UNIVERSITÀ DEGLI STUDI DI MILANO

INFN Istituto Nazionale di Fisica Nucleare

Ist Topical Workshop on Modern Aspects in Nuclear Structure

Advances in Nuclear Structure with arrays including new scintillator detectors

BORMIO 22 - 25 February 2012

http://www.mi.infn.it/WSBormio-Milano2012/

Book of Abstracts

Wednesday 22nd February: Morning Sessions

CHAIRMAN: F. AZAIEZ (IPN-Orsay)

9:00-9.30 **T. Motobayashi** (RIKEN, Japan)
Spectroscopic studies with NaI(Tl) scintillator arrays DALI/DALI2 using fast RI beams at RIKEN

9:30-10.00 **D. Vretenar** (University of Zagreb)
Exotic modes of excitations in nuclei far from stability

10:00-10.25 **S. Siem** (University of Oslo)
Level Density and gamma Strength with the OSLO method

10:25-10.40 **B. Loher*** (EMMI/GSI)
Photon induced γ-γ coincidence experiments to study the decay pattern of low spin states at the γ³-setup at HIγS

10:40-10.55 **X. Roca-Maza*** (INFN-Milano)
Pygmy dipole resonances in stable and unstable nuclei

CHAIRMAN: A. MAJ (IFJ PAN, Krakow)

11:20-11.45 **D. Jenkins** (University of York)
The PARIS Project

11:45-12:10 **M. Kmiecik** (IFJ PAN, Krakow)
Search for Jacobi transitions, status and perspectives (PARIS and SPIRAL2)

12:10-12:25 **M. Ciemala*** (IFJ PAN, Krakow)
Monte-Carlo CASCADE based event generator of fusion-evaporation reactions for GEANT4 software

12:25-12:40 **K. Mazurek*** (IFJ PAN, Krakow)
Influence of the potential energy landscape on the fission dynamics

Spectroscopic studies with NaI(Tl) scintillator arrays DALI/DALI2 using fast RI beams at RIKEN

Tohru Motobayashi

(RIKEN Nishina Center)

Since early 1990s, fast RI beams have been provided at RIKEN with projectile fragmentation of (mostly light) heavy ions as their production mechanism. A scintillator array named DALI (Detector Array for Low Intensity radiation) was designed and constructed for measuring gamma-rays from excited states created by direct reactions in inverse kinematics. It has a high detection efficiency and capability of emission-angle measurements, which can deal with low-intensity RI beams and large Doppler-shift caused by fast-moving gamma emitters. The first experiment wit DALI was for measuring B(E2) for the 0+ to 2+ transition in 32Mg using the intermediate-energy Coulomb excitation. DALI2 was designed as an extension of DALI to cope with faster beams from the RIBF (RIKEN RI Beam Factory) new facility. Several experimental studies with the two scintillator arrays will be presented.

Exotic modes of excitations in nuclei far from stability

Dario Vretenar

University of Zagreb

The multipole response of unstable nuclei and the possible occurrence of new exotic modes of excitation in weakly bound nuclear systems present a rapidly growing field of research. Valuable data on the evolution of the low-energy dipole response in unstable neutron-rich nuclei have been gathered in recent experiments, but the available information is not sufficient to completely determine the nature of observed excitations. We review recent theoretical studies of the evolution of low-energy monopole and dipole modes from stable nuclei to systems near the particle emission threshold, as well as charge-exchange modes and their evolution in neutron-rich nuclei.

Photon induced γ-γ coincidence experiments to study the decay pattern of low spin states at the γ³-setup at HIγS*

B. Löher[1,2], T.Aumann[5], N.Cooper[6], V.Derya[3], J.Endres[3], E.Fiori[1,2], J.Kelley[4], N.Pietralla[5], R.Raut[4], G.Rusev[4], D.Savran[1,2], A.Tonchev[4], W.Tornow[4], V.Werner[6] and A.Zilges[3]

[1]*ExtreMe Matter Institute EMMI and Research Division, GSI Helmholtzzentrum, Darmstadt, Germany*

[2]*Frankfurt Institute for Advanced Studies FIAS, Frankfurt*

[3]*Institut für Kernphysik, Universität zu Köln, Köln*

[4]*Department of Physics, Duke University, Durham, USA*

[5]*Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt*

[6]*WNSL, Yale University, USA*

Photon induced nuclear reactions are a commonly used tool in nuclear structure physics to investigate low spin states below the particle separation thresholds, e.g. the pygmy dipole resonance or the scissors mode. This method utilizes the nuclear resonance fluorescence (NRF) reaction, where the nucleus is excited via photo absorption and de-excites via photon emission. The low momentum transfer in the photo absorption process leads to an almost exclusive population of dipole states, i.e. $J=1^{\pm}$ states in even-even nuclei.

The precise knowledge of the decay pattern of these states, besides information about spin, parity and transition probabilities, is of great importance for benchmarking nuclear structure models. Measurements up to now were in most cases restricted to the investigation of the decay channel back to the ground state of the nucleus. For the complete understanding of the decay pattern, also the transitions to excited states (inelastic transitions) have to be investigated. The amount of low-energy background stemming from atomic interactions and the fact that the branching ratio for these inelastic transitions is on the order of a few percent makes it impossible to properly investigate their properties in single γ-ray spectroscopy.

To increase the sensitivity for observing these transitions and to enable the analysis of the corresponding branching ratios, γ-γ coincidence measurements have to be performed, i.e. the coincident detection of two photons from the cascade. This method will substantially reduce the background from uncorrelated reactions and thus allow to observe even small branching transitions. A novel experimental setup with high efficiency consisting of fast $LaBr_3$ and HPGe detectors with high energy resolution will be installed at the High Intensity γ-ray Source at the Duke Univerity by the γ³ collaboration. This setup will for the first time combine γ-γ coincidence measurements with the NRF reaction to yield unprecedented sensitivity for the investigation of the complete decay pattern. First results from a feasibility test will be presented.

* Supported by the Alliance Program of the Helmholtz Association (HA216/EMMI), the DFG (SFB 634 and ZI 510/4-1) and U.S. DOE grant no. DE-FG02-91ER-40609.

Low-lying dipole response:
isospin character and collectivity

Xavier Roca Maza

INFN-Milano, Italy

In this talk I will present a study of the isospin character, the collective or single-particle nature, and the sensitivity to the slope of the nuclear symmetry energy of the low-energy isovector dipole response, known as pygmy dipole resonance, that are nowadays under debate.

In short, I will show that both the isoscalar and the isovector dipole responses of all studied nuclei how a low-energy peak that increases in magnitude, and it is shifted to larger excitation energies, with increasing values of the slope of the symmetry energy at saturation. In addition, I will also show that the collectivity associated with the RPA state(s) contributing to this peak is different in the isoscalar and isovector case (i.e. it depends on the external probe). In particular, the response of these RPA states to an isovector operator does not show a clear collective nature while the response to an isoscalar dipole operator is recognizably collective.

The PARIS project

David Jenkins

On behalf of the PARIS collaboration

The PARIS calorimeter is intended to be the ultimate spectrometer for medium- and high-energy gamma rays at future radioactive beam facilities such as SPIRAL2. The aim is to have the best possible energy resolution for a scintillator-based spectrometer through heavy employment of novel materials such as lanthanum bromide. The high cost of such materials implies careful consideration of a cost-benefit analysis and a phoswich detector based on lanthanum bromide and sodium iodide presently seems the best compromise in this respect. An overview of the PARIS aims and objectives will be given along with the present status of this project.

Search for Jacobi transitions, status and perspectives (PARIS and SPIRAL2)

Maria Kmiecik

IFJ PAN Krakow, Poland

Jacobi shape transitions is predicted as the shape change of the rotating nucleus with the increasing angular momentum from oblate to prolate through triaxial. The first indications have been seen in the GDR decay measured for 45Sc and 46Ti nuclei. The results of the more exclusive experiment performed to study 46Ti by the high energy gamma rays in coincidence with discrete transitions emitted by residues as well as light charged particles confirmed the observation of Jacobi shape transition in this nucleus and showed for the first time the influence of the Coriolis forces to the splitting of the GDR components. Jacobi shape transition has been studied lately also for heavier nucleus 88Mo produced in 48Ti+40Ca reaction at 300, 450 and 600 MeV beam energy. The results of the analysis will be presented compared to the theoretical calculations done using LSD model. Also perspectives for similar studies using radioactive beams and novel gamma arrays will be shown.

Monte-Carlo CASCADE based event generator of fusion-evaporation reactions for GEANT4 software

M. Ciemała[1], K. Mazurek[1], M. Kmiecik[1], A. Maj[1] et al.

1. IFJ PAN Krakow,

The future experimental set-ups contain new detectors which efficiency and resolution should be simulated to constraint the geometry, materials and electronics used to construct them. To perform calculations, the realistic physics event generators describing investigated processes should be used.

In the talk we present the fusion-evaporation reaction simulated by the event generator, of GEANT4 software, based on statistical model CASCADE [1] code in the evaporation part. The calculations done using this event generator for reaction leading to ^{88}Mo compound nucleus and the decay of this nucleus will be shown. The results will be compared with the experimental data obtained for the measurements performed for Jacobi shape transition investigations in ^{88}Mo [2] at LNL Legnaro.

[1] F. Pühlhofer, Nucl. Phys. A280, 267 (1977).

[2] M. Ciemala et al., Act. Phys. Pol. B Vol42, 3-4 (2011).

Influence of the potential energy landscape on the fission dynamics

K. Mazurek[1], *J.P. Wieleczko*[2], *C. Schmitt*[2], *P. N. Nadtochy*[3], *A. Maj*[1], *J. Dudek*[4]

1. The Niewodniczański Institute of Nuclear Physics - PAN, PL-31-342 Kraków, Poland
2. Grand Accelerateur National d'Ions Lourds, CEA/DSM-CNRS/IN2P3, Bvd Henri Becquerel, 14076 Caen, France
3. Omsk State University, Department of Theoretical Physics, Mira Prospect 55-A, RU-644077 Omsk, Russia
4. Institut Pluridisciplinaire Hubert Curien and Universite de Strasbourg, F-67037 Strasbourg Cedex 2, France

Recent calculations [1] based on the Lublin - Strasbourg Drop (LSD) [2] model showed that at very high angular momenta, where fission starts to set in, nuclear shape can evolve from oblate to prolate (so called Jacobi shape transition) and/or from oblate via prolate to octupole (Poincare shape transition). It is thus interesting and instructive to study the influence of the shape (prolate or octupole) of the compound nucleus on the mass distribution of the fission fragments.

The fission dynamics can be described with the help of Langevin equations in multidimensional deformation space supplemented with the Monte Carlo method to simulate the angular momentum of the compound nucleus, the type and number evaporated or emitted prescission particles.

A realistic three-dimensional Langevin approach has been used to explore the influence of the potential energy surface on the dynamical evolution of a system along its path to fission. Two macroscopic models have been used to parameterize the energy landscape: the Finite Range Liquid Drop Model (FRLDM) [3] and the LSD model. The FRLDM model is commonly used for the description of heavy nuclei and LSD, developed more recently, is expected to be more realistic for describing the shapes experienced by fissioning medium-mass nuclei. In the present contribution both models are found to give similar results for heavy nuclei, whereas we observe striking differences in their prediction for the charge Z and the kinetic energy distributions of the fragments produced in the fission of lighter systems are obtained. Short discussion about the influence of the shape dependent Wigner energy on the charge distribution of the fissioning nuclei will be presented. Our calculations permit to define optimal experimental conditions for constraining the potential energy surface used in the dynamical description of fission [4].

1. A. Maj, K. Mazurek, J. Dudek, M. Kmiecik, D. Rouvel, Int. J. Mod. Phys. E 19 (2010) 532;
K. Mazurek, J. Dudek, M. Kmiecik, A. Maj, J.-P. Wieleczko and D. Rouvel, Acta Phys. Pol., B 42, 471 (2011)
2. K. Pomorski, J. Dudek, Phys. Rev. C 67, 044316 (2003); J. Dudek, K. Pomorski, N. Schunck and N. Dubray,
European Phys. J. A20 (2004) 165.
3. A. J. Sierk, Phys. Rev. C 33, 2039 (1986); P. Moller, A.J. Sierk, A. Iwamoto, Phys. Rev. Lett. 92, 072501 (2004)
4. K. Mazurek, C. Schmitt, J.P. Wieleczko, P.N. Nadtochy, G. Ademard, Phys. Rev. C84, 014610 (2011)

Wednesday 22nd February: Afternoon Sessions

CHAIRMAN: P. REITER (University of Cologne)

17:00-17.30 **J. Simpson** (STFC Daresbury Laboratory)
The AGATA Project

17:30-18.00 **S. Lenzi** (University of Padova and INFN)
Shape evolution far from stability

18:00-18.15 **N. Pillet** (CEA/DAM/DIF)
Low-lying spectroscopy of a few even-even silicon isotopes investigated by means of the multiparticle-multihole Gogny energy density functional

18:15-18.30 **V. Modamio*** (Legnaro Laboratory-INFN)
Lifetime measurements in ^{63,65}Co

18:30-18.45 **C. Michelagnoli*** (University of Padova and INFN)
Lifetime measurement of the 6.79 MeV state in ^{15}O with the AGATA Demonstrator

18:45-19.05 **J. Terasaki** (University of Tsukuba)
Testing Skyrme energy-density functionals with the QRPA in low-lying vibrational states of rare-earth nuclei

19:05-19.25 **C. Fahlander** (Lund University)
Electromagnetic Properties of Nuclei Close To ^{100}Sn

The AGATA Project; Status and Plans

John Simpson

STFC Daresbury Laboratory, UK

The Advanced GAmma Tracking Array (AGATA) is a European project to develop and operate the next generation gamma-ray spectrometer. AGATA is based on the concept of gamma-ray tracking within highly segmented germanium crystals. This relies upon accurate determination of the energy, time and position of each interaction using digital electronics and pulse shape analysis. This information is processed by reconstruction algorithms to build all the events. This results in a device with very high efficiency and excellent spectral resolution even at high nuclear velocities. AGATA has been operated at Legnaro National Laboratory in Italy and a successful campaign of experiments has been performed. The spectrometer is now transferring to the GSI laboratory in Germany for its second science campaign. This talk reviews the technological advances needed for AGATA, the performance of AGATA and preliminary results from Legnaro and the status of project for the GSI phase.

Shape evolution far from stability

S. Lenzi

University of Padova and INFN

Far from the valley of beta stability, the nuclear shell structure undergoes important and substantial modifications. In medium-light nuclei, interesting changes have been observed such as the appearance of new magic numbers, and the development of new regions of deformation around nucleon numbers that are magic near stability. The observed changes help to shed light on specific terms of the effective nucleon-nucleon interaction and to improve our knowledge of the nuclear structure evolution towards the drip lines. The possibility of having a good theoretical description of these phenomena is essential to allow a deep insight into the nuclear effective interaction, to interpret the structure of nuclei far from stability, to predict the position of the drip-lines and to understand the nucleosynthesis pathways.

In the last few years, particular effort has been put on studying light and medium-mass neutron-rich nuclei where these effects manifest more dramatically. Detailed nuclear structure information is becoming available both with stable and radioactive beams nowadays and deeper insight on nuclei approaching the drip line is foreseen with the future radioactive beams facilities. The status of the present scenario in the mass region around N=40 will be discussed, with particular regard to shape evolution along isotopic chains and the phenomenon of shape coexistence.

Low-lying spectroscopy of a few even-even silicon isotopes investigated by means of the multiparticle-multihole Gogny energy density functional

N. Pillet[1], V.G. Zelevinsky[2], M. Dupuis[1], J.-F. Berger[1] and J.-M. Daugas[1]

[1] *CEA,DAM,DIF, F-91297 Arpajon Cedex*

[2] *Department of Physics and Astronomy and National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824, USA*

A multiconfiguration microscopic method has been applied with the Gogny effective interaction to the calculation of low-lying positive-parity states in even-even $^{26\text{-}28}$Si isotopes. The aim of the study is to compare the results of this approach with those of a standard method of GCM type and to get insight into the predictive power of multiconfiguration methods employed with effective nucleon-nucleon force taylored to mean-field calculations. It is found that the multiconfiguration approach leads to an excellent description of the low-lying spectroscopy of ^{26}Si, ^{28}Si and ^{32}Si, but gives a systematic energy shift in ^{30}Si. A careful analysis of this phenomenon shows that this discrepancy originates from too large matrix elements in the proton-neutron residual interaction supplied by the Gogny interaction. Finally, a statistical analysis of highly excited configurations in ^{28}Si is performed, revealing exponential convergence in agreement with previous work in the context of the shell model approach. This latter result provides strong arguments towards an implicit treatment of highly excited configurations.

Lifetime measurements in ^{63,65}Co

V. Modamio[1], J.J. Valiente-Dobón[1], L. Corradi[1], G. de Angelis[1], E. Fioretto[1], A. Gottardo[1,2], D. Montanari[1], D.R. Napoli[1], E. Sahin[1], A.M. Stefanini[1], D. Bazzaco[2], R. Depalo[2], E. Farnea[2], S. Lunardi[2], R. Menegazzo[2], D. Mengoni[2,9], C. Michelagnoli[2], G. Montagnoli[2], F. Recchia[2], F. Scarlassara[2], A. Algora[3], A. Bürger[4], A. Dewald[5], M.N. Erduran[6], A. Gadea[3], K. Geibel[5], M. Hackstein[5], T. Hüyük[3], R. Kempley[7], S. Lenzi[7], B. Melon[8], O. Möller[10], A. Nannini[8], P. Reiter[5], W. Rother[5], P.A. Söderström[11], S. Szilner[12], C. Ur[2] and the AGATA collaboration.

1 INFN, Laboratori Nazionali di Legnaro, Legnaro (Padova), Italy.

2 Dipartimento di Fisica, Università di Padova and INFN, Padova, Italy.

3 IFIC Valencia, Valencia, Spain.

4 Department of Physics, University of Oslo, Oslo, Norway.

5 IKP, Universitätt zu Köln, Köln, Germany.

6 Department of Physics, Istanbul University, Istanbul, Turkey.

7 Department of Physics, University of Surrey, Guildford, U.K.

8 Dipartimento di Fisica, Università di Firenze and INFN, Firenze, Italy.

9 University of the West of Scotland, Paisley, Scotland.

10 Technische Universität Darmstadt, Darmstadt, Germany.

11 Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden.

12 Ruder Boskovic Institute, Zagreb, Croatia.

In the region right below the neutron-rich Ni isotopes, there is an increase of collectivity produced mainly by the monopole part of the tensor interaction of the nuclear force: the interaction between f7/2 protons and both f5/2 neutrons (attractive) and g9/2 neutrons (repulsive) weakens when the proton f7/2 orbital is not fully filled, and therefore the gap between the neutron orbitals f5/2 and the g9/2 decreases. This mechanism will favor particle-hole excitations across N=40 subshell closure and therefore the g9/2 orbital will play an important role in driving the nucleus towards deformation. Low lying states in odd-mass Co isotopes around this neutron subshell closure have been interpreted as the coupling of a f7/2 proton hole with the 2+ Fe core. Therefore, the measurement of the B(E2) values in 63,65Co is of valuable intererest to clarify this interpretation by measuring the 3/2- state lifetime and tell us the robustness of the N=40 sub-shell closure just below Z=28 by measuring the 9/2- state lifetime. To this purpose, the nuclei of interest were populated as products of a multinucleon-transfer reaction with a 64Ni beam directed onto a 238U target. Lifetimes of first excited states in odd-Z neutron-rich Co isotopes were measured by using the Recoil Distance Doppler Shift method (RDDS) with the AGATA Demostrator-PRISMA setup.

Lifetime measurement of the 6.79 MeV state in ^{15}O with the AGATA Demonstrator

C. Michelagnoli, C. A. Ur, R. Menegazzo, D. Bazzacco, C. Broggini, A. Caciolli,
E. Farnea, S. Lunardi
INFN and Università degli Studi di Padova, Padova, Italy
R. Depalo
INFN Laboratori Nazionali di Legnaro, Legnaro, Italy
D. Bemmerer
Forschungszentrum Dresden–Rossendorf, Dresden, Germany
N. Keeley
The Andrzej Sołtan Institute for Nuclear Studies, Warsaw, Poland
and the AGATA and LUNA collaborations

An accurate determination of the lifetime of the first excited $3/2^+$ state in ^{15}O is of paramount importance in the determination of the astrophysical S-factor and the derived cross section for the $^{14}N(p,gamma)^{15}O$ reaction, the slowest one in the CNO cycle. The considered level indeed corresponds to a sub-threshold resonance of this reaction, the width of which is a crucial ingredient in the extrapolation of the cross section in the Gamow energy region. Once this cross section is known, the information of the energy production rate from the CNO cycle can be used together with the neutrino fluxes to shade light on the metallicity in the center of the Sun.

The results of a new direct measurement of the lifetime of the first excited $3/2^+$ state in ^{15}O are discussed. The $^{2}H(^{14}N,n)^{15}O$ reaction in inverse kinematics at 32 MeV beam energy (XTU Tandem, LNL) was used to populate the level of interest, which decays *via* a 6.79 MeV E1 gamma--ray transition to the ground state. Gamma rays were detected with 4 triple clusters of the AGATA Demonstrator array. The energy resolution and position sensitivity of this state-of-the-art gamma spectrometer have been exploited to investigate the Doppler Shift Attenuation in the *lineshape* of the gamma--ray peak in the energy spectrum. This is the first time that the technique of gamma--ray tracking has been used to investigate ~fs nuclear level lifetimes. The deconvolution of the lifetime effects from the ones due to the kinematics of the emitting nuclei has been performed by means of detailed Monte Carlo simulations of the gamma emission and detection. Coupled-channel calculations for the nucleon transfer process have been used for this purpose. The comparison of the experimental and simulated data for high-energy gamma rays de-exciting ~1-10 fs lifetime levels will be shown, both for ^{15}O and for the known case of ^{15}N. This nucleus, produced in the same reaction process, provided a testing ground for the analysis method.

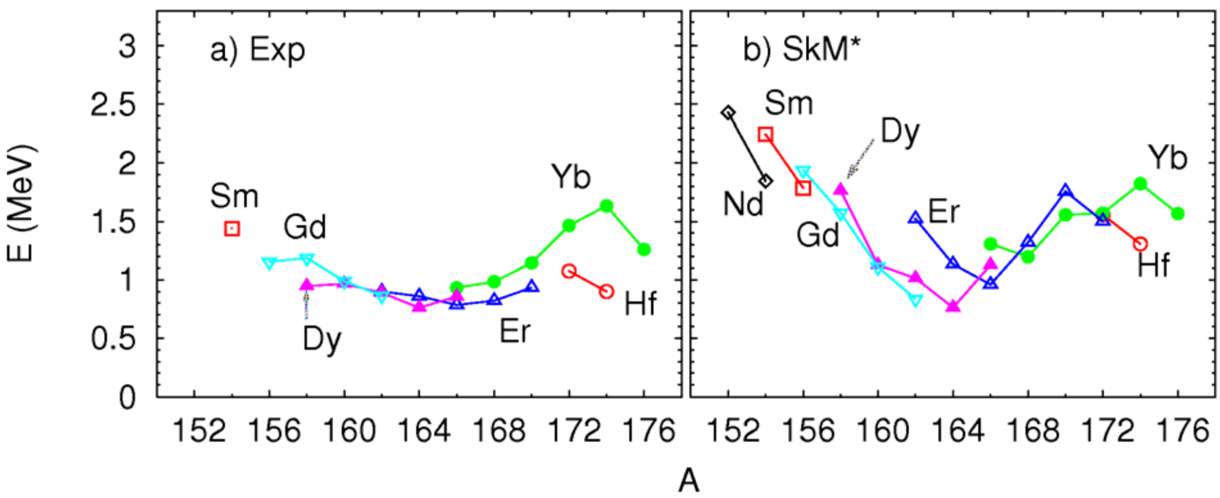
Testing Skyrme energy-density functionals with the QRPA in low-lying vibrational states of rare-earth nuclei

Jun Terasaki

Center for Computational Sciences, University of Tsukuba, Tsukuba 305-8577, Japan

Although nuclear energy density functionals are determined primarily by fitting to ground state properties, they are often applied in nuclear astrophysics to excited states, usually through the quasiparticle random phase approximation (QRPA). Thus, it is important to test performance of the nuclear energy density functionals in comparison with experimental data of the excited states which are not taken into account in determining the energy functionals. Here we test the Skyrme functionals SkM* and SLy4 along with the self-consistent QRPA by calculating properties of low-lying vibrational states in a large number of well-deformed even-even rare-earth nuclei. This is the first time to compare results of the Skyrme-QRPA calculations with the data of those states.

We reproduce trends in energies and transition probabilities associated with the γ-vibrational states (see Figure), but our results are not perfect and indicate the presences of multi-particle-hole correlations that are not included in the QRPA. The Skyrme functional SkM* performs noticeably better than SLy4. In a few nuclei, changes in the treatment of the pairing energy functional have a significant effect. The QRPA is less successful with "β-vibrational" states than with the γ-vibrational states.



Electromagnetic Properties of Nuclei Close To ^{100}Sn

C. Fahlander, D. D. DiJulio, and J. Cederkäll
Department of Physics Department, Lund University, Box 118, SE-221 00 Lund, Sweden

A. Ekström, and M. Hjorth-Jensen
Department of Physics and Center of Mathematics for Applications, University of Oslo, Norway

The single neutron states relative to the closed shell nucleus 100Sn are key ingredients for understanding the nuclear properties of nuclei in the N = 50 shellto the N = 82 shell. They are basic input for shell model calculations in the light Sn isotopes. The ordering of the single-particle orbits is sensitive to the shell model calculated energies, but will also affect the calculated transition probabilities between the various states. The ordering is thus important for the understanding of the behaviour of the measured E2-strengths in light even–even and odd-even Sn nuclei. In this work, new results from Coulomb excitation measurements for the nuclei 107,109Sn will be presented that may shed some light on the ordering of the single-particle orbits relative to 100Sn.

Thursday 23rd February: Morning Sessions

CHAIRMAN: A. VITTURI (University of Padova and INFN)

9:00-9.30 **G. DeFrance** (GANIL)
Recent Results from GALIN

9:30-10.00 **D. Verney** (IPN-Orsay)
Structure studies in the vicinity of the N=50 shell closure: recent results from ALTO

10:00-10.20 **A. Goergen** (University of Oslo)
Recoil-distance lifetime measurement after fusion-fission reactions in inverse kinematics

10:20-10.35 **V. Prassa*** (Aristotle University of Thessaloniki)
Towards the valley of stability with Energy Density Functionals

10:35-10.50 **C. Schmidt** (GANIL)
Prompt γ-spectroscopy of isotopically identified fission fragments

CHAIRMAN: P.F. BORTIGNON (University of Milano and INFN)

11:20-11.50 **D. Savran** (EMMI/GSI)
Systematics and Structure of the Pygmy Dipole Resonance

11:50-12:10 **P. Mutti** (ILL, Grenoble)
EXILL: The Exogam array at the Institut Laue-Langevin

12:10-12:25 **F. Crespi** * (University of Milano)
Study of high-lying collective modes with AGATA and LaBr3Ce scintillation detectors

12:25-12:40 **M. Brenna*** (University of Milano and INFN)
Theory of the gamma decay of nuclear giant resonances within the Skyrme framework

Gamma-ray spectroscopy at GANIL:
Evolution of collectivity around ^{68}Ni and isoscalar pairing below ^{100}Sn

G de France, GANIL

Gamma-ray spectroscopy is intensively used at GANIL to measure low lying states in exotic nuclei on the neutron-rich as well as on the neutron-deficient side of the nuclear chart.

Excited states in a wide range of neutron rich nuclei around ^{68}Ni have been studied using the EXOGAM array in coincidence with the VAMOS large acceptance spectrometer used in a solenoid mode. The nuclei of interest were produced via multi nucleon transfer reactions in inverse kinematics using a ^{238}U beam at an energy of ~16% above the Coulomb barrier. The γ-rays emitted at the target point were measured with the EXOGAM array and the delayed γ-rays were measured in the focal plane of the spectrometer with four germanium detectors.

New results have been obtained in ^{68}Ni. In nuclei located below, our recent experimental work already revealed the possible appearance of a third island of inversion. A sudden increase of collectivity from ^{62}Fe to ^{66}Fe has indeed been observed, later confirmed by W. Rother *et al.* The comparison with shell model calculations, shows the crucial role of the neutron $g_{9/2}$ and $d_{5/2}$ orbitals below N=40 which weakens the N=40 subshell gap and gives rise to a large variety of phenomena including single particle, collective and core coupled states below and above the nickel chain in cobalt and copper isotopes.

On the neutron deficient border, close to the proton dripline, gamma-rays have been observed for the first time in ^{92}Pd in an experiment combining EXOGAM with a large neutron detector, the Neutron Wall and a charged particle detector called DIAMANT. The very high selectivity of this coupling allows one to extract very weak channels corresponding to a relative yield as low as 10^{-5} of the total fusion cross-section. The level scheme which could be established is in remarkable agreement with the shell model calculations providing all the pairing channels are taken into account. In particular the role of the isoscalar channel is highlighted.

Status of the ALTO ISOL-facility and last results in the N=50 region

D. Verney for the ALTO team

The PARRNe ISOL device has been operating at IPN Orsay since more than 10 years. Originally conceived as a test bench for R&D studies in the framework of SPIRAL2, the performance of the setup has proven suitable to undertake a physics research program on the evolution of N=50 towards ^{78}Ni by beta-decay studies. Year 2012 is a very special one as the official kick-off of the ISOL device operated on-line with the electron driver will be celebrated after several years of commissioning. A new secondary beam line emerging from the PARRNe mass-separator has been constructed which now hosts a new (state-of-the-art) tape station system: BEDO (BEta Decay studies in Orsay). The present status of the facility will be presented, as well as the results obtained during the final commissioning period in 2011 when the first radioactive Ga beam produced by the newly operating laser ion source was obtained.

The β-decay of ^{84}Ga (Z=31,N=53) was re-investigated at this occasion.

Recoil-distance lifetime measurement after fusion-fission reactions in inverse kinematics

A. Görgen[1], T.W. Hagen[1], M.D. Salsac[2], L. Grente[2], F. Farget[3], B. Sulignano[2], C. Louchart[2], B. Jacquot[3], T. Braunroth[4], B. Bruyneel[2], I. Celikovic[3], E. Clément[3], G. de France[3], O. Delaune[3], A. Dewald[4], A.Dijon[3], M. Hackstein[4], W. Korten[2], J. Litzinger[4], J. Ljungvall[5], C. Michelagnoli[6], D. Napoli[6], F. Recchia[6], W. Rother[4], E. Sahin[6], S. Siem[1], Ch. Theisen[2], J.J. Valiente-Dobon[6], P. Van Isacker[3]

[1] Department of Physics, University of Oslo, Norway

[2] Service de Physique Nucléaire, IRFU, CEA Saclay, France

[3] GANIL, Caen, France

[4] Institut für Kernphysik, Universität zu Köln, Germany

[5] CSNSM, IN2P3-CNRS, Orsay, France

[6] Laboratori Nazionali di Legnaro, INFN, Italy

Picosecond lifetimes of excited states in a wide range of neutron-rich fission fragments have been measured using a new variant of the recoil-distance Doppler shift technique after fusion-fission reactions in inverse kinematics. In an experiment at GANIL a beam of ^{238}U was accelerated to 6.2 MeV per nucleon and directed onto a ^{9}Be target. The reaction leads to the formation of a ^{247}Cm compound nucleus which fissions while still inside the target foil. The fission fragments exit the target with high velocities and are strongly forward focused due to the inverse kinematics. The velocity of the fission fragments was slowed using a magnesium degrader foil, which was placed in a plunger device at micrometer distances from the target. After passing through the degrader, one of the two fragments was detected and identified in mass, atomic number, and charge state event by event using the VAMOS spectrometer, which was rotated to 20° with respect to the beam axis and equipped with a new, improved detection system at the focal plane. Gamma rays were detected around the target position with the segmented germanium clover detectors of the EXOGAM array and correlated with the fission fragment identified in the VAMOS spectrometer. The lifetime of excited states can be extracted from the intensities of the fast and slow components of Doppler-shifted gamma rays emitted before and after the degrader foil, respectively. Measurements were performed for seven distances between 25 and 1600 μm. In addition, $LaBr_3$ detectors were used to measure lifetimes of longer-lived states using fast-timing techniques. The setting of the VAMOS spectrometer was optimized for the transmission of neutron-rich isotopes of elements with Z=40-50, where lifetimes of excited states are only poorly known. Deformation and collectivity changes rapidly in these nuclei, and triaxiality is expected to be important in this region, making the measurement of electromagnetic transition rates a stringent test and benchmark for nuclear structure models. First results of the experiment will be presented together with the new experimental technique.

Towards the island of stability with Energy Density Functionals

Vaia Prassa *

Department of Theoretical Physics, Aristotle University of Thessaloniki,
Gr-54124, Thessaloniki, Greece

A key issue in modern nuclear physics involves the limits of nuclear mass and charge. In the 1960s the existence of superheavy nuclei was predicted and thereafter the quest of superheavy elements has become an intriguing research topic. Rapid advances of experimental techniques during the past decade have led to the synthesis of elements up to Z=118. Nuclear energy density functionals (NEDF) presently provide the most complete and accurate description of ground-state properties and collective excitations over the whole nuclide chart. The NEDF framework has been applied to the analysis of the structure of superheavy nuclei with atomic numbers in the range of 105<Z<120. The relativistic Hartree-Bogoliubov model has been employed in the calculation of bulk properties, such as binding energies, quadrupole deformations, alpha-decay energies and half-lives, of heavy and superheavy nuclei. The influence of ground-state triaxiality on the alpha decay of SHE has been also analyzed. In addition, for a complete microscopic description of SHE the calculations were extended beyond the mean-field models to include collective correlations.

* This work was performed together with G.A. Lalazissis, Physics Department, Thessaloniki, T. Niksic, and D. Vretenar, Physics Department, Zagreb.

Prompt γ-spectroscopy of isotopically identified fission fragments

C. Schmitt (On behalf of the VAMOS team)

Grand Accélérateur National d'Ions Lourds (GANIL), CEA/DSM-CNRS/IN2P3, F-14076 Caen, France

We report on the measurement of prompt γ−spectroscopy from isotopically identified fission-fragments. Transfer and fusion were used to induce fission in the bombardment of a ^{9}Be target with the high-intensity ^{238}U beam at Ganil. The fragments were detected in the very large-acceptance VAMOS++ spectrometer, and fully characterized in nuclear mass, ionic charge state and atomic number, and their velocity vector was accurately measured. The coincident γ−rays were detected in the EXOGAM array. The power and uniqueness of this technique will be demonstrated. In particular, the assets of the identification in VAMOS++ will be highlighted:

(i) it ensures assignment of even a single γ-ray to a particular nucleus;

(ii) the knowledge of the velocity vector provides accurate Doppler correction event-by-event;

(iii) the structure of the complementary (un-detected) fragment can be investigated as well.

Isotopic identification of fission fragments was so far restricted to the study of isomeric states at the focal plane. Light to medium-mass products could be identified, only. The present achievement, i.e. *prompt γ−spectroscopy of light up to heavy (A,Z) identified fission fragments*, will be illustrated with γ−spectra from a variety of nuclei. The information extracted from the wealth of fragments (over 300) produced simultaneously and with a coherent population pattern allows to investigate nuclear structure along particularly long isotopic and isotonic chains on the nuclear chart. This should permit to draw a clear picture of evolution with N and Z.

Systematics and Structure of the Pygmy Dipole Resonance

Deniz Savran

ExtreMe Matter Institute EMMI and Research Division, GSI, Darmstadt, Germany

Frankfurt Institute for Advanced Studies FIAS, Frankfurt

Beside the Giant Dipole Resonancen (GDR), many nuclei show the feature of an additional low-lying electric dipole (E1) strength below and around the particle separation energies, which is usually denoted as Pygmy Dipole Resonance (PDR). The presence of the PDR in nearly every studied nucleus and the smooth variation of its properties lead to the assumption that the PDR is a newly discovered collective mode. While some of the gross characteristics are reproduced by different theoretical model descriptions, its detailed structure and the degree of collectivity are a matter of ongoing discussions.

An excellent tool to investigate bound E1 excitations is the method of real-photon scattering, which has been used in the last years to perform systematic studies of E1 strength below the neutron separation energy in nuclei of different mass regions [1]. Besides the possibility to perform systematic studies of the gross features of low-lying E1 strength this experimental method allows the investigation of the fine structure and fragmentation of the strength, which is an interesting observable by itself, but also has consequences on the experimental determination of integral quantities such as the total strength [2]. A detailed discussion on results for the N=82 isotones will be presented.

Photon-induced reactions are however not very sensitive to the structure of the E1 excitations, i.e. to the properties of the corresponding transition densities. In order to obtain complementary experimental data, we have investigated the PDR in $(\alpha,\alpha'\gamma)$ coincidence experiments at E_α = 136 MeV at the Big-Bite Spectrometer at the KVI. With this method a good energy resolution and high selectivity to E1 transitions as known from real-photon scattering can be obtained. In comparison to results from the (γ,γ') experiments, a structural splitting of the E1 strength below particle thresholds into two separated groups could be observed in experiments on ^{124}Sn, ^{138}Ba, ^{140}Ce and ^{94}Mo: Whereas the low-energy part of the E1 strength is excited by the (γ,γ') as well as by the $(\alpha,\alpha'\gamma)$ reaction, the high-energy part is not excited in the α-scattering experiment. This different excitation pattern is a clear experimental indication to different structures of the two groups of 1^- excitations. The investigation of the isoscalar and isovector E1 strength in QPM and RQTBA calculations show a qualitative agreement to these experimental observations. While the lower energy E1 excitations show the typical signature of a neutron-skin oscillation often assigned to the PDR, which has a rather strong isoscalar component, the E1 excitations at slightly higher energies show the structure of a transition towards the isovector GDR with a consequently smaller isoscalar component. The combined results of experiment and calculations thus provides for the first time an experimental identification of the E1 excitations showing the structure associated with the PDR picture of a neutron-skin oscillation [3]. The results of this investigation will be presented.

[1] U. Kneissl et al., J. Phys. G 32 (2006) R217
[2] D. Savran et al., Phys. Rev. Lett. 100 (2008) 23501
[3] J. Endres et al., Phys. Rev. Lett 105 (2010) 212503

EXILL: The Exogam array at the Institut Laue-Langevin

P. Mutti, G. de France, U. Koester, M. Jentschel, G. Simpson, T. Soldner, W. Urban

The Institut Laue-Langevin (ILL) in Grenoble is operating the strongest neutron source in the word. The ILL reactor, running at 58 MW thermal power, provides extremely intense neutron beams to the 40 high performance instruments situated all around the reactor's core or in the 2 extension halls. While the main experimental activity of the institute is driven by condense matter physics, material science, chemistry and biology, a group of 4 instruments is totally devoted to nuclear and particle physics. In particular, PF1B is located at 76 m from the vertical liquid deuterium cold source and it delivers a neutron beam of 1.8 x 10^{10} n/cm^2/s with an average wavelength of 4.0 – 4.5 Å. The combination of such an intense beam with the high detection efficiency of the EXOGAM detector's array offers the unique possibility to gather essential and new information from more that a hundred of very neutron-rich atomic nuclei produced in the fission of U and Pu samples. Multiple gamma coincidences will be collected from neutron-induced fission as well as from neutron-capture on stable targets. The campaign of measurements will be performed in 2012 – 2013 lasting for about 100 days. The presentation will cover as well some of the challenging technical aspects of the new trigger-less acquisition system designed to handle the huge amount of data produced during the experiments.

Theory of the gamma decay of nuclear giant resonances within the Skyrme framework

Marco Brenna

University of Milano and INFN

A microscopic formalism that allows the calculation of the gamma decay of nuclear excited states has been developed. The model is entirely based on Skyrme effective interactions. The phonons are calculated within fully self-consistent RPA, while the calculation of the gamma decay width is performed at the lowest contributing order of the perturbation theory within the framework of the Nuclear Field Theory (NFT). In particular, it has been applied to the direct gamma decay of the Isoscalar Giant Quadrupole Resonance in 208Pb to the ground state and to the low-lying octupole state, as well. The decay width to the lowest 3- state turns out to be only a few percent of the decay width to the ground state, as indicated by the experiment.

Study of high-lying collective modes with AGATA and LaBr3:Ce scintillation detectors

Fabio Crespi

University of Milano

We report on the status of the analysis of AGATA-Demonstrator (AD) experiments aimed to study the gamma decay from giant resonances at zero temperature. Two experiments have been performed at Laboratori Nazionali di Legnaro (in June 2010 and December 2011 respectively). The giant resonance modes have been excited by inelastic scattering of 17O at 20 MeV/A (the highest energy available at LNL, provided by the ALPI accelerator) on a series of targets, such as 208Pb, 90Zr (first experiment) and 124Sn, 140Ce (second experiment), approximately 2 mg/cm2 thick. The scattered ions have been detected by two E- E Si telescopes of the TRACE detector system, while the gamma decay has been measured by the AD coupled to an array of LaBr3:Ce scintillation detectors. We aimed at the measurement of a known case first, 208Pb, but with improved experimental conditions, in particular concerning the energy resolution of the gamma detection. 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 well identified yet.

In this and in other in-beam gamma spectroscopy experiments the detection of high energy gamma rays in the range up to 10-20 MeV is a fundamental aspect. The performance of AGATA detectors in this energy range has, however, never been studied in detail. A test measurement of the response to 15.1 MeV gamma rays has therefore been performed using two AGATA triple clusters operating at LNL. Part of the talk will be devoted to the presentation of the results of this study.

Thursday 23rd February: Afternoon Sessions

CHAIRMAN: M. THOENNESSEN (MSU)

17:00-17.30 **T. Nakatsukasa** (RIKEN Nishina Center)
Recent theoretical investigations on properties of low-energy dipole states

17:30-18.00 **T. Aumann** (GSI)
Quasi-free knockout reactions with radioactive beams at R3B

18:00-18.20 **E. Lanza** (INFN-Catania)
Collective states excitation in stable and far from stability nuclei via nuclear and Coulomb fields

18:20-18.40 **I. Mazumdar** (Tata Institute of Fundamental Research)
Studies in GDR and GQR decay from hot rotating heavy nuclei

18:40-19:00 **M. Locatelli** (CAEN-Italia)
Digital Pulse Processing for physics application

19:00-19.15 **R. Peloso** * (Milano Politecnico and INFN)
Application of the HICAM camera for imaging of prompt gamma rays in measurements of proton beam range

19:15-19.30 **P. Busca** * (Milano Politecnico and INFN)
High resolution camera for gamma-ray spectroscopy and imaging in nuclear physics research

Going beyond the dripline with MoNA-LISA

M. Thoennessen for the MoNA Collaboration*

National Superconducting Cyclotron Laboratory and Department of Physics & Astronomy, Michigan State University, East Lansing, MI 48824, USA

Neutron decay spectroscopy has become a successful tool to explore nuclear properties of nuclei with the largest neutron-to-proton ratios. Resonances in nuclei located beyond the neutron-dripline are accessible by kinematic reconstruction of the decay products. These experiments require large, efficient, and position sensitive arrays to measure the neutrons. The Modular Neutron Array (MoNA) with the recent addition of the Large multi-Institutional Scintillator Array (LISA) is located at the NSCL at Michigan State University and utilizes secondary beams from the Coupled Cyclotron Facility and the A1900 fragment separator. An overview of the most recent results covering neutron unbound isotopes from lithium to fluorine will be presented.

*MoNA is a collaboration of Augustana College, Central Michigan University, Concordia College, Florida State University, Gettysburg College, Hope College, Indiana University at South Bend, Michigan State University, Ohio Wesleyan University, Rhodes College, Wabash College, Western Michigan University, and Westmont College.

Recent theoretical investigations on properties of low-energy dipole states

Takashi Nakatsukasa

RIKEN

I present present status on theoretical studies for low-energy dipole states, using time-dependent density-functional methods. There have been extensive studies in the past decade, however, we have not yet reached a unified picture/understanding on their properties. Since different models/calculations produced different results, it was difficult to draw a solid conclusion from these results. I show our recent studies for low-energy dipole strength in stable and unstable nuclei, compared to other models' predictions, discussing agreements/disagreements and possible origins of discrepancies, etc.

Quasi-free knockout reactions with radioactive beams at R3B

T. Aumann

Technische Universität Darmstadt, Germany
GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

The measurement of proton-induced reactions in complete kinematics will be an important part of the physics program at the future R^3B (Reactions with Relativistic Radioactive Beams) experiment at FAIR. In particular the quasi-free knockout processes of the type (p,2p), (p,pn), (p,pα) will be used to investigate the single-particle and cluster structure of neutron-proton asymmetric nuclei and the role of nucleon-nucleon correlations in nuclei.

At the present LAND/R3B setup we have performed experiments using a prototype installation for the detection of high-energy protons and neutrons in (p,2p) and (p,pn) reactions, respectively. Recoil protons have been detected with an array of Si-Strip detectors and the 4-π NaI spectrometer "Crystal Ball". Measurements have been performed with a ^{12}C beam as a benchmark as well as with the proton-dripline nucleus ^{17}Ne. For comparison, breakup of ^{17}Ne induced by a carbon target has been studied as well in complete kinematics. For ^{12}C, proton knockout from different single-particle states has been identified including knockout from the 0s state by reconstructing the excitation-energy spectrum of ^{11}B utilizing γ spectroscopy and the invariant-mass method. In case of proton knockout from ^{17}Ne, the excitation energy of the unbound ^{16}F clearly shows contributions from halo and core knockout. From the analysis of the momentum distributions and cross sections the occupancies for the s and p configurations in the ^{17}Ne ground state have been determined.

Collective states excitation in stable and far from stability nuclei via nuclear and Coulomb fields

E.G. Lanza[a)], A. Vitturi[b)]

a)INFN Sezione di Catania

b)Dipartimento di Fisica "G. Galilei", Università di Padova

In recent years the properties of collective states in neutron-rich nuclei have been attracted a lot of attention due to the presence of dipole strength at low excitation energy well below the dipole giant resonance. Previous calculations have shown that this can be related to the neutron excess number. This strength, carrying few per cent of the isovector EWSR, is present in many isotopes and has been often associated to the possible existence of a new collective mode of new nature: the so called Pygmy Dipole Resonance (PDR).

These states are more pronounced in nuclei far from the stability line but its presence has been established also for very stable nuclei as ^{208}Pb. Indeed, their transition densities show the same features that characterize the well stablished low lying dipole state for the ^{132}Sn.

In this mode the isoscalar component is very strong. The compressional isoscalar dipole response shows that the amount of strength increase as one moves to neutron rich nuclei. The isoscalar and isovector components are strongly mixed as it is clearly manifested in their transition densities. This feature allows the possibility to study these low lying dipole states by using an isoscalar probe in addition to the conventional isovector one.

We show that investigation on the PDR can be carried out by excitation processes involving also the nuclear part of the interaction. The use of different bombarding energies, of different combinations of colliding nuclei involving different mixture of isoscalar/isovector components can provide the clue to reveal the characteristic features of these states. These analyses have been carried out on ^{132}Sn as well as on ^{208}Pb with different partners of the reaction. We found that the excitation induced by the nuclear part of the interaction is almost independent of the incident energy. On the contrary, in the Coulomb case the variation of the incident energies produces structurally different results. This is due to the well known adiabatic cut-off effect.

Therefore the relative population of the PDR with respect to the GDR may be changed by changing the parameters of the reactions. In particular, at low incident energy the excitation probability of the PDR state is sensibly high than the GDR one. Our results then suggest that the investigation of the PDR state can be better performed at low incident energy (below 50 MeV/nucleon). In fact, at these energies the PDR peak should not be masked by the presence of the low lying quadrupole and octupole states because of their narrow widths. On the contrary, at higher incident energy the PDR cross section is higher but its peak may be blurred by the strong tail of the giant resonance states.

Studies in GDR and GQR decay from hot rotating heavy nuclei

Indranil Mazumdar

Department of Nuclear & Atomic Physics,

Tata Institute of Fundamental Research,

Mumbai, 400 005, INDIA

The high energy gamma ray spectrum from the decay of GDR states in excited nuclei is a major source of information about the structural evolution and reaction dynamics of hot and rotating nuclei. In this talk, after a brief review of the current status of hot GDR studies, we will present an overview of our ongoing efforts in this direction. We will discuss exclusive measurements of phase-space selected GDR spectra in order to search for rare shape-phase transitions in heavy nuclei (A~190). Results of theoretical calculations predicting shape-phase transitions in hot nuclei will be presented. We will also discuss the results of our efforts to search for IVGQR decay from hot nuclei. The research and developmental work resulting in the commissioning of a 4p spin spectrometer, the coupling of the spin spectrometer with a gas filled recoil separator and setting up high energy gamma ray spectrometer of large volume Lanthanum Bromide detectors will also be discussed at length.

"Digital Pulse Processing for physics application"

Marco Locatelli

CAEN S.p.A

In recent years CAEN has developed a complete family of digitizers. Besides the use of the digitizers as waveform recorders (oscilloscope mode), CAEN offers the possibility to upload special versions of the FPGA firmware that implement algorithms for the Digital Pulse Processing (DPP); when the digitizer runs in DPP mode, it becomes a new instrument that represents a complete digital replacement of most traditional modules such as Multi Channel Analyzers, QDCs, TDCs, Discriminators and many others.

Application of the HICAM camera for imaging of prompt gamma rays in measurements of proton beam range

R.Peloso[1,2], P.Busca[1,2], C.Fiorini[1,2], M. Basilavecchia[3], T. Frizzi[3], D. Prieels[4], J. Smeets[5], F. Stichelbaut[4], A. Benilov[4], F. Roellinghoff[4]

[1]*Politecnico di Milano, Dipartimento di Elettronica e Informazione, Milano, Italy*

[2]*INFN, Sezione di Milano, Milano, Italy*

[3]*XGLab, Milano, Italy*

[4] *Ion Beam Applications S.A., Louvain-la-Neuve, Belgium*

[5] *Department of Nuclear Metrology, Université Libre de Bruxelles, Brussels, Belgium*

Particle therapy plays nowadays an important role in cancer treatment and growing research efforts are directed in this direction. Strength of this kind of therapy, in particular proton therapy, is related to the possibility to release the maximum of the dose in the target site destroying tumoral cells and limiting otherwise the dose to normal tissue, reducing at the same time the unwanted effect that such an action could induce. For this purpose, the measurement of the proton beam range in the target is very important and one method to reach this goal is based on the measurement of prompt gamma rays emitted by excited nuclei during proton irradiation. This work deals with the application of the recently developed HICAM (HIgh resolution CAMera) camera for the measurements of prompt gamma rays. The camera is composed by 25 Silicon Drift Detectors (SDDs) of 1cm^2 active area each, in a 5x5 format, characterized by a high quantum efficiency (>80%) and low electronic noise. The HICAM camera is characterized by a very high intrinsic resolution (~1mm) and has recently shown good performances both in clinical and pre-clinical measurements. Originally developed only for low-energy gamma-ray imaging in nuclear medicine (140keV of Tc99), in this work we have suitably modified the camera to adapt it to image higher energy prompt gamma rays (2-7MeV) emitted by a target irradiated by protons. The photodetectors are coupled with a LYSO crystal of 1cm thickness, a good compromise between improved detection efficiency and still satisfactory ratio between thickness/FOV. A first measurement session was made to assess the imaging capability of the system with a ^{60}Co source (1.17 MeV, 1.33MeV). The natural emission of Lutetium has also giving a significant component to the energy spectrum and suitable processing of signals has been introduced to minimize its contribution in the images. The ^{60}Co source was placed on the edge of a lead block (thickness of 4 cm) and moved from one boundary of the active area of the camera to the opposite one with steps of 0.5cm in order to cover all the detection area in longitudinal direction, 5cm. The counts of the 2D image are integrated along the vertical axis and reveal very well the edge profile or the irradiation of the source moving across the field of view. The second part of the trials was foreseen in a radiotherapy facility with the purpose to carry out a first experiment of prompt gammas for measurement of the proton range in the target. The experimental set up consists in a proton beam impinging on a PMMA target of 20 cm length. HICAM camera was used with a slit collimator to detect the prompt gammas emitted in a perpendicular direction with respect the beam one. The proton beam energy changed in a range between 100MeV and 160 MeV with a current that was set to be compatible with the capability and sensitivity of the HICAM camera. The results of these preliminary tests will be reported in this work as well as the discussion of future perspectives of the application of the camera in this framework.

This project received funding from the European Union Seventh Framework Program (FP7/2007-2013) under grant agreement n° 241851 and grant agreement n° 264552.

High resolution camera for gamma-ray spectroscopy and imaging in nuclear physics research

P.Busca[1,2], R.Peloso[1,2], C.Fiorini[1,2], N.Blasi[2], F.Camera[2,3], B.Million[2], O.Wieland[2]

[1]*Politecnico di Milano, Dipartimento di Elettronica e Informazione, Milano, Italy*

[2]*INFN, Sezione di Milano, Milano, Italy*

[3]*Università degli Studi di Milano, Dipartimento di Fisica, Milano, Italy*

In nuclear physics basic research and, particularly in gamma spectroscopy, the position sensitivity of a detector is extremely useful to reduce the Doppler Broadening effect in experiments where the gamma-ray source moves with high/relativistic velocity. In such kind of measurements, the energy of the gamma-rays emitted by the moving source is Doppler shifted and, in the energy spectra, the full absorption peak is broadened and degraded because of the finite size of the front face of the detector. Such effect becomes larger as the v/c of the source increases or the distance source-detector decreases. The localization of the interaction region of the gamma-ray inside the crystal will reduce or eliminate such effect recovering the intrinsic performances of the detectors.

For this purpose, gamma-ray detectors that could provide high position resolution in this high-energy range could be foreseen to be employed to recover from Doppler broadening . In this work we suggest the use of a Silicon Drift Detectors based gamma camera to exploit its good performance in terms of spatial resolution for this type of application in nuclear physics research. The camera used for this evaluation, has recently shown good performances for low-energy (140keV from Tc99) gamma-ray imaging thanks to its very high intrinsic resolution (~1mm) . The HICAM (High resolution gamma CAMera) camera is composed by 25 square-shaped SDD of $1cm^2$ of active area each, in a format 5x5, coupled to a CsI:Tl scintillator crystal.

The mechanical structure of the camera was adapted in order to allow the use of crystals with different sizes and thus to optimize the detection efficiency at high energies by choosing the suitable crystal thickness. The crystals foreseen for these studies have thickness of 1cm, 2cm and 5cm. Also the optical treatment of the crystal sides plays an important role in the camera performances and is therefore studied in this work. Different strategies were tested with the 2cm thickness crystal, manufacturing polished and rough sides and applying on the top different typologies of reflectors.To understand all these aspects a set of simulations was first planned in order to better exploit the performances of the camera. Tests with a fast crystal as $LaBr_3$ are also scheduled and results will be also reported and compared with the ones of CsI(Tl).

To preliminary test the HICAM camera with high energy gamma rays, a CsI:Tl crystal, 1 cm thick, was coupled to the photodetectors matrix and tested with a collimated 662 keV gamma source beam (collimator: 2mm diameter, 200mm length). The gamma source was firstly directed perpendicular to the detection head and the beam was shifted with steps of 5mm in 8 irradiation points which were then reconstructed by means of a centroid algorithm. All the points are well distinguishable with a measured spatial resolution of about 2mm, consistent with the nominal collimator spot size. The energy resolution, presently of about 14.7%, will be further optimized, considering also an unavoidable trade-off between spectroscopy and imaging performances, based on the choice of the optical treatment of the crystal surfaces. A similar test was repeated changing the incidence angle between the radiation beam and the detection surface. In particular, the beam was directed on one side of the scintillator, parallel respect the detection plane and the reconstructed image shows the absorption path inside the crystal.

The results of these tests will be reported in this work and a possible applications scenario will be outlined.

Friday 24th February: Morning Sessions

CHAIRMAN: G. COLO' (University of Milano and INFN)

9:00-9.30 **M. Matsuo** (Niigata University)
Surface pairing phenomena in neutron-rich nuclei

9:30-9:50 **E. Vigezzi** (INFN-Milano)
Calculation of absolute cross sections of two-nucleon transfer reactions

9:50-10.10 **N. Marginean** (IFIN-HH Bucharest)
In-Beam Fast Timing Experiments at the Bucharest TANDEM Laboratory

10:10-10.25 **J. M. Regis*** (Institut für Kernphysik der Universität zu Köln)
Fast Timing Characteristics of LaBr3(Ce) Scintillator plus XP20D0 Photomultiplier Detector Assemblies

10:25-10.55 **T. Neff** (GSI)
Fermionic molecular dynamics for the description of light nuclei

CHAIRMAN: T. AUMANN (GSI)

11:20-11.50 **O. Tengblad** (IEM-CSIC, Spain)
A proton and gamma calorimeter for the R3B set-up at FAIR

11:50-12:05 **H. Alvarez-Pol** (Univ. Santiago de Compostela, Spain)
Design and simulation of a calorimeter/spectrometer for the R3B setup: the CALIFA BARREL

12:05-12:30 **B. Pietras*** (GENP-USC, Spain)
The DemoZero for CALIFA BARREL: experimental and simulated results

T. Le Bleis * (T.U. Munich)
PID and plastic phoswitch for CALIFA for R3B

Surface pairing phenomena in neutron-rich nuclei

Masayuki Matsuo

Department of Physics, Niigata University, Japan

The pair correlation in neutron-rich nuclei may exhibit novel behaviors different from those seen in stable nuclei. Because of the small separation energy, neutrons in nuclei near the drip-line move outside the nuclear surface, forming a low density tail. Then the large scattering length of the n-n interaction is expected to cause an enhancement of the pair correlation in this surface region.

In this talk, I will discuss features and consequences of the expected surface enhancement of the pair correlation, using the modern density-functional theory, i.e. the Skyrme-Hartree-Fock-Bogoliubov mean-field model plus the quasiparticle random phase approximation. The calculations performed for neutron-rich Sn isotopes in a wide interval of A=110-150. I shall illustrate the surface pairing phenomena in terms of the compact Cooper pair, the anomalous pair vibration, and the enhanced two-neutron transfer cross sections.

Calculation of absolute cross sections of two-nucleon transfer reactions

Enrico Vigezzi

INFN Milano

Calculations of the absolute differential cross sections along the chain of superfluid tin isotopes will be presented. They are based on second order Distorted Wave Born Approximation, taking into account successive, simultaneous and non orthogonality contributions, and making use of BCS spectroscopic amplitudes which reproduce the overall distortion of the Fermi distribution. Theory provides an overall account of the experimental findings.

In-Beam Fast Timing Experiments at the Bucharest TANDEM Laboratory

Nicolae Marius Marginean

FIN-HH Bucharest

A mixed HPGe-LaBr3(Ce) gamma detector array suitable for in-beam fast timing measurements has been installed at the TANDEM Laboratory of IFIN-HH Bucharest. This setup was used intensively in experimental campaigns during the last three years. The performances of the array, the experimental and data analysis techniques used for in-beam fast timing measurements will be briefly illustrated, as well as several selected physics results.

Fast Timing Characteristics of $LaBr_3$(Ce) Scintillator plus XP20D0 Photomultiplier Detector Assemblies

J.-M. Régis, G. Pascovici, M. Rudigier, J. Jolie, A. Dewald, Ch. Fransen, A. Blazhev,
M. Büssing, M. Elvers, J. Endres, P. Petkov, N. Warr, K. O. Zell and A. Zilges

Institut für Kernphysik der Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany

5% cerium doped 1.5in. x 1.5in. cylindrical $LaBr_3$(Ce) scintillators have been investigated in combination with non-linear XP20D0 photomultiplier tubes. Fast timing experiments have been performed using conventional analogue constant fraction discriminators. The non-linear time walk characteristics also known as the "prompt curve" of the $LaBr_3$(Ce) detector timing assembly is measured using standard γ-ray sources. For 50 keV < E_γ < 1500 keV, the time walk of the centroid of the prompt response function is calibrated as a function of energy. Using the newly developed Mirror Symmetric Centroid Difference (MSCD) method for a two detector timing system triggering the start and stop of a time to amplitude converter, the combined γ-γ time walk for any energy combination is calibrated with absolute accuracy of 6-10 ps resulting in a lifetime determination limit of only 3-5 ps. The simple MSCD method providing cancellation of many possible systematic errors will be presented as well as results of picosecond lifetime measurements obtained using high resolution $LaBr_3$(Ce) scintillator detectors.

Ist Topical Workshop on Modern Aspects in Nuclear Structure
Advances in Nuclear Structure with arrays including new scintillator detectors
BORMIO 22 - 25 February 2012

Structure and Reactions of light Nuclei studied in Fermionic Molecular Dynamics

Thomas Neff

GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany

Fermionic Molecular Dynamics (FMD) is a microscopic many-body approach that uses Gaussian wave packets localized in phase space as single-particle basis states. Many-body basis states are Slater determinants projected on parity, angular momentum and linear momentum. The FMD basis is well suited to describe nuclei with clustering and halos. The effective interaction is derived from a realistic interaction using the Unitary Correlation Operator Method (UCOM).

We will present results for the calculation of the ^{4}He(α,γ)^{7}Be capture cross section within the FMD approach [1]. At large distances bound and scattering states are described by antisymmetrized products of ^{4}He and ^{3}He/^{3}H ground states. At short distances the many-body Hilbert space is extended with additional many-body wave functions obtained by variation after parity and angular momentum projection. These additional configurations are needed to represent polarized clusters and shell-model like configurations. Properties of the bound states like binding energies, charge radii and quadrupole moments are described well, as are the scattering phase shifts. The calculated *S*-factor agrees very well with recent experimental data both in absolute normalization and energy dependence.

We will also present recent results for the structure of the Beryllium isotopes [2]. Triggered by a measurement of the charge radius of ^{12}Be we performed new FMD calculations with a special emphasis on the evolution of the $N=8$ shell closure. We find that the observed increase of the charge radius in ^{12}Be with respect to ^{10}Be and also ^{11}Be is related to ^{12}Be ground state that is dominated by $(sd)^2$ configurations.

[1] T. Neff, Phys. Rev. Lett. **106**, 042502 (2011).

[2] A. Krieger *et al.*, accepted for publication in Phys. Rev. Lett.

A proton and gamma calorimeter for the R3B set-up at FAIR

O. Tengblad

IEM-CSIC, Spain

The R3B collaboration aims at a versatile reaction setup with high efficiency, acceptance, and resolution for kinematical complete measurements of reactions with the relativistic radioactive beams that will become available at the NUSTAR HIGH-ENERGY branch at FAIR. The experimental configuration is based on a concept similar to the LAND reaction setup at the existing GSI, introducing substantial improvement with respect to resolution and an extended detection scheme.

In this contribution we will discuss the Calorimeter that will surround the reaction target, with special emphasis on the R&D for the front end cap, where novel ideas of using LaBr+LaCl phoswich is considered.

Design and simulation of a calorimeter/spectrometer for the R^3B setup: the CALIFA BARREL

H. Alvarez-Pol, D. Cortina-Gil, I. Durán, M. Gascón, D. González-Caamaño, B. Pietras

for the R^3B collaboration

GENP - Universidade de Santiago de Compostela, Spain

CALIFA is the calorimeter proposed for the detection of gamma-rays and light charged particles originating from nuclear reactions induced by relativistic exotic beams [1]. It is intended to surround the target of the R3B experiment [2], a versatile reaction setup with high efficiency, acceptance, and resolution in order to obtain kinematically complete measurements of reactions induced by high-energy radioactive beams.

The requirements imposed on the CALIFA calorimeter reflect the wide spectrum of experiments to be performed employing this versatile setup. In certain spectroscopical physics cases, a high gamma energy resolution (~5% at 1 MeV) and multiplicity determination is requested. In others, the goal is to obtain a calorimetric response with high efficiency. Charged particles of moderate energy, as protons up to 300 MeV, should be identified with an energy resolution below 1%. Part of the complexity arises from the kinematics of the reactions, producing a large Lorentz boost and broadening, the correction of which should be accounted for by the detector.

To overcome these problems, a high granularity scintillator detector is foreseen. The detector is divided into two separate regions: a cylindrical-shaped BARREL, and an ENDCAP for the farthest forward angles. The BARREL section is based on CsI[Tl] crystals and large area advance photodiodes (LAAPDs). The crystal shape has been determined based on the optimization of several design criteria, namely energy resolution in the projectile frame, the use of a reduced set of different crystal shapes and the minimization of the space and material (wrapping and support structures) within the active volume [3]. The results obtained in a complete simulation of the calorimeter confirm its design capabilities to reconstruct the gamma energies within the required resolution in the projectile frame, being the geometrical contribution (originated from the angular uncertainties alone) below 4%. The use of long crystals is supported by the measured small dependence of the resolution with the crystal length [4].

Several prototypes has been constructed with the cristal configuration and geometry corresponding to the previous criteria and their response have been explored under realístic tests with protons of 180 MeV, at the Swedberg Laboratory in Uppsala, and high energy gammas in NEPTUN in Darmstadt, CNAM in Madrid and recently in the Technische Universität in München [5].

References

[1] http://www-land-gsi.de/r3b/docu/R3B-TP-Dec05.pdf

[2] T. Aumann et al. R3B Technical proposal. FAIR- PAC/NUSTAR/R3B (Jan 2005). http://www-land.gsi.de/r3b/

[3] H. Alvarez-Pol et al., Nucl.Inst.and Meth. B266 (2008) 4616-4620.

[4] M. Gascón et al., IEEETrans.Nuc.Sci 55 (2008)1259-1262.

[5] B. Pietras, contribution to this conference.

The DemoZero for CALIFA BARREL: experimental and simulated results

Ben Pietras, for the R3B collaboration,

GENP – Universidade de Santiago de Compostela, Spain

The forthcoming facility FAIR at GSI [1] will present the means to investigate a vast area of the nuclear chart for which only the most general properties have so far been observed. The beam energies required to both transport highly exotic nuclear species to the reaction target and to probe deeply-bound nucleons result in significant relativistic effects; these must be adequately addressed in the design of the experimental setup.

At the heart of the R3B physics program lies the CALIFA calorimeter, a huge multi-national effort intended to develop a calorimeter for the R3B physics program [2]. The necessary technical requirements are extremely exacting, given that the dynamic range to be covered spans from low energy gamma rays to 300 MeV protons, requiring a high energy resolution (from 1 to 10%) and high detection efficiency. A typical R3B experiment investigates interactions induced by projectiles at energies up to 1 A GeV (nominally 700 A MeV), at this energy range Lorentz boost and broadening effects are hugely significant, which necessitates a good angular resolution in order to accurately reconstruct the projectile-frame energy.

The demanding nature of the specifications to be met for CALIFA requires innovative technological advancements, including the novel use of Large Area Avalanche Photo Diodes (LAAPDs), a modern successor to Photo Multiplier Tubes (PMTs) which have several advantages [3]. These include safe operation within regions of magnetic field and a high quantum efficiency; the region of which corresponds well to the light output wavelength of CsI (Tl) [3].

Presented will be experimental results taken from the testing of the DemoZero CALIFA demonstrator. The DemoZero consists of 32 CsI(Tl) crystals in an 8x4 configuration, coupled to 10x20 APDs in a carbon fibre alveoli array.

Incident gamma-rays and protons, ranging up to 15 MeV and 17 MeV respectively, from a recent experiment undertaken at the Technische Universität München, demonstrating the effects of detector thresholds, multiplicity, energy reconstruction algorithms and overall detector performance, both for proton detection and at a range of gamma-ray energies. The contribution of non-obvious effects such as the non-linearity of light output at low energies [5] and methods to correct for this will also be discussed. Additionally, these results will be compared to theoretical predictions from in-depth Monte-Carlo simulations specific to the DemoZero geometry. The comparison is intended to serve not only as a validation of the simulations which have been used to guide the evolution of the CALIFA design so far, but also to investigate the performance of the analogue and digital electronics tested during the experiment.

References

[1] FAIR. http://www.gsi.de/portrait/fair.html

[2] R3B. http://www.gsi.de/forschung/kp/kp2/collaborations/R3B/Program.html

[3] M. Moszynski, *et al*. Nucl. Inst. and Meth. A497 (2003) 226-233.

[4] M. Gascón, *et al*, IEEE Trans. Nuc. Sci 56 (2009) 962-967.

[5] Guohao Ren, *et al*. Nucl. Inst. and Meth. A564(2006) 364-369.

PID and plastic phoswitch for CALIFA for R^3B

T. Le Bleis, M. Bendel, R. Gernhäuser and M. Winkel for the CALIFA collaboration.

Technische Universität München, Germany.

Following the building of the FAIR facility in Darmstadt (Germany), the R^3B setup will study the structure and reactions of exotic beams. Amongst the different detectors composing the setup, CALorimeter for In-Flight detection of γ-rays and high energy charged particles (CALIFA) has a considerable importance. CALIFA has a multi-particle detection capability and works as a calorimeter as well as a spectrometer covering the reaction target from the opening angle of the beam line to a polar angle of 130°. CALIFA is expected to work at a large dynamic range from 300keV to 300MeV with a resolution up to 1% in energy. The proposed detector is composed of a barrel and a forward end-cap separated at 43°.

The barrel is composed of almost 3000 NaI(Tl) crystals with different angles and shape facing the target. The readout of the crystals is made via Large-Area APDs (due partialy to the proximity with a strong magnetic dipole) and then connected to a fast samling ADC. The sampled amplitudes from different crystals are then gathered and processed in a FPGA. The use of a digital electronic allows for a programmable time discrimination and deposit energy reconstruction. Using the properties of the NaI(Tl), namely the two decay constants, an their relative weight, it is possible to identify the type of the particle detected. That identification is performed on-the-flight by the FPGA. Using available synchronisation of the electronic, it is possible to devise complex triggering method in order to focus on low-rate events. The complete electronics is, to some extend self-calibrating and offers the required dynamic and modularity expected from a detector that should last for more than a decade.

Due to the nature of the particles, the strong Doppler effect and the close vicinity with a magnetic field, the forward end-cap is still the subject of investigation. In particular, the nature of the calorimeter is being studied. Among the options are the following concepts: a phoswitch composed of a crystal of $LaBr_3$ followed by a crystal $ClBr_3$; and a NaI(Tl) crystal preceeded by a plastic scintillator. Those have the advantages of combining their calorimetric properties to a ΔE-E or ΔE-ΔE measurement, which is useful for the required dynamic range of the particles to be detected. The use of NaI(Tl) would allow for particle identification as in the barrel.

In this presentation, I will briefly introduce the CALIFA detector and its electronic. Then, I will present the algorithm developped for the in-flight particle identification and the results obtained in experiments with proton beam at the MLL Tandem accelerator of Munich. Finally, I will introduce the concept of the crystal-plastic scintillator and the results obtained in experiment and tests.

Friday 24th February: Afternoon Sessions

CHAIRMAN: S. LUNARDI (University of Padova and INFN)

17:00-17.15 **B. Fornal** (IFJ PAN, Krakow)
New experimental opportunities at the Krakow proton cyclotron

17:15-17.45 **M. Thoennessen** (MSU)
Going beyond the dripline with MoNA-LISA

17:45-18.00 **T. Marchi** * (University of Padova and INFN)
Intermediate energy Coulomb excitation in ^{74}Ni

18:00-18.15 **A. Gottardo** * (University of Padova and INFN)
Shell evolution and effective three-body forces in the newly-explored neutron-rich region around Z=82 and far beyond N=126

18:15-18:30 **A.I. Morales** * (INFN-Milano)
Beta-Decay Spectroscopic Studies Of The Neutron-Rich $^{211,212,213}Tl$ *And* ^{219}Bi *Isotopes*

18:30-18.50 **D. Cano-Ott** (CIEMAT, Madrid)
Neutron detectors and related physics

18:50-19.10 **J. Valiente-Dobon** (Legnaro Laboratory-INFN)
The NEDA project

19:10-19:30 **G. Jaworski** * (Warsaw Univ. of Technology)
How to build neutron multiplicity filter NEDA – simulations and experimental tests

A. Di Nitto * (INFN Napoli)
NEDA – Neutron Detector Array: comparison of digital and analogue pulse-shape discrimination of neutrons and γ*-rays*

New experimental opportunities at the Krakow proton cyclotron

Bogdan Fornal

Institute of Nuclear Physics, Polish Academy of Sciences, Kraków, Poland

In December 2012, a new Proteus-235 proton cyclotron should become operational at the Institute of Nuclear Physics PAN in Kraków. Together with the existing cyclotron AIC-144, it will be a part of the Cyclotron Center of Bronowice (CCB). The new cyclotron, equipped with a dedicated energy selector, will be able to deliver a fairly monoenergetic beam of protons in the energy range between 70 MeV and 230 MeV, and currents between 1 nA and 500 nA. Although the primary objective of the facility is proton cancer therapy, an extensive research program at this cyclotron is planned in the field of nuclear physics, radiobiology, dosimetry and medical physics. The nuclear physics projects that have been proposed so far encompass investigations of the dynamics of few-nucleon systems with emphasis on three-body forces, gamma-ray spectroscopy of giant nuclear resonances and discrete gamma-ray spectroscopy of short-lived isomers. Also, CCB can become a testing laboratory for devices developed by international collaborations within projects pursued at large facilities like FAIR, SPIRAL2 or SPES. During the presentation, the main characteristics of the facility will be shown in order to stimulate interest and discussion on possible other lines of research that might be carried out at CCB.

Intermediate energy Coulomb excitation in ^{74}Ni

T. Marchi[1,2], G. de Angelis[1], T. Baugher[3], D. Bazin[3], J. Berryman[3], R. Clark[4], E. Crawford[4], M. Doncel[5], A. Gade[3], A. Gadea[6], T. Glasmacher[3], A. Gottardo[1,2], F. Gramegna[1], S. McDaniel[3], C. Michelagnoli[2,7], D.R. Napoli[1], B. Quintana[6], A. Ratkiewicz[3], F. Recchia[2,7], E. Sahin[1], A. Shore[3], R. Stroberg[3], D. Weisshaar[3], K. Wimmer[3], R. Winkler[3]

[1] *INFN Legnaro National Laboratories, Legnaro (Pd), Italy*
[2] *Department of Physics, Padua University, Padua, Italy*
[3] *National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824-1421, USA*
[4] *Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA*
[5] *Ionizing Radiations Laboratory, University of Salamanca, Spain*
[6] *CSIC-IFIC, Valencia, Spain*
[7] *INFN Padua, Padua, Italy*

The study of the evolution of the shells far from stability provides useful information which can be linked to the shape and symmetry of the nuclear mean field. Nuclei with large neutron/proton ratio allow to probe the density dependence of the effective interaction. It has also been shown that tensor and three-body forces play an important role in breaking and creating magic numbers being a key element of the shell evolution along the nuclear chart.
Of particular interest is the region of ^{78}Ni. The spin-isospin non-central component of the nucleon-nucleon interaction is expected to modify the relative energies of the single particle states reducing the Z=28 energy gap for large neutron numbers. In such contest particle-hole excitations across the gap are expected to be strongly enhanced driving to enhanced collectivity. Lifetime measurements for the determination of the B(E2) values of the low lying transitions are therefore very important to constrain the interaction used for the shell model calculations.
We have recently measured the B(E2; 0+→2+) in ^{74}Ni using an intermediate energy Coulomb excitation measurement performed at NSCL (MSU). A secondary beam of ^{74}Ni with an intensity of ~ 2 pps was provided by the Coupled Cyclotron Facility of the NSCL. The ^{74}Ni ions were produced by fragmentation through the ^{86}Kr + ^{9}Be reaction at 150 MeV/u. Reaction products were analyzed using the S1900 fragment separator and, after Coulomb excitation, identified at the focal plane detector system of the S800 spectrograph. A total number of 24 10^6 ^{74}Ni events have been collected. An Au foil of 600 mg/cm^2 was used as secondary target. The first 2+ state of ^{74}Ni was Coulomb excited and the γ-rays emitted in the deexcitation of the level were measured using the 4π CAESAR array composed of 192 CsI(Na) scintillation crystals. A total of about 100 counts have been measured for the 1.022 MeV 2+ →0+ transition. The analysis of the data is presently going on. Preliminary results do not indicate an enhanced value for the electromagnetic transition matrix element.

Shell evolution and effective three-body forces in the newly-explored neutron-rich region around Z=82 and far beyond N=126

A. Gottardo[1,2], J.J. Valiente-Dobon[1], R. Nicolini[3], G. Benzoni[3]
and the Rising Collaboration
[1]*INFN, Laboratori Nazionali di Legnaro, Legnaro (Pd), 35020, Italy*
[2]*University of Padova, Padova, 35131, Italy*
[2]*University of Milan and INFN section of Milan, Milan, 20133, Italy*

The study of exotic nuclei has shown that significant changes of the well known shell structure along the stability valley occur. However, little is known on the neutron-rich nuclei around 208Pb, because of the experimental difficulties to reach such nuclei. The study of these heavy nuclei is relevant also for the understanding of the r-process stellar nucleosynthesis in heavy nuclei. Neutron-rich nuclei around 208Pb were populated by using a 1 GeV*A 238U beam at GSI. The resulting fragments were separated and analysed with the FRS-Rising setup. Many neutron-rich isotopes were identified for the first time and a significant number of new isomers were hence discovered, enabling to study the structure of these isotopes. The new exotic isotopes observed, extend up to 218Pb along the Z=82 shell closure and up to N=134 and N=138 for the proton-hole and proton-particle Tl and Bi nuclei, respectively. The very exotic 210Hg nucleus was also produced and studied: its unexpected structure will be discussed. In our talk, the experimental results will be presented within state-of-the-art shell-model calculations. The significant discrepancies between the experimental findings and the behaviour expected from the usual seniority scheme will be pointed out, showing how the inclusion of effective three-body interactions helps to improve the agreement between theory and experiment.

BETA-DECAY SPECTROSCOPIC STUDIES OF THE NEUTRON-RICH 211,212,213Tl and 219Bi ISOTOPES

Ana Isabel Morales Lopez

INFN - Sezione di Milano

The study of the beta-decay process in heavy neutron-rich systems is of main importance to probe the nuclear models used in r-process calculations. Experimental evidence is particularly interesting in nuclei approaching the waiting point A~195, since the r-process nuclei are still inaccessible in laboratory and the beta-decay models used to extrapolate their properties show strong discrepancies in their predictions [1,2].

Here we present the first results of an experiment focused on the investigation of the neutron-rich Pb isotopes, carried out within the “Stopped beam Campaign” of the RISING collaboration at GSI. The nuclei of interest were produced in fragmentation reactions of a relativistic Uranium beam impinging on a thick Be target. The residues were subsequently identified in the magnetic spectrometer Fragment Separator (FRS) and were finally implanted in the RISING Active Stopper [3]. This device consisted of nine Double Sided Silicon Strip Detectors (DSSSD) that recorded the position and time of implantations and beta-electrons. The characteristic gamma-ray transitions of the daughter Pb nuclei were registered using the RISING gamma-ray spectrometer [4], placed in close isotropic geometry around the Active Stopper.

The event-by-event position and time correlations between implantations and gamma-labeled radioactive electrons allowed us to measure the beta-decay half-lives of ^{211,212,213}Tl and ^{218,219}Bi , as well as the low-energy structure of their daughter nuclei ^{211,212,213}Pb and ^{218,219}Po. The comparison of the new lifetimes with the calculations of the nuclear models proposed to describe the r-process provides a significant experimental constraint to their validity near the third r-process abundance peak.

[1] P. Möller et al., Phys. Rev. C 67 (2003) 055802

[2] I.N. Borzov, Phys. Rev C 67 (2003) 025802

[3] R. Kumar et al., Nucl. Instr. Meth. A 598 (2009) 754

[4] S, Pietri et al., Nucl. Instr. Meth B 261 (2007) 1079

Neutron detectors in nuclear structure: status and future perspectives

D. Cano Ott

CIEMAT

The study of the structure of very neutron rich nuclei is intimately linked to the detection of neutrons. In β-decay studies, the β-delayed neutron emission process constitutes a decay mode whose importance increases with the number of excess neutrons, and it becomes dominant far enough from stability. Beta delayed neutron data are necessary for understanding a large variety of nuclear properties and phenomena, as well as applications. A few examples are the nucleosynthesis r-process path and the isotope abundances produced in massive stars, the nuclear structure and decay properties of exotic nuclei, and also nuclear technology driven applications such as the control and safety of Gen IV reactors. Thus, the adequate scientific exploitation of future radioactive ion beam facilities like FAIR, SPIRAL II, SPES or HIE-ISOLDE will require the use of high performance neutron detectos. An overview of the international projects around their construction and the future perspectives will be given.

How to build neutron multiplicity filter NEDA – simulations and experimental tests

G. Jaworski on behalf of NEDA Collaboration

Faculty of Physics, Warsaw Univ. of Technology, Warsaw, Poland;

Heavy Ion Laboratory, University of Warsaw, Poland;

INFN, Laboratori Nazionali di Legnaro, Legnaro, Italy.

Neutron-deficient nuclei, at the proton drip line or sometimes even beyond it, have been studied extensively in the past decades. This led (and still leads) to a considerable knowledge on these nuclei and associated physics – such as single-particle states, residual interactions between valence nucleons or proton-neutron coupling [cede11]. On the other hand, deeper and more fundamental questions arise from the available information, such as: Do we understand neutron-proton pairing and its influence in the isospin T=0 and T=1 channels? Which effects break isospin symmetry? Can we follow the demise of isospin for heavy N~Z nuclei or nuclei with a large proton excess? Where exactly is the proton drip line? Do proton skins or even halos exist?

The primary method of studying yrast and yrare states of extremely neutron deficient nuclei is by using heavy-ion induced fusion-evaporation reactions. In such experiments, gamma radiation is detected in powerful arrays of HPGe spectromers. The nuclei of interest are however produced with very low cross sections and clean reaction channel selection is essential. The best method of such selection is by detection of neutrons and charged particles emitted from the compound nucleus. In fact, this is the efficiency and quality of the detection of particles which determines the limits of acquiring experimental information on more and more exotic and interesting structures. As the most interesting reaction channels are almost always associated with the emission of at least two neutrons, constructing a new powerful neutron detector array – a neutron multiplicity filter – is a key point here. The NEDA project aims at building an array which will have efficiency for clean detection of events with two neutrons emission 4-6 times higher then existing arrays and will enable registering events with even larger neutron multiplicity.

Experimental and simulation results will be shown concerning optimal unitary cell for the NEDA array, as well as comparing properties of BC501A (proton-based) and BC537 (deuter-based) scintillators.

NEDA – Neutron Detector Array: comparison of digital and analogue pulse-shape discrimination of neutrons and g-rays

A. Di Nitto[1)], G. Jaworski[2,3,4)], T. Huyuk[5)], A.Pipidis[4)],P.-A. Soderstrom[6)], J. J. Valiente-Dobon[4)], J. Agramunt[5)], G. De Angelis[4)], M. N. Erduran[7)], S. Erturk[8)], A. Gadea[5)], G. La Rana[1,9)], J. Nyberg[6)] and M. Palacz[3)]

1)INFN, Sezione di Napoli, Napoli, Italy

2)Faculty of Physics, Warsaw University of Technology, Warszawa, Poland

3)Heavy Ion Laboratory, University of Warsaw, Warszawa, Poland

4)INFN, Laboratori Nazionali di Legnaro, Legnaro (Padova), Italy

5)IFIC-CSIC, Universitat de Valencia, Valencia, Spain

6)Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden

6)Department of Physics, Istanbul University, Istanbul, Turkey

7)Nigde Universitesi, Fen-Edebiyat Falkultesi, Fizik Bolumu, Nigde, Turkey

8)Dipartimento di Scienze Fisiche dell'Universita di Napoli, Napoli,

In nuclear-structure physics, especially while exploring unknown regions of the chart of nuclides, the experimenter needs to carefully address the identification of the products from nuclear reactions. The reaction channel selectivity can be achieved through the detection of all, or at least as many as possible, of the emitted light particles (mainly neutrons, protons, and/or alpha particles). However, since the neutrons are more challenging to deal with, a clean and efficient detection of the number of emitted neutrons in each reaction is a critical matter. To this end, a new, neutron-detector array (NEDA) has been conceived, based on the previous knowledge acquired by its predecessor (the Neutron Wall). NEDA will be made of a large number of closely-packed liquid-scintillator detectors suitable for detection of neutrons, in the energy range 0.1−20 MeV. NEDA will be coupled to γ-ray germanium arrays such as AGATA, EXOGAM2 and GALILEO for γ-ray spectroscopic studies.

The aim of the project is to design and build an array with the highest possible neutron detection efficiency, excellent discrimination of neutrons and γ rays, and a very small neutron-scattering probability. At LNL-INFN, we have been testing two types of prototype detectors. The first type involves detectors with the traditional BC501A scintillator liquid, whereas the second type consists of detectors made of the deuterated scintillator liquid BC537.

The main focus of the talk is on the detection of pulses corresponding to low-energy deposition in the detector, since in this case the neutron gamma discrimination is more difficult and the needs for improvements are larger.

The acquisition system is based on a fast sampling analogue-to-digital converter and digital pulse-processing techniques have been adopted. Several different digital neutron-gamma discrimination algorithms have been adopted and the discrimination quality was compared with what could be achieved with an analogue system.

The results regarding the performances of these detectors will be presented.

Saturday 25th February: Morning Sessions

CHAIRMAN: P. VAN DUPPEN (K.U. LEUVEN)

9:00-9.30 **P. Egelhof** (GSI)
The EXL Project @FAIR

9:30-9:55 **P. Doornenbal** (RIKEN, Japan)
In-beam gamma-ray spectroscopy at the RIBF: From DALI2 to SHOGUN

9:55-10.15 **D. Balabanski** (IRNE-BAS, Bulgaria)
Structure of the iodine nuclei when approaching the N = 82 shell

10:15-10.35 **L. Fraile** (Institut Universidad Complutense de Madrid, Spain)
Development towards FATIMA, a fast timing array for DESPEC

10:35-10.55 **O. J. Roberts*** (University of Brighton, UK)
Development of a Fast Timing LaBr3(Ce) Array for NuSTAR

B. Bruyneel * (CEA-Saclay, France)
Geant4 studies for FATIMA

CHAIRMAN: J. STYCZEN (IFJ PAN, Krakow)

11:20-11.50 **A. Krasznahorkay** (ATOMKI, Debrecen, Hungary)
Neutron-skin thicknesses from giant resonance studies

11:50-12:05 **L. Stuhl *** (ATOMKI, Debrecen, Hungary)
Study of the neutron skin and giant resonances with low energy neutron detector (LENA)

12:05-12:25 **D. Santonocito** (Laboratori Nazionale del Sud-INFN, Catania)
Recent results from MEDEA

12:25-12:40 **T. Parascandolo*** (University of Padova and INFN)
Dynamical Dipole Mode In Fusion Heavy-Ion Reactions By Using Stable And Radioactive Beams

The EXL[1] Project @ FAIR

P. Egelhof

GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

The experimental conditions at the future international facility FAIR will provide unique opportunities for nuclear structure studies on nuclei far off stability, and will allow to explore new regions in the chart of nuclides of key importance for nuclear structure and nuclear astrophysics. In particular, the predicted intensities of radioactive beams will allow for the investigation of direct reactions with stored and cooled radioactive beams interacting with internal H, He, etc. targets of the new storage ring NESR. This technique enables high resolution measurements down to very low momentum transfer and provides a gain in luminosity from accumulation and recirculation of the radioactive beams. The design of a complex detector setup is presently investigated by the EXL collaboration with the aim to provide a highly efficient, high resolution universal detection system, applicable to a wide class of reactions. It includes a detector array for recoiling target-like reaction products and gamma-rays, surrounding the internal target, as well as a forward detector for fast ejectiles, and an in-ring spectrometer for the detection of beam-like reaction products. A brief overview on the research objectives, the technical concept and the present status of the EXL project, as well as on feasibility studies and first experiments performed or planned at the present ESR storage ring, paving the way towards the full EXL experiment at FAIR, will be presented.

[1] EXL: EXotic nuclei studied in Light-ion induced reactions at the NESR storage ring

In-beam gamma-ray spectroscopy at the RIBF: From DALI2 to SHOGUN

Pieter Doornenbal

RIKEN

In the Radioactive Isotope Beam Factory (RIBF) stable primary beams of energies up to 345 MeV/nucleon are used to produce radioactive isotope beams via in-flight separation with the BigRIPS fragment separator. In in-beam gamma-ray spectroscopy experiments these beams are incident on a secondary target and the reaction residues are detected by the spectrometer ZeroDegree.

In my presentation I will report on recent in-beam gamma-ray spectroscopy results using our NaI(Tl) based device DALI2 and our developments for a next-generation scintillator-based spectrometer, SHOGUN. With this array we plan to take advantage of the high intrinsic resolution of LaBr3 material. Besides detailed simulation results of possible configurations preliminary test results of prototype crystals will be shown.

Structure of the Iodine Nuclei When Approaching the N = 82 Shell

D. Balabanski

IRNE-BAS, Bulgaria

Excited states in the $^{128,129}I$ nuclei, which lie in the vicinity of the N = 82 shell, were studied with a mixed HPGe-LaBr3(Ce) gamma detector array at the TANDEM Laboratory of IFIN-HH Bucharest. The level schemes of these isotopes were extended significantly and in a few cases lifetimes of excited states were measured with the in-beam fast timing techniques. The results are discussed in the framework of TRS and IBFM calculations.

Development towards FATIMA, a fast timing array for DESPEC

Luis M Fraile for the FATIMA Collaboration

Grupo de Física Nuclear, Universidad Complutense de Madrid, 28040 Madrid, Spain

The measurement of absolute nuclear transition probabilities is a very sensitive tool to study the structure of the atomic nucleus. Direct access to transition rates can be achieved via the lifetime of the nuclear levels de-populated in radioactive decay. The Advanced Time-Delayed (ATD) method, or Fast Timing, is a well-established technique to measure lifetimes down to a few ps. The development of the technique was based on the use of BaF_2 detectors, but a recent major breakthrough occurred with the introduction of $LaBr_3$(Ce) detectors, uniting excellent time response with much superior energy resolution than BaF_2 crystals.

FATIMA, the FAst TIMing Array for DESPEC tries to profit from recent developments in detector and photosensor technologies, and new data processing techniques, to design and build the ultimate fast timing array. The aim is to achieve the best possible time resolution with a scintillator-based spectrometer, in combination with good energy resolution, in order to measure the half-lives of excited states in exotic nuclei at FAIR. The presentation will cover some of the latest tests of new scintillator materials and the optimization the scintillator crystal shape, in order to achieve the best performance compatible with the geometry set by DESPEC. Recent tests of fast photomultipliers will be described. An overview of the aims and status of the project will also be given.

Development of a Fast Timing $LaBr_3$(Ce) Array for NuSTAR

O.J.Roberts

School of Computing, Engineering and Mathematics, University of Brighton, Brighton BN2 4GJ, UK

A relatively new scintillator, $LaBr_3$(Ce) has become increasingly popular in the field of nuclear physics due to its exceptional timing properties, and reasonable energy resolution. Consequently, as part of the UK NuSTAR grant, a new fast timing array is currently under development for use at the future Facility for Antiproton and Ion Research (FAIR). The array will be used to measure the half-lives of excited states in exotic nuclei at the FRS/SuperFRS, ushering in a renaissance of physics, particularly within the field of decay spectroscopy. FAIR will also allow access to r-process, neutron-rich nuclei. Here, the next generation neutron detectors can be used with other detectors, such as the Advanced Implantation Detector Array (AIDA), and the fast timing array detectors to determine the life-time, neutron separation energies and branching ratios of these exotic nuclei. This information can later be used to further research into our understanding of nucleo-synthesis in supernovae.

This presentation will aim to explore the design of the UK fast timing array based on the requirements set-out by the collaboration. In order to determine the maximum efficiency of the array while maintaining the intrinsically good timing properties of the detectors, Monte-Carlo simulations will be carried out for 1, 1.5 and 2" cylindrical and conical detectors. These simulation studies will determine the final design of the array based on criteria of efficiency as a function of gamma-ray energy, and timing performance. The simulations will be validated by previous experiments at Bucharest and GSI, where sub-nanosecond life-time measurements were successfully performed in ^{138}Ce. These results will dictate the final design, and how it will be used in future experimental conditions.

Geant4 studies for FATIMA

Bruyneel Bart

CEA-Saclay DSM/IRFU/SPhN, 91191 Gif-sur-Yvette, France

FATIMA (FAst TIming Array) will consist out of a High efficient LaBr3:Ce array utilizing the ultra fast timing method for the determination of level lifetimes in the range from ~1 ps to ~30 ns. New technologies based on novel scintillation materials and photo-sensors are evaluated for the development of this technique both for decay and in beam studies. Some of the properties of the array can be predicted without the need of developing the full electronics chain. These features comprise efficiency and energy resolution, but Geant4 enables also to properly simulate light yield and time response. This allows optimizing detectors shape and size and makes it possible to provide realistic physics generators.

Determination of neutron-skin thickness from giant-resonance studies

A. Krasznahorkay for the R^3B and EXL collaborations

Inst.of Nucl. Res. of the Hung. Acad. of Sci. (ATOMKI), H-4001 Debrecen, P.O. Box 51, Hungary

Recent progress in development of radioactive beams has made it possible to study the structure of nuclei far from stability. An important issue is the size of the neutron skin of unstable neutron-rich nuclei, because this qualitative feature of nuclei may provide fundamental nuclear structure information. By measuring precisely the thickness of the neutron skin one may constrain the symmetry-energy term of the nuclear equation of state. The precise knowledge of the symmetry energy is essential not only for describing the structure of neutron-rich nuclei, but also for describing of the properties of the neutron-rich matter in nuclear astrophysics. In the first part of my talk I am going to review a few different experimental methods, which could be used with radioactive beams.

In a recent experiment we performed at GSI Darmstadt in the frame of the R^3B collaboration, dipole resonances were excited in the ^{124}Sn(*p,n*) reaction in inverse kinematics. The low-energy neutrons were measured with a novel time-of flight (ToF) spectrometer called LENA (low-energy neutron array), developed in Debrecen. The excitation energy in ^{124}Sb was determined from the energy and angle of the neutrons. The γ-decay was also measured in coincidence with the neutrons by modern, large volume 3.5″ × 8″ $LaBr_3$ detectors assembled in Milano. A broad giant-resonance peak was observed at an energy of 13.05 MeV with a width (FWHM) of 4.3 MeV. According to the excitation energy of the dipole strengths, which centers at about 26 MeV excitation energy, we must have excited the antianalog of the giant dipole resonance (AGDR). The gamma-decay of such resonance is expected to the antianalog of the isobaric analog state (AIAS) in ^{124}Sb.

According to our schematic RPA calculations, the energy of the AGDR depends very sensitively on the neutron-skin thickness. I am going to demonstrate, that the thickness of the neutron skin can be deduced from the energy of such giant resonance. Based on our experimental results, we are suggesting a new method for determining the neutron-skin thickness in radioactive nuclear beams.

Onset of the quenching of the Giant Dipole Resonance in nuclei of mass A ~ 120-130

D. Santonocito[a], D.Huang[a], Y. Blumenfeld[b], C. Maiolino[a], C. Agodi[a], R. Alba[a], G. Bellia[a,c], R. Coniglione[a], F.Delaunay[b], A. Del Zoppo[a], P. Finocchiaro[a], N. Frascaria[b], F. Hongmei[a], V. Lima[b], E. Migneco[a,c], P. Piattelli[a], P. Sapienza[a], J.A. Scarpaci[b]

a) INFN - Laboratori Nazionali del Sud, via S.Sofia 62, I-95123 Catania, Italy

b) Institut de Physique Nucleaire, IN2P3-CNRS, F-91406 Orsay, France

c) Dipartimento di Fisica e Astronomia dell'Università di Catania, via S. Sofia 64 , I-95123 Catania, Italy

The disappearance of collective motion with increasing temperature provides additional information on the properties of hot nuclear matter and can be an additional signature of a phase transition.

We have carried out a detailed study of the saturation of the Giant Dipole Resonance γ-ray yield in hot nuclei. From the systematics is known that up to approximately 250 MeV excitation energy the GDR properties remain remarkably stable [1]. Its energy remains constant equal to the ground state energy, the width increases smoothly from about 5 MeV at zero temperature to 12 MeV at about 150 MeV excitation energy and then it saturates. The gamma multiplicity from GDR decay increases as a function of excitation energy in agreement with 100% of the energy weighted sum rule strenght. In previous experiments performed at GANIL to measure the gamma decay of GDR in hot nuclei produced in incomplete fusion reactions at excitation energies ranging from 350 and 550 MeV a saturation of the GDR γ-multiplicity was observed [2]. This behavior can be qualitatively understood by several models which predict a gradual quenching of the GDR g-emission taking into account the equilibration time of the dipole oscillations with the different degrees of freedom of the hot compound nucleus.

In order to investigate the evolution of the GDR properties in the energy region where the saturation is expected to set in and to extract the energy dependence of the quenching we have studied hot nuclei of mass around 130 with excitation energies between 160 and 350 MeV. Hot nuclei were produced by means of fusion reactions induced by 17 and 23 MeV/A ^{116}Sn beams delivered by the Superconducting Cyclotron of the Laboratori Nazionali del Sud impinging on ^{12}C and ^{24}Mg targets. The GDR properties were studied through its gamma decay using MEDEA multi-detector in coincidence with evaporation residues which were focalized using the SOLE solenoid on the MACISTE telescope system. Identification of the fusion-like residues was performed by means of time of flight. The evaluation of the excitation energies attained in the different reactions was deduced through the measurement of the evaporation residues velocities and the analysis of light charged particles. Some preliminary results will be presented.

[1] J.J. Gaardhoje, Annu. Rev. Nucl. Part. Sci. 42 (1992) 483

[2] D.Santonocito and Y.Blumenfeld, EPJ A30 (2006) 183

DYNAMICAL DIPOLE MODE IN FUSION HEAVY-ION REACTIONS BY USING STABLE AND RADIOACTIVE BEAMS

C. Parascandolo[a], D. Pierroutsakou[b], R. Silvestri[c], C. Agodi[d], R. Alba[d], A. Boiano[b], R. Coniglione[d], E. De Filippo[e], A. Del Zoppo[d], U. Emanuele[f], F. Farinon[g] , A. Guglielmetti[h], G. Inglima[c], M. La Commara[c], C. Maiolino[d], B. Martin[c], C. Mazzocchi[h], M. Mazzocco[a], P. Molini[a],M. Romoli[b], M. Sandoli[c], D. Santonocito[d], C. Signorini[a], F. Soramel[a], A. Trifirò[f] and M. Trimarchi[f]

[a]Università di Padova, and INFN - Sezione di Padova via F. Marzolo 8, I-35131 Padova, Italy
[b]INFN - Sezione di Napoli, via Cintia, I-80126 Napoli, Italy
[c]Università degli Studi di Napoli "Federico II" and INFN, Sezione di Napoli, via Cintia, I-80126 Napoli, Italy
[d]INFN - LNS, via Santa Sofia 62, I-95125 Catania, Italy
[e]INFN - Sezione di Catania, 95123, Catania, Italy
[f]INFN, Gruppo Collegato di Messina and Dip. di Fisica, Università di Messina, Messina, Italy
[g]GSI, Planckstrasse 1, D-64291, Darmstadt, Germany
[h]Università degli Studi di Milano and INFN - Sezione di Milano, via Celoria 16, I-20133 Milano, Italy

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 γ-ray emission from the more charge asymmetric channel was evidenced, in the Giant Dipole Resonance energy range. The beam energy dependence of this extra γ yield was extracted by comparing the results obtained at different beam energies [2-5]. The first angular distribution data taken at E_{lab}= 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 E_{lab}= 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.

References

[1] S. Flibotte et al., Phys. Rev. C77 (1996)1448
[2] D. Pierroutsakou et al, Eur. Phys. J. A17. (2003) 71
[3] D. Pierroutsakou et al., Phys. Rev. C71 (2005) 054605
[4] B. Martin et al., Phys. Lett. B664 (2008) 47
[5] D. Pierroutsakou et al., Phys. Rev. C 80 (2009) 024612
[6] A. Corsi et al., Phys. Lett. B 679 (2008) 197
[7]V. Baran et al., Phys.Rev.Lett. 87(2001)182501
[8] V. Baran et al., Phys. Rev. C79 (2009) 021603(R)

Saturday 25th February: Afternoon Sessions

CHAIRMAN: T. MOTOBAYASHI (RIKEN)

17:15-17.45 **P. Van Duppen** (Leuven)
Recent results from ISOLDE: shape coexistence in the lead region studied through Coulomb excitation

17:45-18.15 **N. Kalantar** (KVI/RuG)
Three-nucleon forces and and their importance in three-nucleon systems and heavier nuclei

18:15-18.35 **F. Gramegna** (Legnaro Laboratory-INFN)
Fazia: a detector for nuclear thermo(dynamics)physics using Stable and Exotic beams at SPES and SPIRAL2

18:35-18.55 **D. LoPresti** (Catania University and INFN)
A real time, large area, high space resolution tracker

18:55-19:15 **J. Sharpey Shafer** (Universities of Western Cape, Johannesburg)
The Study of Yrare States with a Medium Sized Array, AFRODITE

19:15-19.35 **C. Ur** (Legnaro Laboratory-INFN)
The GALILEO project

Recent Results from ISOLDE: shape coexistence in the lead region studied through Coulomb excitation

Piet Van Duppen

Instituut voor Kern- en Stralingsfysica, KU Leuven, Belgium

Shape coexistence whereby quantum states with different deformation occur at low energy in the same nucleus has been observed in different regions of the nuclear chart, mainly around closed proton- and/or neutron shells [1]. This phenomena has recently gained renewed interest in the lead region (Z=82) around neutron mid-shell (N=104) through laser spectroscopy measurements [2], decay studies [3] and Coulomb excitation experiments using the radioactive beams from the ISOLDE CERN facility.

In this contribution we will present and discuss these recent findings, compare the results with beyond-mean field calculations [4] and give an outlook of the prospective offered by the HIE-ISOLDE project.

[1] K. Heyde and J.L. Wood, Rev. Mod. Physics 83 (2011) 1467

[2] T.E. Cocolios, et al., Phys. Rev. Lett. 106 (2011) 052503

[3] J. Elseviers et al., Phys. Rev. C84 (2011) 034307

[4] M. Bender and P.H. Heenen, Phys. Rev. C78, 024309 (2008).

Three-nucleon forces and and their importance in three-nucleon systems and heavier nuclei

N. Kalantar-Nayestanaki
KVI, University of Groningen, Groningen, The Netherlands

It has long been established that the calculation of the binding energies of light nuclei based on two-nucleon forces produces results which are in complete disagreement with experimental observations. The same disagreements are also present for excited states of nuclei. With modern theoretical methods, one can extend the studies to heavier systems and also there, it is observed that two-nucleon forces fail in predicting the nuclear properties. One of the main ingredients being considered presently is three-nucleon force. This force can, however, be best studied in few-nucleon systems for which exact calculations exist.
Three- and four-nucleon systems have been studied in detail at KVI and other laboratories around the world in the last few years. Two categories of reactions have been chosen to investigate these systems, namely elastic and break-up reactions in proton-deuteron and deuteron-deuteron scattering in which only hadrons are involved, and proton-deuteron capture reaction involving real and virtual photons in the final state. In this presentation, results of the first category will be discussed to show how far we have come in the understanding of three-nucleon forces.

FAZIA: A Detector for Nuclear (Thermo)Dynamics Physics using Stable and Exotic beams @SPES &SPIRAL2

Fabiana Gramegna

Laboratori Nazionali di Legnaro

For the FAZIA COLLABORATION

The forthcoming facilities for radioactive ion beams represent a challenge for the next generation of nuclear physics experiments. The nuclear structure as well as the thermodynamics and dynamics of excited exotic nuclei far from the stability valley can be studied. In particular, in the equation of state of nuclear matter it will be possible to explore the dependence of the symmetry energy term on isospin, temperature and density. The aim of the FAZIA collaboration, which is grouping together more than 10 institutions in Nuclear Physics, is the definition and construction of a 4π array for charged particles, with high granularity and good energy resolution, with A and Z identification capability over the widest possible range. It will use the up-to-date techniques concerning detection, signal processing and data flow, with full digital electronics.

The FAZIA collaboration is investigating since several years the use of silicon detectors and of digital sampling techniques: the results of recent works will be discussed. They stress the importance of an accurate control of the used-detector properties, like the resistivity non-homogeneity and the silicon crystal orientation. For optimal performances, the detectors should have a very good resistivity uniformity (around 1%) and channeling effects should be avoided via an off-axis cut of the original ingot.

The demonstrator of FAZIA, made by 192 telescopes will be coupled to existing apparatuses (INDRA, GARFIELD, CHIMERA) to perform experiments in the medium-range plan, waiting for the SPES and SPIRAL2 exotic beams.

"A real time, large area, high space resolution tracker"

D. LoPresti

Catania University

"A new detection system both for tracking and measurement of the residual range, designed and developed with the aim of achieving real-time imaging, large detection areas with high space and time resolutions. The tracker has been designed and tested as a prototype, with a large area of 20 x 20 cm2, consisting in two ribbons of scintillating fibers positioned in the classic bi-dimensional scheme. The prototype uses Saint-Gobain, 500 micron multi-cladding BCF-12 Sci-Fi with square section. The track position information is extracted in an innovative way, using a reduced number of electronics channels."

The Study of Yrare States with a Medium Sized Array, AFRODITE

J F Sharpey-Schafer§, R A Bark¶, S P Bvumbi₪, T S Dinoko§, E A Lawrie¶, J J Lawrie¶, S N T Majola*, S M Mullins¶, J N Orce§, P Papka#, B M Nyakó†, K Nyakó† and M Wiederkind¶.

*§Universities of Western Cape, ₪Johannesburg, *Cape Town and #Stellenbosch, South Africa.*

¶ iThemba Laboratory for Accelerator Based Sciences, PO Box 722, Somerset-West, ZA-7129 South Africa

† ATOMKI, Debrecen, Hungary

The AFRODITE array at iThemba LABS, South Africa, consists of 9 standard HPGe Clover detectors in BGO shields plus a variety of other detectors, including DIAMANT and a detector of low velocity recoils. An overview of the research programme will be given which includes the study of collective states and their coupling to odd nucleons, searches for hints of tetrhedral shapes, chiral bands and the use of direct reaction, such as (^{3}He,n).

GALILEO: the anatomy of a gamma-ray array

Calin A. Ur

INFN Sezione di Padova, 35131 Padova, Italy

GALILEO is a project aiming to the building of a 4pi high-resolution gamma-ray array by using GASP tapered detectors and capsules of the EUROBALL Cluster detectors. The array will be located at the National Laboratories of Legnaro where stable beams are provided by the Tandem-ALPI-PIAVE accelerator complex and, in the future, exotic radioactive ion beams will be delivered by SPES.

One of the most innovative activities of the project is the transformation of the original EUROBALL 7-capsules cluster detectors in triple cluster detectors. The triple cluster detectors will be placed on a ring at 90 degrees with respect to the beam axis while the GASP tapered detectors will cover symmetrically the forward and backward angles. R&D activities are conducted for the development of a complete cryostat for the triple cluster detector and for building new anti-Compton shields optimized for the shape of the new triple cluster detector.

The development of the front-end, digital sampling, preprocessing and readout electronics is advancing in synergy with the recent developments made or ongoing for the AGATA project.

A strong physics case, based on Letters of Intent submitted by several research groups from all over the world, supports the building of the GALILEO array. The research topics contained in the Letters of Intent cover a wide range of high current interest and experimentally challenging subjects in the field of the nuclear structure investigation by the means of the gamma-ray and particle spectroscopy. Topics at the forefront of the experimental and theoretical physics concern the study of nuclei at the edge of stability from the N=Z line to the neutron-rich regions. Subjects such as isospin symmetry in isobar multiplets and mirror nuclei, study of the critical point symmetries, excitation of exotic collective modes, measurement of astrophysical interest cross sections or identification of high-lying isomers acting as waiting points for the s-processes, are only a few examples of proposed study cases. Experiments propose achievement of full spectroscopy of selected nuclei, lifetime measurements with the Doppler shift or fast timing techniques, g-factors and quadrupole moments and transition probabilities measurements in Coulomb excitation and multi-nucleon transfer reactions.

The accomplishment of the proposed experiments is challenging from the experimental point of view and requires the coupling of the gamma-ray array to state-of-the-art ancillary detectors such as the EUCLIDES light charged particle detector, the DANTE MCP array, the RFD recoil detector, the Cologne plunger, the TRACE E-DE Si pixel detector, neutron detectors (n-Ring, N-Wall, NEDA), the LUSIA array of DSSSD detectors, arrays of MW-PPAC. The holding structure of the gamma-ray array is designed in such a way to allow for an easy coupling to a wide range of ancillary detectors.

The talk will make an overview of the status and perspectives of the GALILEO project within the general context of the gamma-ray spectroscopy activity at the National Laboratories of Legnaro.