-Fock calculations.

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Achim Schwenk (Darmstadt/TRIUMF) **LECTURE**

Neutron-rich matter and three-nucleon forces

I will discuss the impact of chiral three-nucleon forces on the structure of neutron-rich nuclei, on the limits of existence, on neutron and nuclear matter, and on constraining neutron star structure.

Timur Shneidman (Dubna) **SEMINAR**

Cluster interpretation of reflection-asymmetric type bands structures in actinides

The properties of rotational and quasirotational negative parity bands with different values of K in actinides are investigated in the frame of dinuclear system model [1]. The model is based on the assumption that the cluster type shapes are produced by the collective motion in mass-asymmetry coordinate. To describe the reflection-asymmetric collective modes characterized by the nonzero values of K, the relative angular motion together with the intrinsic excitations of the clusters are taken into account [2]. The observed excitation spectrum, angular momentum dependence of the parity splitting and the staggering behaviour of the B(E1)/B(E2) ratios are explained in different even-even isotopes of Ra, Th, U and Pu.

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Kamila Sieja (Strasbourg) SEMINAR

Shell evolution and core excitations in semi-magic nickel and tin isotopes

In this talk, I would like to present the recent theoretical progress (within the shell model framework) in the description of semi magic nickel and tin isotopes. The role of the core excitations for the development of the quadrupole collectivity will be discussed in detail along the nickel chain, where novel SM calculations in an extended $fpg_{9/2}d_{5/2}$ model space will be presented. I will also show that these relevant degrees of freedom are of a crucial importance for the description of the new island of inversion below ^{68}Ni. Finally, I will discuss the underlying shell evolution and in particular I will focus on the rigidity of doubly-magic ^{78}Ni and ^{100}Sn.

Sunniva Siem (Oslo) LECTURE

Soft dipole modes - overview and recent results

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The gamma-strength functions is a fundamental property of the atomic nucleus and an important input parameter in reaction cross-section calculations, used in reactor physics and astrophysics models of formation of heavy elements in explosive stellar environments.The Giant Electric Dipole Resonance (GEDR) dominates the gamma-strength function and is found in all nuclei across the nuclear chart. The focus of this talk however is the smaller resonances, also called soft dipole modes, found on the low energy tail of the GEDR. One of these is the scissors mode observed (at around 3 MeV) in deformed nuclei and has been studied by several groups using complementary experimental techniques. Another soft dipole mode observed at around 7-9 MeV might be due to neutron skin oscillations. In experiment done in Oslo an unexpected enhancement of the gamma-strength function at low gamma energy has been observed in several nuclei. The origin of this enhancement is presently not understood and remains a challenge to explain theoretically.

This talk will give an overview of the different soft dipole modes, including the different experimental techniques used to study the gamma strength function. Resent results will be presented and the possible impact of soft dipole modes and the low energy enhancement on astrophysical reaction rates and the calculated abundances of elements in our solar system, will be discussed.

*This work was supported by the Norwegian Research Council.

Yuriy Stepanenko (Kyiv) **SEMINAR**

^{7}Li(^{18}O,^{17}N)^{8}Be reaction mechanism and ^{17}N + ^{8}Be potential; ^{16}N + ^{9}Be optical potential from ^{7}Li(^{18}O,^{16}N)^{9}Be reaction analyses

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^{7}Li(^{18}O,^{17}N)^{8}Be REACTION MECHANISM AND ^{17}N+^{8}Be POTENTIAL

The angular distributions of the ^{7}Li(^{18}O, ^{17}N)^{8}Be reactions have been measured firstly for ground and excited states of ^{8}Be and ^{17}N nuclei at the energy Elab.(^{18}O) = 114 MeV. The experimental data have been analyzed within the coupled-reaction-channels (CRC) method for one- and two-step transfers of nucleons and clusters. The mechanism of given reaction was studied. Using for the entrance channel optical ^{7}Li + ^{18}O-potential deduced from the elastic ^{7}Li + ^{18}O-scattering and shell-model spectroscopic amplitudes calculated within the translation-invariant shell model (TISM), the parameters of the optical Wood-Saxon ^{8}Be + ^{17}N-potential were obtained by fitting the experimental data. It was found that proton transfer dominates in the reaction. The ^{8}Be + ^{17}N potential have been compared with the potentials for ^{8}Be interactions with ^{9}Be, ^{13}C, ^{15}N.

^{16}N + ^{9}BE OPTICAL POTENTIAL FROM ^{7}LI(^{18}O, ^{16}N)^{9}BE REACTION ANALYSES

New experimental data of the angular distributions of the ^{7}Li(^{18}O, ^{16}N)^{9}Be reaction were measured simultaneously with the ^{7}Li + ^{18}O scattering at the energy Elab(^{18}O) = 114 MeV for ground and excited states of ^{9}Be and ^{16}N nuclei. The reaction data were analyzed within the coupled-reaction-channels (CRC) method for one- and two-step transfers. In the CRC-calculations, the ^{7}Li + ^{18}O potential deduced by fitting elastic scattering data was used. The needed spectroscopic amplitudes were calculated within the translation-invariant shell-model (TISM). The ^{9}Be + ^{16}N potential parameters were deduced by fitting the reaction data. It was found that the deuteron transfer dominates in this reaction. The ^{9}Be + ^{16}N potential are compared with that of ^{9}Be + ^{16}O and ^{9}Be + ^{14}N scattering.

László Stuhl (Debrecen) **SEMINAR**

High resolution study of the Gamow-Teller strength distribution in Sc isotope

The Gamow-Teller (GT) strength distributions are sensitive to changes in shell structure and study the GT strength distribution can be a tool for investigating the changes in the shell structure along an isotopic chain.

Since the extraction of GT strengths from charge exchange (CE) data is nearly model-independent, a detailed and unbiased testing of shell-model interactions is possible. In order to check the shell structure of Sc isotopes, and to discuss the spin-isospin interaction in pf-shell region, high resolution experiment was performed with the (^{3}He,t) reaction on Ca isotopes. The experiment was carried out at the Research Center for Nuclear Physics (RCNP), Osaka University.

The energy of the ^{3}He beam of 400 MeV was achromatically transported to the ^{40}Ca, ^{42}Ca, ^{44}Ca and ^{48}Ca targets with thicknesses of 1.63 - 1.87 mg/cm2. The typical beam intensity was 5 enA. The energy of tritons was measured with

a magnetic spectrometer using complete dispersion matching techniques. The energy resolution obtained was about 20 keV.

The spectrometer was set at 0° and 2.5° with an opening angle of ±20 mrad horizontally and ±20 mrad vertically defined by a slit at the entrance of the spectrometer.

The J^{π} of the transitions were determined by comparing the angular distributions to the DWBA predictions. In this way we determined 11 new 1^{+}, 8 new 3^{+} and 96 new L≥1 levels by the ^{40}Sc, 39 new 1^{+}, 32 new 3^{+} and 97 new L≥1 levels by the ^{42}Sc, 118 new 1^{+}, 24 new 3^{+} and 64 new L≥1 levels by the ^{44}Sc and 98 new 1^{+}, 23 new 3^{+} and 48 new L≥1 levels by the ^{48}Sc.

The GT strength distribution for Sc isotopes was determined and the GT strength distribution for ^{48}Sc was normalized in a similar way as published in Ref. [1]. The corresponding theoretical analysis of the strengths is in progress.

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Natalia Targosz-Ślęczka (Szczecin) **SEMINAR**

Enhanced pycnonuclear reactions in metallic environments

Pycnonuclear reactions taking place in dense astrophysical plasmas at very low temperatures are enhanced due to electron screening of the Coulomb barrier even by many orders of magnitude. Study of the d+d reactions at very low energies in metallic environments, being a very good model for the strongly coupled plasma, enables us to determine the strength of this effect in the terrestrial laboratories. First experiments performed under high vacuum (HV) conditions showed that the experimentally determined screening energies corresponding to the reduction of the Coulomb barrier height were larger than the theoretical values calculated in terms of the dielectric function theory by at least a factor of two.

Since contamination of the target surface plays a crucial role in the screening experiments we performed a series of new experiments dealing with atomically clean targets under ultra-high vacuum (UHV) conditions. The resulting screening energies turned to be significantly larger than the previous experimental values, stepping up the discrepancy to the theoretical data. As the origin of the so-called enhanced screening effect observed in nuclear reactions taking place in metals still remains unexplained we discuss here two alternative scenarios. First, we analyse a strong long-range correlation between conduction electrons as a solid-state effect. On the other hand, we examine the interplay between a strong plasma screening and a narrow resonance placed close to reaction threshold, which leads to the target material dependence of the reaction cross section.

Peter Thirolf (München) **LECTURE**

Laser particle acceleration: status and perspectives for nuclear physics

High power short-pulse lasers with peak powers presently reaching Terawatts and even Petawatt levels routinely reach focal intensities of 10^{18} - 10^{21} W/cm^2. These lasers are able to produce a wide array of secondary radiation, from relativistic electrons and multi MeV/nucleon ions to high-energetic X-rays and gamma-rays. In many laboratories world-wide large resources are presently devoted to a rapid development of this novel tool of particle acceleration, targeting fundamental and high-field physics studies as well as various applications e.g. in medical technology for diagnostics and tumor therapy. Within the next 5 years a new EU-funded large-scale research infrastructure (ELI: Extreme Light Infrastructure) will be constructed, with one of its four pillars exclusively devoted to nuclear physics based on high intensity lasers (ELI-Nuclear Physics, which will be built in Bucharest). There the limits of laser intensity will be pushed by three orders of magnitude to yet unprecedented 10^{24} W/cm^2.

The talk will review the present status of laser particle acceleration and give an outline of future perspectives for nuclear physics in fundamental and applied research.

James Vary (Iowa) **LECTURE**

Ab initio nuclear theory - progress and prospects

The vision of solving the nuclear many-body problem with fundamental interactions tied to QCD appears to approach reality. The goals are to preserve the predictive power of the underlying theory, to test fundamental symmetries with the nucleus as laboratory and to develop new understandings of the full range of complex nuclear phenomena. Recent progress includes the derivation, within chiral perturbation theory (ChPT), of the leading terms of the nucleon-nucleon (NN), three-nucleon (3N) and four-nucleon (4N) potentials. Additional substantial progress includes solving nuclear structure and reactions in nuclei up to mass 16 and selected heavier nuclei around closed shells using these ChPT interactions. Advances in theoretical frameworks (renormalization and many-body methods) as well as in computational resources (new algorithms and leadership-class parallel computers) signal a new generation of theory simulations that will yield valuable insights into origins of nuclear shell structure, collective phenomena and complex reaction dynamics. I will outline some recent achievements and present ambitious consensus plans for a coming decade of research that will strengthen the links between nuclear theory and nuclear experiment, between nuclear physics and astrophysics, and between nuclear physics and nuclear energy applications.

Dario Vretenar (Zagreb) **LECTURE**

Relativistic nuclear energy density functionals

Among the microscopic approaches to the nuclear many-body problem, energy density functionals (EDF) provide the most complete and accurate description of ground states and collective excitations over the whole nuclide chart.

The current generation of relativistic EDFs, using parameters adjusted to reproduce empirical properties of nuclear matter and bulk properties of finite nuclei, has been applied to studies of arbitrarily heavy nuclei, exotic nuclei far from beta-stability, and systems at the nucleon drip-lines.

In addition to recent advances, future challenges for nuclear EDFs will be reviewed. Arguably one of the most important is a fully microscopic foundation based on the underlying theory of strong interactions. When considering applications, equally important is to develop EDF-based structure models that go beyond the static mean-field approximation. Detailed predictions of excitation spectra and transition rates necessitate the inclusion of correlations related to the restoration of broken symmetries and to fluctuations of collective variables.

Robert Wadsworth (York) **LECTURE**

Spectroscopy of N~Z nuclei above mass 60

The presentation will discuss updates on some of the key features of interest for N~Z nuclei in the mass 60-100 region. One area of specific interest is the study of shape co-existence in N~Z nuclei around mass 70, where the latest experimental results and theoretical calculations will be presented. The talk will also cover some new results on neutron-proton pairing in the mass 90 region. The latter will focus on the recent identification of energy levels in the N=Z nuclide ^{92}Pd, which provides the first indications for isoscalar np pairing, and the search for the decay of the predicted 16^+ spin-gap isomer in ^{96}Cd.

Michał Warda (Lublin) **SEMINAR**

Theoretical description of cluster radioactivity in Ba isotopes

Cluster radioactivity is an exotic nuclear decay predicted by Sandulescu et al. [1] and discovered in 1984 by Rose and Jones [2]. In this process light nucleus (^{14}C -^{32}Si) is emitted. Heavy mass residue is doubly magic ^{208}Pb or similar nucleus. Cluster radioactivity has been found in 20 isotopes from actinides region. Another region of possible cluster radioactivity was predicted near doubly magic ^{100}Sn. In this domain ^{12}C or ^{14}C clusters would be emmited from Ba isotopes. Such events have not been experimentally confirmed [3,4] and only upper limits of this decay were established.

We want to investigate cluster radioactivity in Ba isotopes. We will consider this decay as fission with very large mass asymmetry between fragments. We will analyse potential energy surfaces calculated in Hartree-Fock-Bogoliubov theory with Gogny force [5]. Constrains on quadrupole and octupole moments applied in the self-consistent calculations allow to control simultaneously elongation as well as reflection asymmetry of the fissioning system. This method was successfully applied for studies of cluster radioactivity in actinides [6,7,8].

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Trine Wiborg-Hagen (Oslo) **SEMINAR**

Spectroscopy of transfermium nuclei using the GABRIELA setup

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The heaviest elements provide a unique laboratory to study nuclear structure and nuclear dynamics under the influence of large Coulomb forces and large mass. The spectroscopy of transfermium elements has made great progress in recent years thanks to the use of efficient detector arrays around the target position and at the focal plane of recoil separators. The data, although scarce, have shed light on some theoretical weaknesses. For e.g. there exists now a rather clear disagreement between the predictions of shell positioning obtained from all existing effective interactions/energy density functionals (predicting N=150 and Z=98,104 as sub-shell closures) and experiment (which seems to predict N=152 and Z=100 as subshell closures). Hence, the systematic study of the structure and decay properties of deformed transfermium elements is essential, and probably for many years, the only available way to reach an understanding of the structure at the upper end of the nuclear chart.

A detection system [1] dedicated to the spectroscopy of transfermium nuclei has recently been constructed at the focal plane of the VASSILISSA separator at the FLNR, Dubna, by a Franco-Russian collaboration. The results from the last campaign will be presented.

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Hans-Jürgen Wollersheim (GSI) **LECTURE**

Coulomb excitation of exotic nuclei

Coulomb excitation experiments have been used for many years for the study of electromagnetic properties of nuclear states. With low energy heavy ions one can make sure that one has pure electromagnetic interaction between projectile and target nuclei by keeping the bombarding energy below the Coulomb barrier. For relativistic heavy ions, pure Coulomb excitation may be distinguished from nuclear reactions by demanding extreme forward scattering or avoiding those collisions in which violent reactions take place.

The preformed RISING (Rare Isotope Investigations at GSI) experiments exploited secondary unstable beams at relativistic energies in the range from 100 MeV/u to 400 MeV/u. The exotic beams were used for Coulomb excitation experiments in order to obtain important nuclear structure observables with γ-ray spectroscopic methods. The experimental methods, data analysis and results will be discussed in detail.

The future experiments for the first PreSPEC campaign will also be discussed which focus on shell structure of exotic doubly magic nuclei and their vicinity as well as shapes and shape coexistence.

Katarzyna Wrzosek-Lipska (Warszawa) **SEMINAR**

Coulomb excitation of ^{100}Mo

Molybdenum isotopes with neutron number close to 50 have a spherical shape and can be well described by shell model [1]. As the number of neutrons increases the influence of collective motion on the electromagnetic structure gets stronger, resulting in unusual features of nuclei from N=54 for ^{96}Mo to N=58 for ^{100}Mo.

The neighboring ^{98}Mo nucleus is one of the four stable even–even nuclei having the first excited state of spin and parity 0^+. A very low-lying 0^+ excited state, close in energy to the first excited 2^+ state, was also observed in the ^{100}Mo isotope. Such a rare structure is the first experimental indication of shape coexistence and cannot be easily interpreted.

Multiple Coulomb excitation is one of the most important experimental methods to study nuclear shapes. While lifetime measurements allow determining reduced transition probabilities, Coulomb excitation technique can bring information on relative signs of the matrix elements. Moreover it is sensitive to diagonal matrix elements via second-order effects, making it possible to extract quadrupole moments including their signs, which are the measure of the shape associated with a given state. Low-energy Coulomb excitation is the only experimental technique that can distinguish between prolate and oblate shape of the nucleus in a short-lived excited state.

Coulomb excitation experiment of the ^{100}Mo isotope was performed at HIL in Warsaw using the ^{32}S beam from the U-200P cyclotron. Gamma rays depopulating Coulomb-excited states were detected by the OSIRIS-II array in coincidence with back-scattered particles [2]. The OSIRIS-II spectrometer was a multi-detector system consisting of 12 HPGe detectors equipped with anti-compton BGO shields. The scattered projectiles were detected by 45 silicon PiN diodes, placed inside a small spherical chamber of 5 cm radius. Scattering angle coverage extended from 110 to 152 degrees with respect to the beam direction.

Twenty E2 and M1 reduced matrix elements, including three quadrupole moments, connecting eight low-lying states have been determined using the least-squares code GOSIA [3,4]. Such a rich set of reduced matrix elements makes it possible to extract, using the quadrupole sum rules approach, the shape parameters: the overall deformation parameter, as well as triaxiality in the ground and first excited 0^+ states.

Experimental results concerning the shape parameters of the low-lying 0^+ states in the ^{100}Mo isotope will be presented for the first time. They will be compared to theoretical predictions based on the generalized Bohr Hamiltonian approach [5], and confronted with general trends of shape evolution in this mass region.

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Guilain Ademard (GANIL) **POSTER E1**

Persistence of structure effects in the asymmetric fission of medium mass compound nuclei

Fragments with atomic number $4 \leq Z \leq 28$ have been studied from the reactions ^{78,82}Kr + ^{40}Ca at 5.5 AMeV incident energy by using the 4π-INDRA array at GANIL. Kinetic energy and angular distributions of fragments are compatible with an equilibrium statistical process. Results from the study of the average emission velocities and coincidence measurements between fragments show that binary-fission-like breakup of a completely fused nucleus, is the predominant mode of production for a large part of reaction products, and that the production mechanism is driven by Coulomb interaction. Absolute cross-sections were deduced by the normalization with respect to the elastic scattering. The cross-sections indicate the coexistence of macroscopic behavior and structural effects. For both reactions, a strong odd-even staggering is observed in the yields of asymmetric fission ($5 \leq Z \leq 12$) and the staggering is bigger for the neutron rich compound system. The symmetric fission yields is higher for the neutron rich ^{118}Ba nucleus.

Analysis of the fragment-particle coincidence indicates that in asymmetric fission, the light partner is produced at excitation energy below the proton and alpha separation energy and consequently the secondary decays do not blur the properties of the primary splitting. Thus, the staggering in the yields may reflects the persistence of structure effects in strongly deformed system at the scission stage. This is qualitatively supported by the fact that the staggering of the yields seems to follow the staggering of the proton or alpha separation energies.

Experimental results are discussed in the framework of statistical and dynamical models.

Thamer Alharbi (Guildford) **POSTER E2**

Beta-Decay of ^{104,106}Y; the structure of ^{104,106}Zr

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The use of projectile fragmentation reactions has become an effective tool for the population of exotic nuclei. One of its advantages is the relatively high probability to populate isomeric states in exotic nuclei. Facilities such as the GSI laboratory, Darmstadt, Germany use high energy E/A=0.5-1.5 GeV beams to induce such studies.

The nuclei of interest were produced using a projectile-fission fragmentation of a 1 GeV/nucleon ^{238}U impinging on a 2 g/cm^2 ^{9}Be target and an FRS efficiency of 2% at the SIS/FRS facility at GSI laboratory

Darmstadt, Germany. The GSI fragment separator, operated in monochromatic mode, was used to select and separate the nuclei of interest preceding implantation in an active stopper at the final focal plane. The stopper is surrounded by fifteen (HPGe) detectors (RISING array) and used to measure the gamma-rays.

The aim was to use the beta decay of the neutron-rich isotopes ^{104,106}Y to study the level schemes of the even-even nuclei ^{104,106}Zr. The particular focus is to measure the non-yrast structure in ^{104}Zr and to observe levels in ^{106}Zr for the first time. These nuclei are important to measure since this region is one where prolate and oblate minima are predicted to compete.

In the present contribution, experimental details and preliminary results will be given.

Marzena Bakoniak (Katowice) **POSTER I1**

The Monte Carlo calculations of energy spectra of the 6 MV X-ray beams from medical linac

The energy spectra in water phantom for the therapeutic high-energy X-ray beams are not easy to determine because the experimental methods are very difficult to perform whereas the Monte Carlo calculations need the suitable computer power. This fact is evidenced by the lack of extensive data including the energy spectra in water. Even dosimetry protocols do not include such kind of information. Authors present usually X-ray spectra determined in air in the vicinity. However, the spectra in air cannot be generally used to characterize accurately the beam quality in another irradiated medium. The energy spectra for the 6 MV X-ray beam were determined along the beam central-axis in water - a medium recommended by the dosimetry protocols. The spectra were derived using the Monte Carlo method for open and wedged radiation fields of 3cm x 3cm and 10cm x 10cm. The GEANT4 code with the Low Energy models of interactions of photons with matter was applied for the calculations. All calculations were performed under the linux operation system, on computers in the Department of Nuclear Physics and Its Application of Institute of Physics of University of Silesia in Katowice (Poland). The calculations were realized by the computer simulations. The simulation program was verified by the comparison of the calculated depth-dose characteristics in water with those measured with the use of the Markus ionization chamber. The spectra were calculated in the range of the depths up to 27.35cm for SSD=100cm. This work showed that the shapes of the spectra as well as the mean energy Ed of the beam depended strongly on the radiation field size, depth d in water phantom and appearance of the wedge. In the case of the 3cm x 3cm field, Ed increases with the increasing depth d and it ranges from 1.720MeV to 2.192MeV for the open field and from 1.845MeV to 2.276MeV for the wedged field. A decrease of the mean energy is observed for larger radiation fields. In the case of the 10cm x 10cm open field, Ed decreases as the depth increases up to d=6cm (E0.1cm=1.591MeV, E0.1cm/E6.1cm=1.070) and it increases past the depth of d=9cm (E9.1cm=1.488MeV, E9.1cm/E27.35cm=0.921). Analogous dependence appears for the wedged 10 cm x 10 cm field. Ed decreases with the increasing depth up to d=6cm (E0.1cm=1.721MeV, E0.1cm/E6.1cm=1.076) and then Ed increases past the depth of d=9cm (E9.1cm=1.596MeV, E9.1cm/E27.35cm=0.940). Shape of the characteristics of Ed(d) in water are similar for the open as well as the wedged radiation fields. However, the use of the wedge makes energy greater of about 0.1MeV. The detailed knowledge of the energy spectra of therapeutic beams from medical linacs is essential for the calculations of the stopping power ratios or the beam quality correction factors, for dose calculation algorithms in advanced treatment planning, for investigations of treatment machine head design etc.

Mili Biswas (Kolkata) **POSTER E3**

Study of transfer reaction channel produced in the system $^{12}C+^{27}Al$ at 73 MeV

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In recent years, there has been a lot of interest in studying transfer reactions and heavy ion induced reactions provide a wide opportunity for studying various transfer channels. Recently, we have studied one nucleon transfer (proton transfer) in the reaction $^{12}C+^{27}Al$ which ends up with $^{11}B+^{28}Si$ as exit channel. The experiment was carried out at BARC-TIFR 14UD Pelletron Accelerator Laboratory, Mumbai, India using 73 MeV ^{12}C ion beam on ^{27}Al target. The thickness of the self-supporting ^{27}Al target was 545 microgm/cm^2. Emitted fragments have been detected in Si-Si telescope in a wide angular range. The solid angle coverage was 2.26x10-4 sr. The distance of the telescope from the target was 20.9 cm. The well separated ridges corresponding to different fragments are clearly seen in ΔE-E scatter plot. Here, in this paper, the scattering of ^{11}B from different states of ^{28}Si will be presented.

The experimental data have been analyzed with the software LAMPS. The experimental angular distributions of ground state ^{11}B scattered from 0^+ state of ^{28}Si obtained from the reaction ^{12}C on ^{27}Al have been found. The theoretical finite range distorted wave Born-approximation calculations have been done using the code DWUCK5. The required optical model potential parameters were extracted by fitting the elastic angular distribution data for the systems $^{12}C+^{27}Al$ (entrance channel) [1] and $^{11}B+^{28}Si$ (exit channel) [2] respectively using the code ECIS94. Though the theoretical DWBA calculation reproduces the shape of the experimental angular distributions for the ground, first and second excited state very well, still they vary in magnitude. DWBA calculation underpredicts the differential scattering cross sections.

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Debasmita Bondyopadhaya nee Kanjilal (Kolkata) **POSTER E4**

Observation of excited states and isomeric decays in doubly odd $^{208,210}Fr$

As our knowledge of the nuclear chart is extended towards the proton drip line, away from the valley of stability, new experiments become increasingly difficult because of the fact that such heavy proton rich nuclei are created with extremely low cross-section (~ 10 mb or less) & with a very high fission background. Spectroscopic studies of these nuclei provide a big challenge for the experimentalists. The nuclei near the doubly magic ^{208}Pb are predicted to exhibit various interesting structural phenomena, one of which is wealth of isomerism. However, little experimental data are available in Z > 82, N ≤ 126 mass regions till date. Recently a few spectroscopic investigations on the proton rich lighter Francium (Z = 87) isotopes (A= 206 to 209) have been made. Lots of nuclear phenomena from core excitation populated single particle states to the existence of shears band in these extreme proton rich heavy nuclei were observed. Structure of such trans lead nuclei can be interpreted in terms of the shell model states, and the high spin states of these nuclei are interpreted as single particle configurations arising from the ($1h_{9/2}$, $1i_{13/2}$, $2f_{7/2}$) protons and ($3p_{1/2}$, $2f_{5/2}$, $3p_{3/2}$, $1i_{13/2}$) neutrons. One of the major interests in the spectroscopic investigation of these nuclei is the role played by the $i_{13/2}$ state in creating isomeric levels which decay through transitions of higher multipolarity, or are hindered by the close proximity of the levels below. A systematic study of these nuclei will possibly reveal many other interesting structural features.

Although our experiment was aimed at exploring the nuclear structure of ^{208}Fr, the yield of ^{210}Fr (for which almost no published data of nuclear structure exists) at 88 MeV was found to be significant to establish its level scheme. The experiment to produce $^{208,209,210}Fr$ was carried out at the Inter-University Accelerator Centre (IUAC), New Delhi, INDIA, using the Indian National Gamma Array (INGA) of clover detectors at three different beam energies (100, 94 and 88 MeV). Based on the earlier observation of a couple of low lying transitions connecting the 6^+ ground state of ^{210}Fr, and a few strong transitions, the excitation function studies of ^{210}Fr at three different energies are done, and found to be in good agreement with similar studies made from independent offline decay analysis reported earlier. Based on our results, a preliminary level scheme for ^{210}Fr is established for the first time. From our γ $\gamma\Delta T$ correlation analysis, we could find only significant life time of 41.4 ± 2.1 ns of an isomeric transition. Further refinements of analysis, interpretation of the results based on nuclear structure calculations are currently undertaken.

Mouna Bouhelal (Strasbourg/Tebessa) **POSTER E5**

Negative parity states in the P isotopes with N= 15 to 20: a 1ħω shell model description

A wealth of experimental data has been reported recently on the structure of neutron rich nuclei belonging to the sd shell in general and the phosphor chain in particular. In the obtained experimental spectra, there is coexistence, at relatively low excitation energy, of the normal 0ħω positive parity states and the intruder 1ħω negative parity states. It is the aim of our present work to describe both types of states in the shell model framework.

The properties of normal states in sd shell nuclei are well described using the shell model with USD (USDA or USDB) interactions. The intruder states result from the promotion of one nucleon from the p to sd shell or from the sd to pf shell. Up to now there has been no consistent description of these states. To study them, we must enlarge the model space from the 0ħω sd space (^{16}O core) to the full p-sd-pf space allowing one nucleon jump (1ħω space, ^{4}He core). This extension of the valence space requires the development of a new interaction compatible with the new space. The obtained interaction called PSDPF reproduces well both positive and negative parity states in nuclei through the sd shell. There are some discrepancies in the middle of sd due to the large number of valence nucleons. In this case, the wave functions of the intruders are strongly mixed and thus very sensitive to the nature of the 1ħω excitation.

The new PSDPF interaction was used to calculate the energy spectra and electromagnetic properties of the chain of phosphor isotopes with N =15 to 20. Results of these calculations and their comparison with experimental data will be presented and discussed.

Michael Bowry (Guildford) **POSTER E6**

Investigating isomers in heavy neutron-rich nuclei populated in relativistic projectile fragmentation of ^{238}U

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A relativistic, high intensity beam of ^{238}U ions (Energy/Nucleon = 1 GeV) with an intensity of $2x10^9$ ions per 'spill', provided by the SIS synchrotron at the Helmholtz Centre for Heavy Ion Research (GSI , Darmstadt, Germany) was fired at a 1.6 g/cm^2 ^{9}Be target to create radioactive beams of neutron-rich nuclei far from stability. The experiment was performed in October 2009. The aim was to produce a variety of new isotopes of mass number A ~ 200 via the fragmentation of the initial, stable ^{238}U beam upon the target. The GSI Fragment Separator (FRS), operated in achromatic mode, was used to select and identify nuclei of interest preceding implantation in a stopper at the final focal position, whereupon the nuclei are stopped completely. Gamma-ray transitions de-exciting isomeric states were detected with high resolution with the high efficiency RISING array of 15 High-Purity Germanium cluster detectors surrounding the stopper. The technique is sensitive to isomeric decays with half-lives of between 100 nanoseconds and 1 millisecond [1].

Relativistic projectile fragmentation reactions have proved to be a powerful method in populating neutron-rich nuclei. The present study complements previous experiments using a ^{208}Pb beam, which provided a large amount of data regarding several new exotic neutron-rich isotopes[2].

Results from two FRS settings will be presented. Our 'exotic' FRS setting focused on nuclei around ^{200}Os (Z=76) and the data analysis is still ongoing. Interest in this region is driven by the need to test and improve theoretical models, particularly those regarding the ground-state shapes of these heavy nuclei, a variety of which are known to exist with increasing mass and proximity to the N = 126 neutron shell closure. For example, from the observation of excited states in ^{198}Os it was concluded that this nucleus is oblate deformed [3].

Another setting was used to select and transmit nuclei located much closer to stability through the FRS. Information on new isomeric states in three nuclei, ^{195}Au, ^{201}Tl and ^{215}Rn was obtained.

Results on isomeric states in the A~200 region will be presented. The obtained experimental level schemes will be compared with theoretical calculations and systematics.

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Michael Bunce (Guildford) **POSTER E7**

Identifying neutron rich nuclei using projectile fragmentation at GSI

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The work presented in this abstract was carried out at Helmholtz Centre for Heavy Ion Research (GSI, Germany). The beam used to create the isotopes of interest was produced using the SIS-18 synchrotron which delivers the beam particles to the target at an energy of ~1 GeV/u. A high intensity (~2x10^9 particles per spill) primary beam of ^{238}U was incident on a 1.6 g/cm^2 ^{9}Be target producing a radioactive beam of neutron rich nuclei for investigation. The radionuclide of interest is selected via passing the radioactive beam through the fragment separator (FRS). The FRS consists of four large dipole magnets and a number of quadrupole magnets which are used for particle selection and focussing of the beam onto the detectors for investigation. After passing through the FRS the the ions are implanted into a passive stopper. The stopper is surrounded by 15 High Purity Germanium (HPGe) detectors (RISING array) which are used to observe the gamma-rays emitted from the de-exciting isomeric states in the implanted nuclei. The aim of this experiment was to observe a large variety of neutron rich isotopes in the region of A=200. The experimental setting presented is a calibration setting optimised for ^{205}Pb, with nuclei ranging from Rn to Au observed.

One of the central goals of nuclear physics is to understand how nuclear structure evolves and to create accurate theoretical models of the structure of nuclei. For this to occur the models must be tested by surveying the chart of nuclide's to establish their validity. A region of particular interest is nuclide's that lay on or close to closed shells (e.g. N=126). By investigating the neutron rich nuclide's far from beta stability but near a closed shell theoretical models can be tested for these previously unknown nuclei.

The experimental procedures used to create the nuclei of interest and techniques used to identify them are presented with preliminary results shown.

Stefano Carboni (Firenze) **POSTER I1**

FAZIA: a new detector for nuclear physics

For the next generation of nuclear physics experiments it is important to optimize the isotopic resolution of reaction fragments with the lowest possible thresholds. Pulse Shape Analysis techniques coupled to digital signal processing are very useful to this aim.

In the last years the FAZIA collaboration and other groups have investigated the behaviour of silicon detectors for pulse shape applications. It was found that, for stopped ions, the discrimination capability with PSA strongly depends on the homogeneity of the detector resistivity and on a careful control of channeling-related effects.

Previous studies of the FAZIA collaboration demonstrated the importance of using silicon detectors from wafers cut along the so called "random" directions, namely those which make the crystal appear like an amorphous material to impinging particles.

The silicons of the FAZIA telescopes were built adopting such type of cut. Moreover only detectors with doping inhomogeneities of about 1% or better were used. This last selection was done with a laser-based non-destructive method developed by the collaboration, that allows building a map of the resistivity as a function of the position on the silicon.

In the present work the response of eight silicon-silicon-CsI(Tl) and silicon-silicon telescopes with purposely developed high quality silicon detectors has been tested. In particular the silicon detectors were manufactured with stringent requirements for what concerns doping homogeneity, thickness uniformity and crystal orientation, to avoid channeling effects. All these features are obtained by proper choice of the silicon material and cutting geometry, without significantly affecting the cost of the detectors. Custom-developed digital electronics and original digital signal processing techniques have been extensively used.

Beams of ^{84}Kr and ^{129}Xe at 35 AMeV, accelerated by the CS in Laboratori Nazionali del Sud (Catania), impinging on targets of natNi, ^{93}Nb, ^{120}Sn and Au, produced fragments over a large range of charge, mass and energy. The aim was to explore the capabilities of various solutions exploiting the digital techniques of Pulse Shape Analisys (PSA) for the Z and A identification of stopped ions.

The results of the digital PSA technique for identifying stopped ions are very satisfactory: full charge separation is obtained up to the maximum observed Z=54. Partial mass identification until Z=12 has been observed with a higher energy gain in other beam-tests done in Laboratori Nazionali di Legnaro and GANIL.

The ΔE-E (Si-Si) correlations allow isotopic separation up to Z=23-24, not far from the physical limit imposed by the energy straggling, as suggested by simulations.

Natalia Cieplicka (Kraków) POSTER E8

New, high-lying isomers in the proton-particle three-neutron-hole nucleus ^{206}Bi

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The ^{206}Bi nucleus is a one-proton-particle, three-neutron-hole system with respect to the doubly magic ^{208}Pb core. Its low-energy structure arises from 1p-3h couplings involving $1h_{9/2}$, $2f_{7/2}$, and $1i_{13/2}$ proton particles, and $3p_{1/2}$, $2f_{5/2}$, $3p_{3/2}$, and $1i_{13/2}$ neutron holes. The ^{206}Bi ground state, with spin-parity $J^{\pi}=6^{+}$, is of pi $h_{9/2}$ ni $(f_{5/2})$-1 character, with the isomeric ($T_{1/2}$=7.7 mi s) $J^{\pi}=4^{+}$ member of the $\pi\ h_{9/2}\ \nu\ (p_{1/2})^{-1}$ multiplet lying only 60 keV above it. At higher excitation energies, two other isomeric states have been identified in an earlier study with the $^{205}Tl(\alpha,n\gamma)$ reaction[1]. These are the 10^{-} state at 1045 keV with $T_{1/2}$=0.89 ms and an assigned $\pi\ h_{9/2}\ \nu\ (i_{13/2})^{-1}$ configuration, and the 15^{+} excitation at 3147 keV, with a 15.6 ns half-life of $\pi\ h_{9/2}\ \nu(p_{1/2})^{-1}(i_{13/2})^{-2}$ character. The highest yrast states known thus far in 206Bi, i.e., 17^{+} and 18^{+} levels at 3604 and 4305 keV have been located in the $^{205}Tl(\alpha,n\gamma)$ work as well.

An experiment performed recently at Argonne National Laboratory, USA, in which gamma rays emitted during reactions induced by a ^{76}Ge beam on a thick ^{208}Pb target were measured with the Gammasphere array, showed that deep-inelastic processes populate relatively high-spin states in nuclei located "north-west" of ^{208}Pb. One of the intense products was ^{206}Bi.

We analyzed the spectra of delayed gamma rays (emitted between beam bursts separated by ca. 410 ns) by requiring coincidences with the known ^{206}Bi yrast transitions. A series of higher-lying gamma rays, deexciting two previously unknown ^{206}Bi isomers, have been found. Inspection of the double gates set on these newly discovered transitions, allowed us to extend the ^{206}Bi level scheme up to an isomeric level located at approximately 10 MeV.

We have been able to propose spin and parity assignments for the new states, based on their decay pattern and on comparisons with the shell model calculations. The yrast excitations located at energies up to approx. 7 MeV can be described in terms of the 1p-3h couplings. Higher lying yrast states, including the two new isomers, probably involve neutron excitations across the N=126 shell gap. These will be discussed as originating from proton-particle, neutron-particle, and four neutron-hole couplings.

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Margit Csatlós (Debrecen) POSTER E9

High resolution study of fission resonance structure in ^{233}Th

From detailed study of the hyperdeformed states in $^{234,236}U$ isotopes, we obtained new insight into the fission barrier landscape in the actinide region. We observed numerous hyperdeformed rotational bands in $^{234,236}U$ isotopes [1,2] and from the density of the states considerably deeper third minima were deduced than predicted earlier, and these new values are in good agreement with the latest theoretical predictions [3]. In a high resolution experiment Blons et al. identified for the first time rotational bands in the $^{232}Th(n,f)$ reaction [4] and suggested a very shallow third minimum contrary to our experimental findings for uranium isotopes. Moreover, it was also shown that using a triple humped potential barrier with a shallow third minimum and broad transitional states the energy dependence of the cross section can be described [5].

In order to determine the depth of the third minimum also in ^{233}Th we remeasured the fission probability and the angular distribution of the fission fragments in a wider excitation energy range and with better resolution compared to the study of Blons et al. The $^{232}Th(d,pf)$ experiment was performed at the Tandem accelerator of the Maier-Leibnitz Laboratory at Garching with a deuteron beam of E=14 MeV. The energy of the protons was measured with a high resolution Q3D magnetic spectrograph in coincidence with the fission fragments. The position sensitive avalanche fission detectors supplied also precise angular distribution data. The energy and angular resolutions were 6 keV and $\leq 5^{o}$ respectively, during the experiment.

We have observed new resonances in the covered excitation energy region. The average energy difference of the observed resonances is comparable to the ones observed previously for ^{234}U [1] and ^{235}U [2], suggesting much deeper third minimum than the one assumed by Blons earlier.

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Nikit Deshmukh (Baroda) **POSTER E10**

The Breakup threshold anomaly of the ^{6}Li + ^{116}Sn system from the elastic scattering measurements

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In nuclear reactions, the elastic scattering experiments plays a ital role to proide the information of nuclear properties. The study of interacting potentials with tightly bound nuclei as a function of energy, near the Coulomb barrier has been useful to inestigate the Threshold Anomaly (TA) [1,2], where the real and imaginary parts of the potential shows a rapid ariation and is consistent with the dispersion relation [3,4]. Howeer, the scenario changes drastically when the weakly bound nuclei such are inoled. Here the projectile being weakly bound couples to the breakup channels as a result the breakup cross section becomes larger than the fusion cross section at the sub barrier energies [5]. This contradicts to the usual TA and this effect is named as Breakup Threshold Anomaly (BTA) [4]. In BTA, the imaginary part shows the increasing trend with a small reduction in the real part of the potential near the barrier. This is due to a repulsie real polarization potential [6] and opening of the breakup channel near and below the Coulomb barrier.

In the present work we hae also tried to inestigate the BTA by performing elastic scattering experiment below and aboe the Coulomb barrier iz., 20, 21, 22, 23, 24, 26, 30, 35 and 40 Me energy range, using the weakly bound projectile 6Li. The beam was deliered by the 14UD Pelletron accelerator of the TIFR/BARC facility in Mumbai, India. The beam was bombarded on a 450 µg/cm2, self supported enriched ^{116}Sn (≥ 98%) target and the elastically scattered ^{6}Li ions were detected by three solid state silicon surface barrier ΔE + E telescopic arrangements. Two monitor detectors were used for the absolute normalization. The angular distributions were measured in steps of 2.5° to 5° at angles $\theta_{lab} \leq 173°$ for lower energies and $\theta_{lab} \leq 105°$ for higher energies.

Optical model analysis has to be carried out to extract the optical potential parameters and reaction cross sections using two different potential models, namely (i) a phenomenological Woods-Saxon potential (WSP) and (ii) the Sao Paulo double folding potential (SPP). The above mentioned aspects are at the preliminary level and thus will be presented in the Conference.

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Artur Dobrowolski (Lublin) **POSTER T1**

Puzzle of tetrahedrality in ^{156}Gd and ^{156}Dy nuclei

Theoretical predictions indicate that the shell gaps comparable or even stronger than those of the spherical shape may exist in nuclear systems. Group-theoretical analysis supported by realistic mean-field calculations point out that some rare-earth as well as actinide nuclei can be characterized by the tetrahedral T_d symmetry group.

Recently, the problem of existing high rank symmetries in atomic nuclei has become also a big challenge for experimental teams as a possible test of more and more sophisticated facilities.

This work, in fact is tightly connected to the two recent experiments for ^{156}Gd and ^{156}Dy nuclei carried out in the ANL and ILL laboratories. Their results reveal totally opposite behavior of these two isobars with respect to the "tetrahedral scheme".

Using well established GCM+GOA and TDHF microscopic approaches on top of the realistic mean-field spectra we attempt to refer to the results of both these experiments.

Prasad Edayillam (Calicut) **POSTER T2**

Deformation and quasifission

Quasi fission process is a non-compound nucleus process, a major challenge in the formation of super heavy evaporation residues and elements. It is well known that the entrance channel parameters such as mass asymmetry, deformation of the reaction partners, fissility etc, play important role in the dynamics of fusion-fission process. We report the onset of quasi fission process for very asymmetric reaction $^{24}Mg+^{186}W$ forming the composite system ^{210}Rn. The charge product Z_pZ_t is very much less than 1600 in the present study. Comparisons with systems where quasi fission is reported in literature indicates the role of deformation in the dynamics. Mass distribution of different beams on same target hints the possible role of projectile deformation in the case of highly deformed projectiles like ^{24}Mg. Experimental results and observations will be discussed in detail.

Maria Esther Estevez Aguado (Valencia) **POSTER E11**

Study of shape effects in ^{190}Pb using the total absorption technique

The neutron deficient nuclei around Z=82 are of particular interest because of shape effects and shape coexistence [1]. Recent theoretical calculations by P. Sarriguren et al. [2] show that the shape of the ground state of the mother nucleus can be inferred from measurements of the distributions of the B(GT) for masses A = 192, 190, 188, 186, 184. In this contribution we present preliminary results of our study of the beta decay of ^{190}Pb using the Total Absorption Technique at the ISOLDE facility.

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Alexandr Gegechkori (Omsk) **POSTER T3**

Orientation degree of freedom as an essential collective coordinate in fission dynamics

Despite the fact that the orientation degree of freedom (K state), which is the angular moment about the elongation axis, is used in transition state theory to calculate fission fragment angular distribution, it has been omitted in most dynamical studies of fission process except for several recent publications [1-4].

Lestone [1, 4] pointed out that the inclusion of K state is necessary for the correct fission width calculations in both statistical model and Langevin dynamics. Lestone also proposed an overdamped Langevin equation for K coordinate.

It was shown in [5] that both statistical saddle-point and scission-point transition state models fail to describe the large variety of experimental data regarding anisotropies of fission fragment angular distributions. This highlights the necessity of dynamical calculation of the above mentioned quantity and hence the dynamical treatment of the orientation degree of freedom.

We have generalized the Lestone's approach to the case of three shape degrees of freedom introduced on the basis of {c, h, α}-parametrization, thus implementing a four-dimensional dynamical model. Calculations have shown that the inclusion of orientation degree of freedom leads to the increase in the mean fission time and the decrease in the stationary fission rate. The increase in the mean fission time is about 1.5 times for ^{210}Po. This model was also applied to calculate fission fragment angular distributions and anisotropies of angular distributions in several fusion-fission reactions with heavy ions in the wide range of projectile's energy. This calculations have demonstrated that treating the orientation degree of freedom in the framework of Langevin dynamics yields results that are in reasonable agreement with the experimental data. The impact of dynamical model dimensionality on the results of fission fragment angular distributions calculation is also discussed.

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Dmitry Gin (St. Petersburg) **POSTER E12**

Study of the ^{9}Be(α,nγ)^{12}C reaction for the high temperature plasma diagnostic

Reaction ^{9}Be(α,nγ)^{12}C is interesting for the nuclear theory, astrophysics etc. and can be used as the fast neutron source [1, 2]. In present work this reaction is regarded as the basis for the high temperature plasma alpha-particles diagnostic. Alpha-particles are playing key role in ensuring efficient plasma heating in DT fusion and important in many other regimes, so the study of its behavior is needed for the implementation and finding of optimal operation scenarios in large tokamaks. The line shape (LS) measurement and analysis of the Doppler broadened 4.44 MeV gamma line corresponded to the 2^+ ^{12}C level de-excitation allow to obtain spatial and velocity distribution functions (DF) of alpha- particles. Compared to other diagnostics, for example, based on atomic- and mass-spectroscopy methods, this technique gives the opportunity for the most direct DF parameters measurement, especially in the MeV energy range. Calculations of the LS require knowledge of the reaction kinematics. For the reaction study the dedicated series of experiments has been carried out using the Ioffe Institute Cyclotron alpha-particle beam in the energy range of Eα=1.9-6.5 MeV with 0.1-0.5 MeV step. LS measurements were performed with HP Ge detector placed at 0, 15, .. 150 degrees relative to the beam axis. The neutron and gamma angular distributions (AD) also have been measured [1]. Since level's spin is not zero, kinematic and therefore LS calculation cannot be performed using information about only AD but angular correlation function (ACF) data is needed in this case. ACF can be represented in the form of the associated Legendre polynomial superposition with the coefficients (parameters) depending on Ea. Cyclotron measurements together with EXFOR cross-section [2] data were used to find ACF parameters energy dependence. For this purpose the Doppler Monte-Carlo (DMC) (which takes into account angular and energy resolution of the detectors, relativistic and other effects) as well as special parameter set limitation techniques were developed [3]. In September 2009 for the first time 4.44 MeV LS was measured with the HP Ge detector on JET. In these experiments the ion-cyclotron heating of the 4He plasma was used [4]. The reaction kinematic data, which were found in Ioffe Cyclotron experiments with described developed technique, were used to analyze LS measured on JET. In Maxwell approach particles temperature can be roughly estimated as about 150 keV, which is conform to expected value for given experiments. The simulation of the absolute count-rate turns to be in good agreement with the experiment. Suggested technique is under continuous improvement and planned to be used for other reaction and, in perspective, can be regarded as important instrument for gamma diagnostics on ITER.

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Alain Goasduff (Strasbourg) **POSTER T4**

Coexistence of 0ħw and 1ħω excitations at low energy in Ne neutron rich isotopes

Negative parity states in Ne chain are experimentally well known but never described by shell model calculations. In order to explain these states, one must take into account an excitation of odd number particles between two major shells of different parity (in our case: p to sd or sd to pf). Using a new complete 1ħω interaction, recently developed by M.Bouhelal et al.1, we propose a new quantitative interpretation of these states.

We will present the comparison between calculations results on lifetime and electromagnetic transitions using the new interaction and experimental data.

Thomas Gorbinet (Saclay) **POSTER E13**

Study of the spallation of ^{136}Xe in collisions with hydrogen at 1 GeV per nucleon

Spallation reactions allow studying the deexcitation of well defined systems with moderate excitation energy and in particular the possible onset of multifragmentation. The spallation of ^{136}Xe in collisions with hydrogen at 1AGeV has been studied in inverse kinematics with a modified SPALADIN setup at GSI in 2009. Coincidences of residues with low-center-of-mass kinetic energy light charged particles, neutrons and fragments have been measured. Such a coincidence measurement will allow studies as a function of excitation energy and the decomposition of the total reaction cross section into the different possible deexcitation channels, as it has been done for ^{56}Fe + p at 1 GeV per nucleon (E. Le Gentil et al. PRL 100 022701(2008)). Status of the analysis of the experiment will be shown as well as the physics of the measurement, based on the comparisons to different model predictions.

Yannen Jaganathen (GANIL) **POSTER T5**

A unified framework for nuclear structure and reactions within the GSM formalism

A Unified Framework for Nuclear Structure and Reactions within the GSM Formalism.

Ulrika Jakobsson (Jyväskylä) **POSTER E14**

Isomeric states in ^{197,199}At and ^{203,205}Fr

Recently a rotational band has been observed to feed the $13/2^+$ isomer in both ^{197}At and ^{199}At [1]. The evolution of the isomeric state itself when approaching the neutron mid-shell, from becoming yrast in ^{199}At and α-particle decaying in ^{193}At [2], has earlier been studied. Moreover, a spherical $29/2^+$ isomer has been identified to feed the $i_{13/2}$ band in ^{199}At. This high-spin isomer has been observed sporadically throughout the neutron- deficient odd-mass astatine isotopes.

Preliminary results from a recent recoil-decay tagging [7] study reveal decays from iso- meric states detected in ^{203}Fr and ^{205}Fr for the first time. These could present a single-step decay of the intruding $13/2^+$ isomer to the ground state.

The experiments were performed at JYFL using the gas-filled recoil separator RITU [3] together with the Ge-detector array JUROGAM [4,5] and the focal plane spectrometer GREAT [6].

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Grzegorz Jaworski (Warszawa) **POSTER I3**

Optimizing the neutron detection capabilities of NEDA – the NEutron Detector Array for spectroscopy studies

One of the tasks of the SPIRAL2 Preparatory Phase project is to design a new neutron detector system, with the primary aim to improve neutron multiplicity filtering in gamma-ray spectroscopy fusion-evaporation experiments, especially when neutron emission is very rare. The main difficulty in such studies is that one neutron may scatter between two or more detectors in a multi detector system and this can lead to the apparent increase of the number of detected neutrons. As the most exotic, most interesting nuclei are often produced with the emission of two or more neutrons, with very low cross sections, gamma-ray spectra gated by multiple neutrons are usually dominated by events in which neutron multiplicity larger than one was spuriously deduced from interactions of one particle.

Present status of investigations leading to the design of the neutron detector array named NEDA will be shown. The investigations aim at optimizing single detector size, dimensions of the entire array, its granularity, solid angle coverage and timing properties. Possible advantages of using deuterated liquid scintillator instead of standard proton based one are also evaluated. The following three parameters are of utmost importance: i) neutron detection efficiency, ii) quality of the neutron-gamma discrimination, iii) efficient and clean determination of the number of detected neutrons. Application of digital signal processing boards and methods to the analysis of the electronic signals from the neutron detectors are as well studied.

Dragana Jordanov (Belgrade) **POSTER E15**

New method of mesurement of temperature in spallation reaction

In our study of nuclear reaction $^{20}Ne+^{27}A$ at 84AMeV we proposed the new method of temperature measurements at spallation events. We have shown that this temperature can be determined applying the friction model of energy dissipation in participant spectator model of spallation process. The first order estimate of the dependence of temperature of participant zone on reaction Q-value is obtained from Fermi gas model considerations. The heat diffusion process is also discussed.

Kazunari Kaneko (Fukuoka) **POSTER T6**

Puzzling E2 transition and a new island of inversion in the neutron-rich Ti isotopes

We investigate the puzzling behavior [1,2] that for the neutron-rich $^{52\text{-}56}$Ti isotopes the fp-shell model calculations with recent effective interactions reproduce well the first excited 2^+ energies, but are unable to describe the staggering of the $B(E2;2^+\rightarrow0^+)$ values. We will report that this problem can be solved by introducing the $g_{9/2}$ orbital into the fp-shell model space and the fpg shell model calculations [3] reproduce well the measured staggering pattern. It is clarified that the $g_{9/2}$ orbital plays an important role for small B(E2) value in the Ti isotopes around the N=32.

It is also predicted that the excitations from the fp-shell to the $g_{9/2}$ orbital provide the stronger binding energy corresponding to the larger deformation for the Ti isotopes around N=40. In this meeting, we demonstrate that the present calculations suggest a possible indication of a new island of inversion around the ^{62}Ti, which is consistent with the recent experimental data of the enhanced cross sections [4].

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Ryan Kempley (Guildford) POSTER E16

Neutron-rich nuclei in the vicinity of ^{208}Pb studied with the AGATA demonstrator

R. S. Kempley[1], Zs. Podolyák[1], D. Bazzacco[2], A. Gadea[4], E. Farnea[1], J. J. Valiente-Dobon[3],D. Mengoni[2],[5], F. Recchia[2], E. Sahin[3], A. Gottardo[3], L. Corradi[3], E. Fioretto[3], S. Szilner[9],V. Anagnostatou[1], N. Al-Dahan[1], G. De Angelis[3], M. Bellato[2], L. Berti[3], D. Bortolato[2], M. Bowry[1], M. Bunce[1], P. Cocconi[3], A. Colombo[2], Zs. Dombrádi[10], C. Fanin[2] , W. Gelletly[1], R. Isocrate[2], S. Ketenci[7], N. Kohdratiev[9], I. Kuti[10], P.J.R. Mason[1], C. Michelagnoli[3], T. Mijatovic[9], P. Molini[2], G. Montagnioli[2], D. Montanari[2], M. Nakhostin[1], D.R. Napoli[3], D. Pellegrini[2], P.H. Regan[1], G. Rampazzo[2], P. Reiter[6], D. Rosso[3],F. Scarlassara[2], A. Stefanini[3], P. P. Singh[3], N. Toniolo[3], C.A. Ur[2]

and the AGATA Collaboration

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Experimental information on the neutron-rich nuclei in the vicinity (‘south’ and south-east’) of ^{208}Pb is scarce, with information on excited states restricted to a small number of nuclei. An experiment with the aim to obtain information on the shell-model states in nuclei along the N=126 line, as well as in nuclei with N>126, Z<82 was performed in May 2010 at Legnaro, Italy. The experimental information on the structure of these nuclei, such as the energies of excited states with simple configurations, can be used as building blocks for calculating more complex configurations.

One of the main aims of the experiment was to obtain information on the yrast structure of ^{208}Tl. The understanding of the one proton-hole, one neutron-particle ^{208}Tl nucleus is crucial for the whole Z<82 and N>126 region. In the present experiment we expect to identify yrast and possibly close to yrast states involving the high–j orbitals $\pi h^{-1}_{11/2}$, $\nu i_{11/2}$ and $\nu j_{15/2}$. Shell model calculations indicate that the states with $\pi h^{-1}_{11/2}\nu g_{9/2}$ configuration are yrast at ~1.2 MeV, with the $\pi h^{-1}_{11/2}\nu i_{11/2}$ and $\pi h^{-1}_{11/2}\nu j_{15/2}$ configurations forming the yrast line above 2 MeV excitation energy.

The nuclei of interest were populated by impinging a ^{136}Xe beam on a 1 mg/cm^2 thick ^{208}Pb target placed at an angle of 40 degrees with respect to the beam. The beam, provided by the PIAVE+ALPI accelerator complex had an energy of 930 MeV, ~30% above the Coulomb barrier. The gamma rays were detected with the AGATA demonstrator [1,2], positioned at 18.8 cm from the target. Three triple clusters where in operation, with PRISMA placed at 42° with respect to the beam. The beam-like products were identified event-by-event using the PRISMA magnetic spectrometer. Information on the heavy target-like nuclei is obtained by selecting the corresponding beam-like partner with PRISMA. Doppler correction of the gamma spectrum was done on an event by event basis with PRISMA. This method was successfully employed earlier at PRISMA+CLARA in a ^{82}Se+^{170}Er reaction to study the excited states of $^{168,(170)}$Dy [3]. The DANTE heavy ion detector array was also employed, using four of its elements. It has a high solid angle coverage, allowing for improved gamma coincidence statistics.

Ali Ihsan Kilic (Szczecin) POSTER E17

Branching ratio of the d+d reactions in metallic environments at very low energies

A. I. Kilic[1], K. Czerski[1,2], A. Huke[2], P. Heide[2], G. Ruprecht[2], N. Targosz-Ślęczka[1]
1 Institute of Physics, University of Szczecin, Poland
2 Institut fuer Optik und Atomare Physik, Technische Universitaet Berlin, Germany

Our recent investigations of the mirror reactions $^{2}H(d,n)^{3}He$ and $^{2}H(d,p)^{3}H$ in the energy range 5 keV – 60 keV applying different self-implanted deuterized metallic targets show that the neutron-to-proton branching ratio and the corresponding angular distributions depend on the target material. Experimental results obtained for the transition metals Zr, Pd, Ta and Al do not differ from those known from gas-target experiments. For the (earth) alkaline metals Li, Sr and Na at deuteron energies below 20 keV an enhancement of the angular anisotropy in the neutron channel and a quenching of the neutron-to-proton branching ratio by about 20% have been observed. This effect can be explained by an induced polarization of the reacting deuterons within the crystal lattice, which could be simulated by changing of the individual transition matrix elements within both R-matrix and DWBA calculations. The reasons for the deuteron polarization in metallic environment remains, however, still unknown.

Mariola Kłusek-Gawenda (Kraków) POSTER T7

Exclusive production of $\rho^0\rho^0$ and $\mu^+ \mu^-$ pairs in ultrarelativistic heavy ion collisions

Heavy ion is a source for high-energy gamma gamma collisions. I will present realistic cross section for exclusive electromagnetic production of two neutral ρ mesons and two charge $\mu^+ + \mu^-$ leptons in coherent photon-photon processes in ultrarelativistic heavy-ion collisions. I will consider ($AA \to AA\ \rho^0\rho^0$) and ($AA \to AA\ \mu^+ \mu^-$) reactions for Au-Au and Pb-Pb collisions. In addition, to illustrate the sensitivity of calculations on detail of the form factor, I will compare results with realistic charge density with results for monopole form factor. I will show that inclusion of precise charge densities in nuclei is essential in realistic evaluating the nuclear gamma-gamma cross sections. The cross section is calculated by means of two methods: in the equivalent photon approximation and in momentum space.

In the first method, we include vector-dominance-model (VDM)-Regge contribution which becomes important at large gamma-gamma energy.

We will present the predictions for collaboration: PHENIX, STAR (at RHIC) and CMS, ALICE (at LHC).

Michał Kowal (Warszawa) POSTER T8

Low-energy shape oscillations of negative parity around the main and shape-isomeric minima in actinides

We study low-energy shape oscillations of negative parity in the first and second (isomeric) minima in actinides. As a main tool we use the phenomenological Woods-Saxon potential with a variety of shape deformations. This allows to include a mixing of various multipolarities when considering oscillations with a fixed K quantum number. The phonon energies are determined either from the collective Hamiltonian with the microscopic-macrocopic energy and cranking mass parameters, or from the simplified version of it with the constant mass parameters.

The results for the first minima are in a reasonable agreement with experimental data, including predicted E1 transitions. As compared to the data in the second minimum of ^{240}Pu, our K=1,2 energies are slightly overestimated while the K=0 energy is two times too large. This might signal a serious flaw of the model in the second minimum, but more data on the K=0 phonon are needed to decide if this is so.

Asli Kusoglu (Istanbul) POSTER T9

The effect of valence neutrons on spin-orbit splitting

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The contribution of the spin-orbit interaction to the mean nuclear potential and the evolution of the energy gaps of closed shells with increasing valence nucleon number and isospin are systematically investigated. Effective single particle energies for the isotopic chains of some even-even closed shell nuclei are calculated. The effective single-particle energies are obtained by Hartree-Fock method utilizing a harmonic oscillator potential. The microscopic effective nucleon-nucleon interaction is assumed as zero-range, central Skyrme type effective force. Z=8, 20, 28 and 50 magic proton nuclei of stability valley and their even-even neighbours are selected and a limited systematic investigation is performed for the isotopic chains of C, O, Si, Ca, Ni, Sr, Sn, Te, and Ce isotopes. The modification of proton spin-orbit partners' energy splitting of those isotopes is investigated with valance neutron numbers extending to the neutron drip-line. The effect of neutron diffuseness, monopole tensor interaction and core polarization on the modification of spin-orbit partners' energy spacing is discussed. The effect of increased valance neutron number on proton effective single particle levels is deduced. The calculated spin-orbit splittings are compared with the available experimental closed-shell energy gaps.

Dorothée Lebhertz (GANIL) **POSTER I4**

Performances of the future multidetector PARIS illustrated on the radiative capture physics case

Exotic compound nuclei at high excitation energy and/or angular momentum de-excite with gamma-ray of high multiplicity in a range of energy between 1 and 50 MeV. This complex gamma-decay is a sensitive probe for the study of collective phenomena and their evolution with temperature and rotation. In order to study such kind of radiation we have to optimize efficiency and resolution. Taking advantage of the recently developed $LaBr_3$ scintillators both characteristic will be obtained. The mutidtetector PARIS [1,2], one of the future SPIRAL2 detectors, will be composed of ~200 modules of pure crystals of $LaBr_3$ or crystals of $LaBr_3$ coupled in a phoswich mode with NaI or CsI scintillators. It will be dedicated to the study of the gamma-radiation of hot nuclei.

An example of the power of PARIS can be illustrated on the radiative capture physics case. The radiative capture, i.e. the complete fusion of projectile and target, cooling only by gamma emission, could be the ideal mechanism to highlight ^{12}C-^{12}C or ^{12}C-^{16}O cluster states predicted by numerous theoretical calculations. The radiative capture process is able to probe, at the same time, the overlap between the entrance channel and states of the composite system and the overlap of these same states with the bound or quasi-bound states. This property can be used to look for the gamma-link between the high deformed cluster bands.

Due to a high Coulomb barrier and a large Q-value the heavy ion radiative capture is a rare process. Nevertheless we measured the full gamma spectrum of the radiative capture using the state of the art 0° spetrometer Dragon and its associated BGO gamma array at Triumf (Vancouver). The data obtained show an important feeding (>50% of the flux) of the doorway states around 10-11 MeV in ^{24}Mg and ^{28}Si [3,4]. A non statistical behavior was found since a single spin in the entrance channel is the best conditions to reproduce the data. Unfortunately the resolution of the BGO array does not allow us to extract the exact number and nature of the intermediate states involved. To be able to conclude, for instance about a cluster behavior, we need to use a gamma spectrometer with higher efficiency and better resolution for gamma-rays between 1 and 25 MeV. These two requests will be fulfilled by the future detector PARIS.

We will first make a short status on the PARIS project, present general performances for a complete array of 200 modules of $LaBr_3$ based on GEANT4 simulations and show the promising results with this multidetector for the radiative capture physics case. In order to get a complete overview of the PARIS possibility we will also present results of simulation for other PARIS physics cases involving large multiplicity in gamma-decay.

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Tomasz Malkiewicz (Grenoble) **POSTER E18**

Recent results of prompt and delayed gamma-ray and conversion-electrons spectroscopy of neutron-rich lanthanide nuclei

The neutron-rich N=93 isotones, ^{155}Sm and ^{153}Nd, have been studied by delayed gamma-ray and conversion-electron spectroscopy at the Lohengrin mass spectrometer of the Institut Laue-Langevin, Grenoble.

A half-life of 2.9(5) microseconds has been measured for the $5/2^+[642]$ state at 16.5 keV in ^{155}Sm.

The decay of a 1.17(7)-microsecond isomer in ^{153}Nd, at 191.7 keV, has been remeasured and its spin has been reassigned as $5/2^+$. This state contains a strong component of the neutron $5/2^+[642]$ Nilsson orbital.

In addition, a new 1.00(8)-microsecond isomeric state at 538.6 keV, with a probable neutron $11/2^-[505]$ Nilsson configuration, has been observed in ^{155}Sm. Triple gamma-ray coincidence data, from the spontaneous fission of a ^{252}Cf source placed inside the GAMMASPHERE array, were used to extend the collective band on top of the $(5/2^+)$ isomeric state of ^{153}Nd and a new band, with the same band head spin has been observed in ^{151}Ce. The observation of this new band and an additional new transition in the ground state band has led us to change the ground state spin of ^{151}Ce to $(3/2^-)$. Quasiparticle-Rotor-Model calculations successfully reproduce the majority of the features of the gamma decays of these nuclei, including branching ratios and isomeric half-lives. As this model uses a reflection-symmetric core we conclude that the polarizing effect of the odd particle is responsible for the dipole moment present in the $5/2^+[642]$ states of the three nuclei studied and the $11/2^-[505]$ level of ^{155}Sm.

A review of new and existing data in the A=150 region will also be presented.

Enrique Minaya Ramírez (GSI) **POSTER E19**

Direct mass measurements above uranium

For the SHIPTRAP Collaboration

The masses of the nuclides ^{255}No and $^{255-256}$Lr have been measured with high accuracy using the Penning trap mass spectrometer SHIPTRAP at GSI Darmstadt. The radionuclides were produced in fusion-evaporation reactions and separated by the velocity-filter SHIP from the primary beam. Lawrencium 256 is the nuclide with the lowest yield measured with a Penning trap. Moreover, until now, the two Lawrencium masses were only estimated from the extrapolation of systematic trends of the Atomic Mass Evaluation (AME2003). These new results represent a further step towards the exploration of the Island of stability. These investigation continue our pioneering experiments started in 2008 at SHIPTRAP with the first direct mass measurements of three nobelium isotopes $^{252-254}$No. In addition, during this last experiment, the uncertainty of ^{252}No and ^{254}No masses was further improved. The future objective of this study is to measure nuclides in the region of Z = 104-105 in order to fix the endpoints of α-decay chains starting from superheavy nuclei in the vicinity of the predicted island of stability. Furthermore, the knowledge of nuclear masses enables the direct determination of the binding energy of the nucleus. This quantity allows exploring the shell structure and consequently it is another way to determine the stability of a nucleus.

Hamidreza Moshfegh (Tehran) **POSTER T10**

Critical behaviour of baryonic matter

The Equation of state (EOS) of dense baryonic matter plays an important role in study of Nuclear physics. On the basis of Thomas-Fermi approximation as a semi-classical mean-field method, the EOS at finite temperature for different structures of baryonic matter such as symmetric and asymmetric nuclear matter, pure neutron matter and beta stable matter are determined by using extended phenomenological nucleon-nucleon interaction of Seyler and Blanchard, presented by Myers and Swiatecki.

By a functional variation an explicit form of distribution function has been derived. In our statistical approach, the thermal properties of these dense structures are studied. The quantities such as free energy, energy, entropy, specific heat capacity, incompressibility and the pressure which is known to be the EOS are calculated as the functionals of the distribution function for given temperature and density. Special attention is also payed to the investigation of critical behavior of these systems. As a result, the critical temperature and critical exponent of symmetric nuclear matter are found while there is no phase transition in the pure neutron matter and beta stable matter. Our results are in good agreement with experimental predictions and other theoretical investigations.

Mohamad Moukaddam (Strasbourg) **POSTER E20**

Search for the neutron $d_{5/2}$ level in neutron-rich nuclei

The position the neutron $2d_{5/2}$ orbital is a crucial benchmark for calculations in the N=40 region using large valence neutron space. In order to improve their predictive power, these calculation models must be constrained using experimental data giving the precise position of this level. Therefore the transfer reaction ^{68}Ni(d,p)^{69}Ni, feeding this level, was produced and measured in inverse kinematics at GANIL. The beam of radioactive ^{68}Ni, delivered on a thin CD_2 target, was produced at 25.16 MeV per nucleon in the LISE spectrometer.

The experimental setup consisted of two beam tracking CATS detectors enabling the reconstruction of the position of the reaction's location on target, four MUST2 telescopes identifying protons at backward angles and giving their energies and positions, and a plastic detector coupled to an ionization chamber in order to identify the ^{69}Ni downstream. Preliminary results of analysis are shown.

Farheen Naqvi (Köln/GSI) POSTER I5

Development of Slowed Down Beams at GSI/FAIR

Farheen Naqvi [1,2] , Plamen Boutachkov [1], Magdalena Górska [1] , Jürgen Gerl [1], Fabio Farinon [1], Katarzyna Hadynska [3], Rudo Janik [4], Ivan Kojouharov [1], Nikolay A. Kondratyev [5], Alvarez Marcos A.G. [6], Ivan Mukha [7], Pawel Napiorkowski [3], Chiara Nociforo [1], Daniel Pietak [3], Wawrzyniec Prokopowicz [1], Stephane Pietri [1], Andrej Prochazka [1], Henning Schaffner [1], Peter Strmen [4], and Helmut Weick [1]

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The slowed down beam facility at GSI/FAIR will be dedicated to spectroscopy and reaction studies at energies in the range of 5-10MeV/u .The relativistic beams separated by the FRS/SFRS [1] will be decelerated using a thick degrader. This method is aimed to study short lived nuclei, difficult to access in other facilities worldwide.

The slowing down of relativistic particles introduces beam contamination, energy and angular straggling making it necessary to identify and track the ions after slowing down. Large area detectors with a position resolution of a few mm and a timing resolution of ~ 100ps are required for this purpose.

A test experiment of the technique and prototype detectors was performed at the GSI/FRS. Primary beam of ^{64}Ni with energy of 300MeV/u was slowed down to 10MeV/u, using a thick Al degrader. The beam was tracked before slowing down with a pair of TPC detectors. For identification and reconstruction of the trajectory after slowing down , two MCP detectors were used.

Coulomb scattering of slowed down ^{64}Ni ions on a gold target was investigated to test the experimental setup.The Au target was surrounded by two Double Sided Silicon Strip detectors and an array of 6 NaI scintillators for gamma-ray detection. The results from the test experiment will be presented.

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Mehdi Nasri Nasrabadi (Isfahan) POSTER I6

Shielding design for an Am-Be neutron source considering different sites to achieve maximum thermal and fast neutron flux using MCNPX code

This study investigates shielding design of an isotropic ^{241}Am-^{9}Be neutron source using Monte Carlo Code MCNPX. Typical Am-Be neutron sources emit neutrons with a broad spectrum. Different materials were studied in terms of both moderating power of first layer and absorbing ability of the second one. This arrangement is consistent with safety requirements, cost limitations and material availability. After optimizing the moderator thickness by MCNP code, different materials for attenuating neutrons, most of which were thermal because of moderating, were examined. Then moderator was fixed and the best shield configuration was chosen to minimize equivalent dose outside the shield. For this purpose, MCNPX flux to dose conversion factor was used. Finally, proper sites were determined in order to achieve maximum thermal, epithermal and fast neutron flux. This configuration enables us to use neutron flux of sites with different energy ranges for irradiating samples without exposing personnel to radiation.

Bożena Nerlo-Pomorska (Lublin) **POSTER T11**

Rotational bands in Fm isotopes within LSD and Yukawa-folded models

The potential energies of heavy and superheavy even-even nuclei were evaluated within the macroscopic-microscopic method using the LSD macroscopic model [1] and the Yukawa-folded mean field potential [2]. The Strutinsky shell correction method [3] and the BCS pairing theory [4] was used to determine the ground state deformation of rotating nuclei. The cranking model [5] was used to evaluate the moments of inertia. The calculations were performed for even-even Fermi isotopes and heavier nuclei using the modified Funny Hills deformation parameters set [6]. The binding energies, the quadrupole moments and rotational energies of the lowest states evaluated in the equilibrium deformation agree well with the experimental data. The energies of the ground state rotational bands are predicted for all investigated nuclei.

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Paivi Nieminen (Jyväskylä) **POSTER I7**

Characterising isomeric states - complementary instrumentation

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Characterisation of isomeric nuclear states requires detailed knowledge on their de-excitation paths, as well as on level structures built on these states. The present contribution introduces complementary aspects of two sets of instrumentation, across the globe, to examine isomeric states in heavy nuclei.

At the Heavy-Ion Accelerator Laboratory of the Australian National University (ANU), a new spectrometer module, SOLENOGAM [1], is being developed for the focal plane of a compact 6.5-Tesla superconducting solenoidal fusion product separator SOLITAIRE [2,3], designed for reaction studies. Gamma rays and internal conversion electrons de-exciting isomeric states are measured with arrays of Ge/LEPS and Si(Li) detectors in close geometry, and selected by time-correlation techniques facilitated by flexible beam pulsing. The efficiency and selectivity in detecting gamma rays and conversion electrons populating these isomeric states can be provided by the versatile detector arrays combined with the recoil separator RITU [4], at the Accelerator Laboratory of the University of Jyväskylä (JYFL), Finland.

The two instrumentations will be discussed in terms of selectivity, efficiency and sensitivity for radiation emitted in intervals of time. The first physics focus for the SOLENOGAM device is shape coexistence in the neutron-deficient lead region [5], an interest strongly shared with the JYFL research programme.

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Vivek Parkar (Huelva) **POSTER I7**

Fusion of ^{9}Be with ^{124}Sn

The complete and incomplete fusion cross-sections for ^{9}Be+^{124}Sn system have been deduced from the online gamma ray measurement technique, as all major evaporation residues formed in this reaction are stable. Two clover detectors were used, one at 125 deg. for absolute fusion cross-section estimation and other at 90 deg (No Doppler shift) for identification of unshifted gamma lines. Along with this two charge particle telescopes and one monitor detector were placed at 65, 160 and 30 deg, respectively. The data have been acquired in the particle-gamma ‘OR’ condition. The coincidence between 55 deg clover detector and particle telescopes (TAC1, TAC2) was also recorded in ADC. These TAC spectra have been further utilized for putting the gates in the gamma spectra and identification of gamma lines of the residues from incomplete fusion process.

The measured cross-sections have been compared with the one dimensional barrier penetration model and coupled channel calculations. The barrier distribution have also been extracted from the measured data and compared with the theoretical calculations. The extracted complete fusion cross-sections showed a suppression of ~ 28 % compared to the coupled channel calculations. The projectile dependence for fusion on ^{124}Sn target has also been studied and found that for ^{9}Be nuclei the enhancement at below barrier energies is substantial compared to that of tightly bound nuclei.

Dieter Pauwels (Leuven) **POSTER I7**

Beta-decay studies of neutron-rich manganese isotopes

The region south of ^{68}Ni (Z=28, N=40) is of particular interest due to an observed onset of deformation in the cobalt [1], iron [2] and chromium [3,4] isotopes. The shape-driving orbitals in this region are believed to be $1g_{9/2}$ and $2d_{5/2}$. The tensor interaction [5] between neutrons in the latter orbitals and protons in the $1f_{7/2}$ orbital further enhances collectivity with decreasing proton number. Shell-model calculations in the proton($f_{7/2}$, $p_{3/2}$, $f_{5/2}$, $p_{1/2}$) and neutron($p_{3/2}$, $f_{5/2}$, $p_{1/2}$, $g_{9/2}$) model space are on the verge of explaining the observed nuclear structure. This work will report on a beta-decay study of the neutron-rich $^{58,60-68}$Mn isotopes. The isotopes were produced at the ISOLDE facility (CERN, Geneva, Switzerland) in a proton-induced fission of ^{238}U and selected using resonant laser ionization combined with mass separation.

Spectra and decay schemes will be shown and the latest results will be presented. The detailed level schemes of both the Fe daughter and Co grand-daughter isotopes will constitute an important benchmark for establishing proper effective interactions in the ^{68}Ni region.

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Pauli Peura (Jyäskylä) **POSTER E23**

Recoil decay tagging studies of ^{173}Pt, ^{175}Pt

The very neutron deficient region near the Z = 82 proton shell closure has been actively studied for many years. Nuclei in this region are well known to exhibit characteristics typically associated with shape coexistence. Studying odd-mass nuclei sheds light on the single-quasiparticle orbitals present near the Fermi surface. Two nuclei, ^{173}Pt and ^{175}Pt, have not been studied extensively before mainly due to the difficulties with clean correlations in recoil decay tagging (RDT) measurements. Problems arise from many possible particle evaporation channels and alpha-decay branching ratios accompanied by long alpha-decay half-lies.

Two separate measurements have been performed at JYFL using a ^{86}Sr beam to bombard thin self-supporting ^{92}Mo targets. The first of these measurement was a RDT measurement, while the latter was a differential plunger life-time measurement.

In this work the previously observed yrast bands for ^{173}Pt and ^{175}Pt have been confirmed. For ^{175}Pt additional non-yrast structures have been discovered and the $13/2^+$ band head of ^{173}Pt was found to be isomeric. The ground state of these nuclei have shown evidence of alpha-decay fine structure

Daniel A. Piętak (Warszawa) **POSTER I8**

An application of genetic algorithm to the COULEX data analysis

A multidimensional optimisation is a technique used in many problems of physics and constitutes challengers for numerical methods of computer science. As an example the development of a new genetic algorithm designed for the data analysis in the Coulomb excitation experiments will be presented. Calculations performed with a multidimensional test function identified the weakness of standard operators of a real representation implemented to the genetic algorithm. The corrections to the algorithm were proposed and the method was tested on a real case data. A probabilistic theory and graph theory were applied to establish a new method of a multidimensional surface investigation close to the optimum. New features as statistical analysis of chi square surface sampling will be demonstrated to determine the quality of a fit as well as an experimental uncertainty of the result.

A successful implementation to the data analysis of Coulomb execution of ^{100}Mo will be presented and possible further application of the method will be discussed.

Mustafa Rajabali (Leuven) **POSTER I9**

The CRIS beam line at ISOLDE and associated spectroscopy station

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A new experimental station is currently under construction at ISOLDE. It will use the technique of Collinear Resonant Ionization Spectroscopy (CRIS) for the study of very rare isotopes. Additionally, this method is an effective way to remove virtually all isobaric contamination. This is possible due to the high selectivity afforded by resonance ionization spectroscopy, which can even separate nuclear isomeric-states from the ground state. The Ultra-High Vacuum (UHV) condition (10^{-10} Torr) enhances the effect of resonance ionization by suppressing collisional ionization of the ions with the residual gas. The installation of the new ion cooler and buncher (ISCOOL) at ISOLDE and the production of bunched ion beams is essential for the CRIS technique. By bunching the ion beam, it is possible to remove any losses associated with the duty cycle of the pulsed lasers. The pure beams will arrive at a spectroscopy station, which consists of a rotating wheel implantation system for alpha and beta decay spectroscopy with high purity Ge detectors around the implantation sight for gamma-ray detection. One of the main challenges in designing such a spectroscopy station is to cater for the UHV conditions. The CRIS beam line and its spectroscopy station will be described in this contribution.

Łukasz Standyło (Warszawa) POSTER E24

Elastic scattering of the halo nucleus ^{6}He from ^{206}Pb below the Coulomb barrier

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The elastic scattering of ^{6}He nuclei from ^{206}Pb target has been measured at energy of 18MeV, what is below the Coulomb barrier ~ 20 MeV. This is a part of a study dedicated to exotic nuclei interaction with atomic nuclei at sub-barrier energies. The measurement was performed at the Cyclotron Research Centre in Louain-la-Neue, employing LEDA (Louain Edinburgh Detectors Array) and LAMP detection systems. The interest of measuring elastic scattering of ^{6}He arises because of specific properties of this nucleus: a weak bounding and the three-body n+n+α structure with an extended neutron distribution, which significantly affect the dynamics of the collision.

Apart from the elastically scattered ^{6}He a large bump corresponding to α - particles produced by $^{6}He \rightarrow \alpha + 2n$ breakup and 1n and 2n transfer reactions was observed, especially at the backward angles region. Optical Model calculations have been done using the double-folding potential derived from the both densities of the colliding nuclei and the parametrized dynamic polarization potential which simulates the effects of channel couplings. The calculations confirm the long range nature of this polarization potential.

Iulian Stefan (Orsay) POSTER E25

Deep-inelastic reactions at untypical energies

The availability in the future of the LINAG accelerator at GANIL will offer a unique opportunity of high intensity stable ions beams that could be used to produce neutron rich nuclei in multi-nucleon transfer and deep inelastic reactions. At the energies available from LINAG, the production of exotic nuclei selected at 0° with respect to the beam direction from this type of reactions is poorly known.

To shed a light on this topic an experiment was performed recently at GANIL using VAMOS and EXOGAM spectrometers to measure the production of neutron-rich nuclei produced with a 10 MeV/A 48Ca beam impinging a 0.1 mg/cm2 thin ^{238}U target. VAMOS allowed the selection and identification of the beam like ejectils and EXOGAM, in coincidence with VAMOS, gives spectroscopic information about the nuclei produced. We performed measurements at different values for the VAMOS magnetic rigidity and angle, 0° included, allowing a full overview of the exotic species produced. The energy in the centre of mass for the reactions is 1.7 times the coulomb barrier. Considering that the typical energy in the centre of mass used in "deep-inelastic" experiments is around 1.1 times the Coulomb barrier, our experimental cross-sections can be directly compared with well-known results from deep-inelastic experiments at grazing angle. The preliminary results will be presented.

Jerzy Szerpo (München) **POSTER I10**

Target Laboratory at the University of Munich (LMU)

In the LMU Target Laboratory both stable and radioactie targets can be produced. Production methods involve rolling (both in air and in Ar-atmosphere), chemical vapour deposition (CD) and sputtering. This contribution will present the existing equipment and the scope of accessible targets.

Tayebeh Taherkhani (Tehran) **POSTER I11**

Simulation of dose distribution in electron irradiation system in water phantom using MCNP code

Rhodotron type electron accelerator has been used for radiation processing. In this work using the MCNP code and with regard to the real geometry system radiation dose distribution in scanning and conveyor direction for electron and x-ray with energy 2 MeV calculated and compared with experimental results. The performances of the industrial electron beams processing, with 5 and 10 MeV energies, investigated by measuring two- dimensional dose distribution in electron beam profile. In addition, the mentioned measurements are also performed for x-ray (Bremsstrahlung) beam that were converted by interaction of electron with a high power x-ray target. The obtained results clearly show that the electron beam emerging out from scanning horn has a good uniformity along the electron beam profile. As well, results of the measurements show good agreement with MCNP code.

Keyword: Electron beam; X-ray converter; Dose distribution; Electron accelerator

Aurélie Vancraeyenest (Lyon) **POSTER E26**

Search for feeding transitions of isomeric states in ^{138}Nd, ^{139}Nd and ^{140}Nd

Nuclei around N=82 closure shell are a fertile field of investigation to establish quasiparticule configurations and to test nuclear potential who predict high spin isomers in those nuclei. In this way, an experiment was performed in August 2009 at Jyväskylä laboratory to investigate these predicted high spin isomers in Nd nuclei.

We use a ^{48}Ca+^{96}Zr fusion-evaporation reaction to populate medium spin states. Experimental setup involved JUROGAM II germanium array around the target for a high efficiency detection of prompt gamma rays. Then the residual nuclei were transported by the RITU separator in few hundred of nanoseconds to the focal plane where the GREAT detector array was used to detect gamma rays issued from isomer decay.

Our first work on time spectra permit us to measure lifetime of four isomers, three of which stand in Nd isotopes considered in this work. The high quality data we obtained allows the measurement of these lifetime with high precision. The off-line analysis is still in progress and the prompt-delayed coincidences enable us to observe new feeding transitions in different isomers and to construct the level scheme above isomers.

Marzena Wolińska-Cichocka (Oak Ridge) POSTER I12

New Modular Total Absorption Spectrometer at the HRIBF (ORNL, Oak Ridge)*

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A new detector, the Modular Total Absorption Spectrometer (MTAS) is under construction at the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory. This detector is designed to efficiently measure the gamma radiation emitted in the decay of radioactive nuclei. The studies of beta-gamma strength pattern including so called “decay heat” released in the decay of fission products occurring in the nuclear fuels [1] are among the goals of the project. Neutron-rich nuclei produced in the proton-induced fission of ^{238}U at the HRIBF will be studied with MTAS using the ranging-out method [2,3]. These measurements of true beta-strength distribution will help develop the microscopic description of neutron-rich matter.

The detector array consists of 19 NaI(Tl) hexagonal shape blocks, each 21" long and 6.92" measured face to face. The modular design of MTAS enables the construction of a detector with a very large active volume. The housing of the individual modules is kept at the minimum (~0.8 mm carbon fiber) to reduce gamma absorption effects. The photo-peak efficiency is expected to reach nearly 90% around 300 keV and over 75% for a 5 MeV single gamma transition [4].

The details of the design and the results of first tests of individual MTAS modules will be presented.

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