XX

REUNIÃO DE TRABALHO SOBRE FÍSICA NUCLEAR NO BRASIL

PROGRAMA E RESUMOS

de 31/08 a 04/09 de 1997, Clube dos 500, Guaratinguetá, SP

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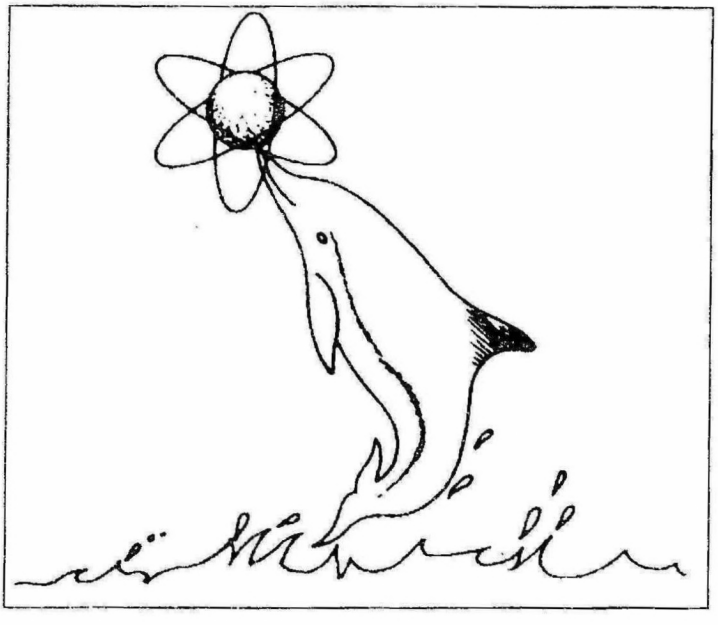

XX REUNIÃO DE TRABALHO SOBRE FÍSICA NUCLEAR NO BRASIL

31 de agosto a 04 de setembro de 1997
Clube dos 500, Guaratinguetá, SP

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Índice

	31/08	01/09	02/09	03/09	04/09
		Sessões Temáticas			
		Estrutura Nuclear	Interação Nucleon-Nucleon	Reações Nucleares	
08:30		C. Bertulani	B. Loiseau	L. C. Maximon	Saída
09:10		P. Ring	R. Machleidt	A. Lepine-Szily	
09:50		Café			
10:20		A. O. Macchiavelli	M. Robilotta	L. F. Canto	
11:00		R. Ribas	J. Tjon	C. N. Papanicolas	
11:40		G. Maiano	T. Frederico	D. Pereira	
12:20		Almoço			
14:00		Comunicações Orais			
15:30		Café			
		Palestras e Atividades Gerais			
15:45		Painéis			
17:00	Chegada	C. Robilota	A ser definido	Máquinas	
18:00	Coquetel	Grupos de Trabalho	Grupos de Trabalho	Máquinas	
19:00		Grupos de Trabalho	Grupos de Trabalho	Assembléia	
20:00		Jantar			

02/09 - Sessão Paralela - Física Nuclear Aplicada

10:20	D. Elmore
11:00	
11:40	W. Treimer
12:30	Almoço
14:00	Comunicações Orais

Conferencistas Convidados

- **Estrutura Nuclear**

C. Bertulani - UFRJ (Brasil) - Multiphonon Resonant States
A.O. Macchiavelli - Berkeley (USA) - Highlights from GAMMASPHERE
G. Maino - ENEA (Itália) - Weak Processes as a Probe of Nuclear Structure far from the Stability
R. Ribas - USP (Brasil) - g-factor of Magnetic Rotational States in Pb Isotopes
P. Ring - Munique (Alemanha) - Relativistic Description of Drip Line Nuclei

- **Interação Nucleon-Nucleon**

T. Frederico - CTA (Brasil) - Renormalization in Few Nucleon Systems
B. Loiseau - Paris (França) - A Review of the Nucleon-Nucleon Paris Potential
R. Machleidt - Idaho (USA) - Nuclear Forces and Nuclear Structure
M. Robilotta - USP (Brasil) - Chiral Symmetry and Nucleon-Nucleon Interaction
J. Tjon - Utrecht (Holanda) - Relativity and the Nuclear Interaction

- **Reações Nucleares**

L. F. Canto - UFRJ (Brasil) - Nuclear Reactions with Exotic Nuclei
D. Pereira - USP (Brasil)- Non Local Effects in Heavy-Ion Scattering
A. Lepine-Szily - USP (Brasil) - Experimental Studies of Exotic Nuclei
L. C. Maximon - Washington (USA)
C. N. Papanicolas - IASA (Grécia) - The Issue of the "Deformation" of the Proton and itsInvestigation with out-of-plane Spectrometry

- **Física Aplicada**

D. Elmore - Purdue (USA) - New Directions in Accelerator Mass Spectrometry
C. Robilotta - USP (Brasil) - Nuclear Physics and Medicine
W. Treimer - TFH (Alemanha) Neutron Tomography

- **Maquinas**

N. Added - USP (Brasil) - "The Pelletron-Linac project"
M. N. Martins - USP (Brasil) - "The São Paulo Racetrack Microtron"
M. H. Tabachnics - USP (Brasil) - "The Laboratory of Analyses of Material by Ionic Beams"

Apresentações dia 01/09/97

Comunicações Orais - 14:00 - 15:30

Interação nucleon-nucleon

Painéis - 15:45 - 17:00

Interação nucleon-nucleon

Apresentações dia 02/09/97

Comunicações Orais - 14:00 - 15:30

Estrutura Nuclear

Física nuclear aplicada

Painéis - 15:45 - 17:00

Estrutura Nuclear

Física nuclear aplicada

Apresentações dia 03/09/97

Comunicações Orais - 14:00 - 15:30

Reações nucleares

14:00 LONG-LIVED PRODUCTS OF THE SPALLATION OF ^{nat}Te AND ^{nat}Mo BY PROTONS
P. Perso, P. B. Rios, R. M. Oliveira, J. C. O. Morel, M. N. Martins, E. B. Norman, M. T. F. da Cruz.. 32

14:20 Nuclear radii of proton-rich radioactive nuclides near the N=Z line
G. F. Lima, A. Lépine-Szily, A. C. C. Villari, R. Lichtenthaler, W. Mittig, J. M. Casandjian, M. Chartier, M. Lewitowicz, M. Maccormick, N. Ostrowski, J. C. Angelique, A. Orr, G. Audi, A. Cunsolo, A. Foti, C. Stephan, T. Suomijarvi, L. Tassan-Got, C. Donzeaud, A. Gillibert, S. Lukyanov, D. J. Morrissey, N. A. B. M. Sherrill, D. J. Vieira, J. M. Wouters..... 32

14:40 Photofission and Multiple Nucleon Photoemission of ^{232}Th at Intermediate Energies
João Dias de Toledo Arruda-Neto, Vladimir Petrovich Likhachev, Fermin Garcia, Joel Mesa, Ana Cecília de Souza Lima, Marcelo Filadelfo, Sebastião Simionato, Airton Deppman, Oscar Rodriguez, Fernando Guzmán, Maurício Tavares..... 33

15:10 THE DOORWAY EXPANSION METHOD APPLIED TO HEAVY-ION COLLISIONS INVOLVING A NEUTRON-RICH EXOTIC NUCLEUS
A. M. S. Breitschaft, V. C. Barbosa, L. F. Canto, M. S. Hussein..... 33

Painéis - 15:45 - 17:00

Reações nucleares

P001 ABSORPTION AND TUNNELING EFFECTS IN ONE- AND TWO-PROTON TRANSFER REACTIONS
H. D. Marta, R. Donangelo, D. Tomasi, J. O. Fernández Niello, A. J. Pacheco..... 33

P002 General Expressions for the Matrix elements of $SU(3)$ Wigner and Majorana Interactions
J. A. Castilho Alcarás..... 37

P003 S AND D WAVES OF $E1$ TRANSITIONS OBSERVED IN TRITON ANGULAR DISTRIBUTIONS FROM THE REACTION $\gamma(^7\mathrm{Li}, t)\alpha$
V. P. Likhachev[1], M. N. Martins, J. F. Dias, M. T. F. da Cruz, J. D. T. Arruda-Neto, L. P. Geraldo, R. Semmler..... 36

P004 MEASUREMENTS OF THE PHOTOFISSION CROSS SECTION FOR ^{239}Pu IN THE ENERGY INTERVAL FROM 5.2 TO 10.8 MEV
R. Semmler, L. P. Geraldo, O. L. Gonçalez..... 36

P005 STUDY OF THE GENERATION AND DECAY OF FISSIONING HYPERNUCLEI
S. A. Paschuk, H. R. Schelin, J. D. T. Arruda-Neto, V. P. Likhachev, A. V. Glamazdin, V. G. Gorbenko, V. I. Noga, Yu. M. Ranyuk, I. G. Evseev, V. G. Nedoresov, Fermin Garcia, Joel Mesa, Oscar Rodriguez, Fernando Guzman..... 36

P006 Time Scales for Fusion-Fission Reactions
A. A. P. Suaide, N. Added, W. H. Z. Cardenas, M. M. de Moura, E. M. Szanto, A. Szanto de Toledo, N. Carlin..... 35

P007 Shadow effect on a heavy-ion elastic scattering at very forward angles
Manabu Ueda, Noboru Takigawa..... 37

Interação nucleon-nucleon

Interação nucleon-nucleon – 01/09/97

SKYRMIONS AND THE NUCLEON-NUCLEON INTERACTION

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We study the main features of nucleons and nucleon-nucleon interactions in the framework of the Skyrme model, based on an effective lagrangian consistent with QCD. In this model, baryons are solitons of a chiral symmetric theory where mesons interact weakly. Skyrme's lagrangian [1] represents a possible effective model for strong interactions at low energies, where perturbation theory cannot be applied.
The spherically symmetric solitonic solution of Skyrme's lagrangian, with topological number equal to one, gives rise to baryons, such as nucleons and deltas. Nucleon-nucleon interactions are easily derived from the model in the sudden approximation, by means of an *Ansatz* for the composite field of two skyrmions. Since the skyrmion range is rather short, the so called Product *Ansatz* [2] yields good results for long distances between skyrmions. However, the intermediate range attraction of the NN potential is not achieved.
We analyse the advantages and problems of the Product *Ansatz*, and we propose an alternative one.

[1] T.H.R. Skyrme, *Nucl. Phys.* **31** (1962) 556

[2] A. Jackson *et al.*, *Nucl. Phys.* **A432** (1985) 567

STUDY OF THE REACTION $p+p \to d+\pi^+$ ACCORDING TO CHIRAL PERTURBATION THEORY

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U. VAN KOLCK, G. MILLER
University of Washington - Seattle

We use power-counting arguments [1,2] as an organizing principle to apply chiral perturbation theory, including an explicit Δ, to the $p+p \to d+\pi^+$ reaction near threshold. There are three lowest-order leading mechanisms expected to contribute to the amplitude with similar magnitudes: the Weinberg-Tomosawa (WT) term, the impulse term, and the Δ-excitation mechanism. We examine formally sub-leading but potentially large mechanisms, including S-wave pion-rescattering, the galilean correction to the WT term, and short-ranged contributions. We show that due to the interference between S and D waves in the Deuteron final state, the Weinberg-Tomosawa is the leading term and practically reproduces the cross-section data alone; the pion-rescattering contribution, which is enhanced by off-shell effects, has a sign opposite to the Δ contribution. In addition, we have modeled the short-ranged interaction using σ and ω exchange mechanisms, but their contributions revealed small. Our result shows also that in the impulse term, the S and D waves add destructively and its net result is small. The total amplitude obtained including all of these processes is found to yield cross sections in very good agreement with the data.

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[2] U. van Kolck, G.A. Miller e D.O. Riska, Phys. Lett. B388, 679 (1996).

OFF-SHELL EFFECTS IN PION - NUCLEON BREMSSTRAHLUNG

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Until this moment the πNg reaction has been studied within the Soft Photon Approximation, where the total amplitude depends only on the elastic πN scattering T-matrix. Here we propose a dynamical model that treats the amplitude to all orders in the photon energy and thus permits to investigate the off-shell behavior of the πN interaction. In addition to obtain a total gauge invariant amplitude, two-body meson exchange currents are included. The off-shell behavior of different interactions are compared to each other and with UCLA and SIN data. This makes possible to determine the interaction where the approximations involved in the model are acceptable, or eventual problems in the behavior of the interactions in the off-shell regime.

Bethe-Salpeter equation on the Light-Front

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We study in a bosonic model the two-body Bethe-Salpeter equation in the ladder aproximation on the Light-Front. The ladder comes from the exchange of an intermediate boson between the other two. The equivalence of the covariant B.-S. equation and the Light-Front B.-S. is found when all the intermediate states with any number of exchanged boson is allowed in the kernel. The formal proof of the above

statement, is achieved when the kernel of the Bethe-Salpeter equation is integrated in the light-front energy ($k^- = k^0 - k^3$) in each momentum loop of the iterated equation. The first step corresponds to perform the k^- integration in the original Bethe-Salpeter equation. The forward propagating intermediate virtual state in the light-front time appears explicitly, which has at most three-particles: the intermediate boson plus the other two bosons. In order to generate all light-front forward propagating intermediate states with any number of particles, we iterate the Bethe-Salpeter equation as many time as we need. Using this method, we construct the kernel of the Bethe-Salpeter equation with at most four particles in the intermediate state, which are composed by two intermediate bosons plus the other two and corresponds to the one time iterated B. S. equation. The truncation of the intermediate propagation in a state with a maximum number of particles, breaks the covariance of the B.-S. equation. Thus, increasing the number of particles in the intermediate states, the covariance of the Light-Front B.-S. equation should be approached. We made numerical calculations allowing up to four particles intermediate states, in order to study the effect of the high Fock state components in the bound two-boson system.

Work supported by FAPESP and CNPq.

Interação nucleon-nucleon - 01/09/97

DISINTEGRATION OF THE DEUTERON BY LINEARLY-POLARIZED PHOTONS AT LOW ENERGIES

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This work presents results of the deuteron photodisintegration cross section and the Σ-asymmetry, measured with linearly polarized photons on the near-threshold energy region. The data are compared with calculations performed in the framework of the Lorentz-, gauge-invariant (LGI) and diagrammatic approaches, and the Partovi and Laget models. Minimum discrimination requirements for experiments in the low-energy region are analyzed.

The experiment was carried out in the direct beam of the Kharkov 2-GeV linac. The experimental facility, the main characteristics of the beam and some preliminary results were described previously. In this work only those aspects relevant to this particular deuteron experiment will be presented.

The Σ-asymmetry data are well described in the framework of the diagrammatic approach for meson exchange currents (MEC) with final state interaction (FSI). An analogous calculation in the LGI approach slightly overestimates the data.

The data for $\frac{d\sigma_\parallel}{d\Omega}(E_\gamma)$ are in good agreement with the calculation in the LGI approach using the Paris deuteron wave function (PDWF). The calculated $\frac{d\sigma_\parallel}{d\Omega}(E_\gamma)$ is not sensitive to FSI effects.

The data of $\frac{d\sigma_\perp}{d\Omega}(E_\gamma)$ for $\theta_p = 90°$ are consistent with the data obtained with non-polarized photons $\frac{d\sigma_0}{d\Omega}(E_\gamma)$, for $\theta_p = 0°$. Both sets of data agree well with calculations in the diagrammatic approach using the Bonn model and MEC, with and without FSI. These two calculations are indistinguishable in the energy region of the measurements.

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TWO PION EXCHANGE NN POTENTIAL AND $N-\alpha$ SCATTERING

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It has been pointed out [1] that the intermediate component of the NN interaction has an outer part, due to the exchange of two pions, which is directly related to off-shell πN scattering and hence strongly influenced by chiral symmetry. In this work we discuss the possibility of obtaining information on the intermediate part of NN potential from the study of $N-\alpha$ scattering.

The α particle has no spin and isospin and hence cannot couple to a single pion. Therefore, it is a rather suitable system for the study of the intermediate part of the nuclear interaction. When low energy neutrons and protons (if we forget the Coulomb barrier) are considered the angular momentum may be used to select the various regions of the potential.

A relationship between the tail of the two-pion content of the nucleon-nucleon potential and neutron-alpha scattering observables was sought. We calculate the energy dependence of the phase shift for S, P, D and F waves for the Argone, Bonn, Nijmegen, Paris and SSC potentials. A comparison bettwen these potentials existing in the literature is under way. The result of this comparison will allow to decide wich potentials have the correct two pion exchange contribution at intermediate

distances.

[1] G. Brown and D. W. Durso, Phys. Lett. **B35** (1971) 120

CHIRAL SYMMETRY AND NUCLEON-NUCLEON SCATTERING

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We assume that the nucleon-nucleon interaction for low and intermediate energies is given just by the exchanges of one and two pions. In the latter case we adopt a model based on chiral symmetry and subthreshold pion-nucleon interaction amplitude, which contains no free parameters. Chiral symmetry is very relevant because it is the responsible for the organization of various processes into autonomous families. This gives rise to cancellations in the intermediate pion-nucleon interaction, which is the main building block of the nucleon-nucleon interaction. The subthreshold pion-nucleon amplitude is supplemented by empirical information in the form of the Höhler, Jacob and Strauss (HJS) coefficients. Predictions from this model for nucleon-nucleon observables are calculated in the momentum space and compared with experimental data.

Null Plane Model of Proton

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We present a calculation of the proton electric form-factor ($G_E(q^2)$), using a three quark Faddeev wave-function in the null-plane[1]. The null-plane wave-function is obtained from the solution of the Faddeev equation with zero-range force acting between the constituent quarks. No confinement is present in our effective model. The totally symmetric spatial part of the wave-function is obtained numerically in a three-boson calculation. We use the covariance of the proton model under kinematical front-form boosts to calculate $G_E(q^2)$, and compare our numerical results with the avaliable experimental data. $G_E(q^2)$ scales with q^4 in the asymptotic region and describes the data for low momentum transfers.
Our attempt, using such a schematical model, is based on the notion of relativistic constituent quarks. We have also seen examples in the literature [2], in which the spontaneous breaking of chiral symmetry creates the constituent quark mass. Such a mechanism is modeled using the Nambu-Jona-Lasinio contact interaction and applied to hadronic phenomenology.
Our schematical model has both ingredients together: relativistic constituent quark and a contact interaction. We test the totally symmetric spatial part of the proton wave-function with these two minimal ingredients in a calculation of the proton eletric form-factor. The confinement has no explicit role in the model but is buried in the effective degrees of freedom. Relativistic dynamics is required by the mass of the constituent quarks and the size of the nucleon wave-function. The reason for choosing a three boson dynamics, is to just concentrate on the specific form of the spatial wave-function, and obtain insight in to it without the complications arising with the use of the spin.
The relativistic spin structure is planned to be included in our model through the Melosh rotation of the spins. [3].

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[2] U.Vogl and W. Weise, Prog. Nucl. Part. Phys. 27 (1991) 195.

[3] P.L.Chung and F. Coester, Phys. Rev. D44 (1991) 229.

Deformed algebras and chiral symmetry breaking

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In the beginning of the sixties, Nambu and Jona-Lasinio proposed a model based in an analogy with the theory of superconductivity [1]. Originally the Nambu–Jona-Lasinio model (NJL) was constructed as a pre-QCD theory of nucleons that interact via an effective two-body interaction. This model is reinterpreted today as a theory with quarks degrees of freedom. The Lagrangian of the NJL model was constructed in such a way that the symmetries of QCD are also part of it. One of the most important of these symmetries is the chiral symmetry, which is essential to the understanding of the lightest hadrons and is spontaneously broken in QCD. The NJL model is very useful for observing how these things happen. In particular, the dynammic generation of fermion masses brought about by the breaking of chiral symmetry is one of the features of this model. Our porpose is to simulate the explicit chiral symmetry breaking by deforming the algebra of the model. This idea was motivated by recent applications of q-deformed algebras in nuclear structure problems. In this context, for instance, the pairing in a single j shell, the spectra of rotational nuclei and the phase transitions in the Lipkin model were studied [2].

[1] Y. Nambu and G. Jona-Lasinio, *Physical Review* **122**, 345 (1961). [2] D. Galetti, J. T. Lunardi, B. M. Pimentel and C. L. Lima, *Topics in Theoretical Physics*, **IFT** (1995).

Neutrino trapping in supernova shock wave generation

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We investigate the effects of the neutrino trapping on the dynamical evolution of the supernova core collapse[1,2]. An equation of state of the cold hadronic stellar matter obtained from the relativistic mean field theory explicitily including trapped neutrinos is applied[3,4]. An effective lagrangian description is used to the hydrodynamics of supernovae core, allowing us to calculate the intensity of the shock wave generated during the core-bounce. The basic characteristics of the supernova-core collapse, and the shock wave generated during the bounce, are reproduced. We discuss the neutrino trapping through its effect on the equation of state properties.

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Estrutura Nuclear

Estrutura Nuclear – 02/09/97

UNIVERSALITY IN LOW ENERGY THREE BODY SYSTEMS

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The general basis for the existence of Efimov states [1] is studied, through the use of universal properties of three body systems at low energies. The approach is parameterized by the two and three body energies in a zero-range model. The renormalizability of the quantum mechanical implies that all the low energy properties of the three-body system are well defined if one three-body and the low-energy two body physical informations are known [2]. The sensibility of the three body binding energy to the interaction properties comes from the collapse of the system in the limit of zero-range force, the Thomas effect [3].
The recently discovered light halo nuclei brought a lot of attention to the search for Efimov states, because such systems can be viewed as a three body system with two loosely bound neutrons (n) and a core (c) which is more bound [4]. In our approach, we use the correlation of the value of the ground state energy and the first excited Efimov state, and find the set of values of the $n-n$ and $n-c$ energies that allows the existence of at least one excited Efimov state. Considering the available data, we conclude that ^{20}C is the strongest candidate for having one excited Efimov state, with a binding energy below 14 KeV relative to the lowest scattering threshold [5]. Our calculation and the available data exclude the possibility of having Efimov states in any other light halo nuclei known to us, like ^{11}Li, ^{12}Be, ^{18}C or oxygen isotopes.

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DEFORMATION ALONG THE YRAST BANDS IN THE Z=N NUCLEUS ^{48}Cr AND IN ^{50}Cr: THE NEW DSAM PROCEDURE NGTB.

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The N=Z nucleus ^{48}Cr has been recently experimentally studied [1] because it is considered of special interest to understand the properties of the T=0 neutron-proton interaction. Moreover, being at the middle of the $1f_{7/2}$ subshell it is suitable to study the interplay between single particle and collective degree of freedom. Shell model calculations in the full f-p shell [2] reproduce very well the energies of the yrast positive level band up to the band termination at I=16, where the 8 $1f_{7/2}$ neutrons and protons fully align. Consistently the B(E2) values are predicted to be quite large at low spins ($\beta \simeq 0.25$) and to smoothly decrease approaching the band termination ($\beta \simeq 0.10$). Very recent experimental B(E2) values are however in disagreement with this picture [3].
The aim of this contribution is to present the results of further DSAM lifetime measurements, performed with much higher statistics. Moreover a lineshape analysis has been made, while the centroid analysis of ref. 3 could be affected by systematic errors. A new DSAM procedure named NGTB (Narrow gate on Transitions Below) has been used for the first time in order to avoid any influence of the sidefeeding. In parallel with the analysis in ^{48}Cr also a similar analysis in the more efficiently populated nucleus ^{50}Cr has been made.
We have populated ^{48}Cr in the reaction ^{28}Si(^{28}Si,2α) at 115 MeV. The target consisted of 0.8 mg/cm^2 of ^{28}Si on 15 mg/cm^2 of Au. The lifetimes of transitions of 3032 keV ($16^+ \rightarrow 14^+$), 1869 keV ($14^+ \rightarrow 12^+$), 1347 keV ($12^+ \rightarrow 10^+$), 1874 keV ($10^+ \rightarrow 8^+$), 1743 keV ($8^+ \rightarrow 6^+$), 1585 keV ($6^+ \rightarrow 4^+$) and 1106 keV ($4^+ \rightarrow 2^+$) have been determined.
For the lineshape analysis a modified version of the MonteCarlo code LINESHAPE [4] has been used. The analysis of the 1874 keV transition was particularly critical, because it is mostly populated by the rather slow

1347 keV transition and it overlaps with the 1869 keV one. The NGTB procedure was decisive to determine its lifetime, as well as for extending the lifetime measurement to the 1743 keV and the 1585 keV transitions. Data will be presented also for lifetimes in the negative parity sideband in ^{48}Cr as well as for the yrast band in ^{50}Cr. A good agreement has been generally found with the Shell Model predictions both for the B(E2) and the B(M1) values. This stresses the high quality of wave functions obtained recently with Shell Model calculations.

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[4] Lineshape Code. J. C. Wells and N. Johnson, Report No ORNL-6689(1991)44.

Title to be announced

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STUDY OF THE INNER BREMSSTRAHLUNG FOLLOWING THE ELECTRON-CAPTURE DECAY OF ^{193}Pt

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We are measuring the inner bremsstrahlung photons emitted in some of the electron-capture decays of ^{193}Pt (IBEC). Due to its low Q-value (61 keV) ^{193}Pt does not undergo K-capture (from $1s_{1/2}$ shell). While the overall agreement between theory and experiment is about 5 to 10% for this kind of experiment, ^{193}Pt shows an anomaly, where a hydrogenoid-type calculation is the only one to produce good agreement, apparently fortuitous. This work is an effort to improve the quality of the experimental data available in order to investigate the origin of this anomaly and to improve the limit of the electron-neutrino mass.

The source was prepared with 0.87 g of 99.999% pure Pt in metal form, shaped as a 5-cm long wire, 1 mm in diameter. It was irradiated with neutrons at a flux of 10^{13} cm^{-2}s^{-1} for 52 days and let to cool down for eight months. The remaining activities were 100 μCi of ^{193}Pt (half-life 50 yr) and 15 μCi of ^{192}Ir (half-life 74 d), the latter coming from (n,γ) reactions on a small content (~0.4 ppm) of Ir. We have used a radiochemistry method to reduce the Ir contents of the source by two orders of magnitude. The resulting Pt compound will be dissolved in a plastic scintillator 3-mm thick and 53 mm in diameter. Since about 95% of the photons coming from the ^{192}Ir decay are in coincidence with a fast electron, the signal of the latter in the plastic will be used in anti-coincidence with the signal of the IBEC photons, caught in a Ge x-ray detector. We have performed simulations of the efficiency and absorption effects in the detection geometry and the absolute efficiency calculated is about 6% in the energy range of interest.

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The nuclear vorticity

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The electron scattering by nuclei gives information about its distribution of charge and current.For a given multipole we have four quantities,one charge density multipole and three components of the current density multipole.The components of the current are not independent ,since they are related to the density by the continuity equation. These observations poses the question of how to find two independent quantities to characterize the current distribution of nuclei. In reference one, a such quantity is introduced, the nuclear vorticity. In our work we have shown that we can split the current as the sum of an irrotational and a vortical current, whose source is the nuclear vorticity. The former is enterily fixed by the continuity equation, while the later is unconstrained by it. We show how to extract experimental information about the nuclear vorticity from the experimental data on the longitudinal and transverse form factors. This is done for the transition to the $J^\pi = 2^+$,T=1 state in ^{12}C with excitation energy equal to 16.11 Mev. We also show how to calculate theoretically the nuclear vorticity considering the transition to the $J^\pi = 3^-$,T=0 state in ^{16}O with E_{ex}=6.13 Mev, described by the RPA. In both cases we compare the components of the vortical and irrotational currents and we investigate if its relative importance is connected to the collectivity of the state.

ISOVECTOR EXCITATIONS BY NEUTRINO SCATTERING IN ^{16}O

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The use of the weak interaction as a tool to understand hadronic structures, has been proved a very useful and reach technique [1]. By the other hand, the growing of the available experimental facilities using neutrinos as a probe [2], bring us some motivation to better understand the type of new information that we can infer from the corresponding reaction. The cross-section for the neutrino scattering through a hadronic target can generally be given in the form [1]:

$$\left(\frac{d\sigma}{d\Omega}\right)_{\nu,\overline{\nu}} = \left(\frac{d\sigma}{d\Omega}\right)^{direct}_{\nu,\overline{\nu}} \mp \left(\frac{d\sigma}{d\Omega}\right)^{interference}_{\nu,\overline{\nu}}$$

where the direct term can be written as a function of the usual eletromagnetic form factors and the interference term depends also on the so-called axial form factors; the $\mp$sign refers to the neutrino or antineutrino projectile respectively. Our main interest is to investigate the role of the second term for a certain kind of excitations in a nucleus. Specifically, we are interested in isospin excitations from a even-even nucleus, once in this case the part of the cross-section which depends on the axial form factors should be more sensitive.
Using the Tamm-Dancoff [3] model and.a harmonic oscillator basis, we calculate the inelastic neutrino (antineutrino) scattering form factors, from which we are able to build up the above cross-section. In order to achieve that goal, we use a non-relativistic approximation for the nuclear current in order $1/M$, where M is the mass of the nucleon. A numerical application is then made for the isovector excitations in the ^{16}O nucleus.

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Energy Levels in ^{129}I from (n,γ) and (n,2n) Reactions

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The low-energy levels of ^{129}I were investigated using γ-sources obtained from ^{128}Te(n,γ)^{129}Te and ^{130}Te(n,2n)^{129}Te nuclear reactions. The singles spectra were taken using a Ge(Li) detector of 45 cm^3 (FWHM=1.89 keV) and a 671 ORTEC amplifier. Two different methods were employed for the production of ^{129}Te sources. The first one involved the irradiation of the enriched telurium (96% for ^{129}Te) with thermal neutrons flux of 10^{13} n.cm^2.s^{-1} at the IEA-R1 reactor. Using this procedure it was possible to study the β^- decay of ^{129}Te ($T_{1/2}$=70 minutes). The second method was the irradiation of natural telurium (with 33,8% of ^{130}Te isotope) with 14MeV neutrons at van de Graaff accelerator at IPEN. In this experiment, a series of γ-rays from the both reactions, in the range from 20 keV to 2.5 MeV, were recorded during 60 hours of live counting. In order to identify the origin of γ-rays, spectra were accumulated through four sucessive half-lives. The energy and relative intensity of the γ-rays have been determined and the results from β^- decay and the (n,2n) nuclear reaction were compared. Among the total number of γ-transitions observed, several of them were observed for the first time. In addition, a number of γ-transitions previously attributed were confirmed.

Directional Correlation of γ-transitions in ^{76}Se

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The directional angular correlation of coincidence γ-transitions in ^{76}Se has been measured following the β^- decay of ^{76}Se using a HPGe spectrometer. The radioactive samples of ^{76}Se were obtained by neutron activation of 99.99% pure natural As, in metal form, in the IEA-R1 reactor at São Paulo. Approximately 5mg of As were irradiated in a flux of 10^{13} neutrons.cm^2.s^{-1} for three minutes.The $\gamma-\gamma$ spectrometer consisted of two hyperpure Ge detectors. The fixed and the movable detectors had volumes of 90cm^3 and 60cm^3 respectively. Each detector had a 1cm thick conical lead shield, in order to prevent true coincidences arising from compton-scattered γ-rays. The measurements were carried out at angles of 90^0, 120^0, 150^0 and 180^0. A conventional fast-slow coincidence circuit, with a time resolution of 11ns in the range from 200keV to 3.0MeV, has been used. Two equalized hardware gates were set on the timing spectrum, to tag the coincidence events

either as true or chance. For each master gate three parameters, the energy of both detectors and the coincidence tag, were recorded with a CAMAC input register, assisted by a MBD-11 microprocessor, connected to a PDP-11/84 computer. The measurements were made on 15 direct and 4 skip cascades, for the first time. Based on the angular correlation results it was possible to determine the multipole mixing ratios for 10 transitions: $\delta(402) = -0.07\pm0.07$, $\delta(456)=-0.06\pm0.07$, $\delta(472) = -0.79^{+0.42}_{-0.36}$, $\delta(571)=0.75\pm0.05$, $\delta(575) = 1.79^{+0.46}_{-0.68}$, $\delta(695) = 0.40^{+0.84}_{-0.53}$, $\delta(809) = 0.57^{+0.48}_{-0.34}$, $\delta(980)=-0.27\pm0.02$, $\delta(1232) = 1.48\pm0.23$ and $\delta(1956) = 0.66^{+0.45}_{-0.81}$. The present results show that a large number of γ transitions have considerable M1 admixtures which are difficult to explain in terms of simple vibrational model. More refined models which take in to account the interaction between collective and quasi-particle effects may be necessary to explain the level structure in this nucleus.

TESTING THE DYSON EXPANSION WITHIN THE QUON ALGEBRA

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In the literature fermion pairs are replaced by bosons in many known physical situations [1,2]. This is normally performed with the help of boson mappings, that link the fermionic Hilbert space to another Hilbert space constructed with bosons. Of course boson mapping techniques are only useful when the Pauli Principle effects are somehow minimized.

In this work, the quon algebra [3], which interpolates between the Bose and Fermi algebras and depends on a free paramenter q, is used to generate a deformed Dyson boson expansion of the quadrupole operator, which is written in terms of three deformed bosons (s, d and g bosons). Then we obtain a quadrupole-quadrupole hamiltonian, for a single j-shell, in terms of this deformed bosonic operator. The hamiltonian is diagonalized and its eigenvalues are compared with the ones obtained from the fermionic quadrupole-quadrupole hamiltonian. The deformation parameter helps in achieving the correct energy levels, what cannot be encountered in practice with the usual non-deformed Dyson expansion. We use a kinematical criterion for fixing the q parameters by invoking the Pauli principle and compare the results to a best fitting procedure.

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Dipole excitations of low energy in deformed nucleus studied by Nuclear Resonance Fluorescence

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Low lying dipole excitations in heavy nuclei are of actual interest in modern nuclear structure physics. Low energy photon scaterring off bound states, nuclear resonance fluorescence (NRF), represents a higly selective and sensitive tool to investigate low lying dipole excitations in heavy nuclei. The discovery of a new class of enhanced *magnetic* dipole excitations in heavy deformed nuclei in high resolution electron scattering experiments by Richter and coworkers in 1984 initiated a large number of both experimental and theoretical work[1,2]. Numerous electron and photon scattering experiments were performed to study the systematics and fragmentation of this low lying, predominantly orbital mode often referred to as *"Scissors Mode"*[3]. On the other hand, the recent NRF experiments also provided evidence for enhanced, low lying *electric* dipole excitations in deformed nuclei. The structure of the corresponding $J^\pi = 1^{-1}$ states is discussed in terms of different collective excitation modes or two-phonon excitations.

For odd mass nuclei by far less spectroscopy data are available. Recently the Stuttgart group succeeded to observe the first time the *"Scissors Mode"* in an odd deformed Nucleus (^{163}Dy)[4]. Similar results were found for ^{161}Dy, however, in ^{157}Gd the dipole strength is completely fragmented into more than 80 transitions[5]. This different behavior of diverse odd deformed nuclei of the Rare Earth region is completely non understood.

The purpose of these work is further investigation of the dipole strength distributions in odd-mass nuclei (^{153}Eu). The Eu nuclei are odd proton isotopes in between the well studied, deformed Gd isotopes and the already investigated Sm isotopes showing a transition from spherical to deformed nuclear shapes. NRF experiments in ^{153}Eu were performed at the bremsstrahlung facility installed at the Stuttgart Dynamitron accelerator, to contribute more experimental data on the dipole

strength distributions in deformed, odd-mass. The objective was to find explanations for the different behaviour of diverse odd deformed nuclei of the Rare Earth region.

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THREE-BODY FADDEEV CALCULATION FOR ^{11}Li WITH SEPARABLE POTENTIALS

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The halo nucleus ^{11}Li is treated in the three-body model corresponding to ^{9}Li core plus two valence neutrons. For the neutron-core interaction we use a separable potential with a modified gaussian form factor in momentum space which acts on the $s_{1/2}$, $p_{3/2}$ and $p_{1/2}$ waves. We make the assumption that the neutron-^{9}Li system has a $p_{1/2}$ resonance of width 0.15MeV at an anergy 0.42 MeV[1] and also a $s_{1/2}$ virtual state corresponding to a scattering length -20fm[2]. The Pauli forbidden $1s_{1/2}$ and $1p_{3/2}$ single particle states are projected out by adding repulsive terms to the $s_{1/2}$ and $p_{3/2}$ potentials. The interaction between the valence neutrons is described by separable potentials of the Yamaguchi type which act in the $^{1}S_0$ and the $^{3}P_1$ states. By solving the Faddeev equations, we obtain the correct experimental value (0.293MeV) for the 2n separation energy. However, the calculated width of transverse momentum distribution of the core was found 80 MeV/c which is too large compared to the experimental width.

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Generalized Loss of Particle and Hole Neutron Spectroscopic Intensity in ^{103}Ru: a Sign of Significant Differences Between the Odd Nucleus and the G.S. of Both Even Neighbors

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The Ru isotopes, known for several transitional aspects, have been the subject of detailed investigations through (d,p) and (d,t) reactions performed by the Nuclear Spectroscopy Group. The excellent beam and energy resolution characteristics of the Pelletron – Enge-split-pole-spectrograph facility, and the use of nuclear emulsions as detectors, normally allow for high-quality data. Recent ^{102}Ru(d,p) results [1] complement the information already gathered by the Group and put ^{101}Ru and ^{103}Ru, now, on the same footing. With respect to formerly available pick-up data, below 3.8 MeV about 40 levels were detected for the first time and, for transferred angular momenta $l \leq 3$, the detection limits lie mostly below 2% of the total expected spectroscopic intensity. Nevertheless, in contrast with ^{101}Ru, where about 90% of the valence strength was found [2], in ^{103}Ru the (d,p) and (d,t) reactions located only 53% and 63% of the respective valence hole and particle expectations. The strengths are, furthermore, widely spread among all available valence orbitals, neither of which is completely full or empty. For each l, the lowest excitation is always favored. The loss of $\sim 40\%$ of the neutron quasi-particle strength is well outside experimental uncertainties and is taken to also indicate the small similarity of the odd nucleus with the ground states of its even neighbors plus or minus one neutron. As already put forward [2], the other important indicator for this fact is the small population of the ^{103}Ru ground state in both one neutron transfer reactions.

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WOODS-SAXON POTENTIAL PARAMETRIZATION AT LARGE DEFORMATIONS FOR ODD-PLUTONIUM NUCLEI

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The theoretical description of the fission process is one of the oldest and most challenging problems in nuclear physics. Although many aspects of the fission process have already been clarified, a consistent description of fission has not yet been found. The difficulty resides in the fact that the fission process involves both collective aspects and single-particle effects superimposed on a macroscopic background. In this way, it is necessary to pay an special attention to the parametrization of the spin-orbit part of the deformed nuclear potential, in order that quantitative description of the properties, as e.g. fission isomeric states. Therefore, a good parametrization of the spin-orbit part of the potential, which is mostly responsible for the single-particle level order, it is extremely important in the analysis of properties of the single-particle levels at deformations corresponding to the secondary minima of the total energy surfaces of fissioning nuclei. In this work, the structure of the single-particle levels in the secondary mimima of ^{237,239,241}Pu fissioning nuclei is analysed with the help of an axially-deformed Woods-Saxon potential. The nuclear shape was parametrised in terms of the Cassinian ovaloids. The parametrization of the spin-orbit part of the potential in the region corresponding to large deformations (second minimum), which only depends on the nuclear surface area Bs, was obtained. λ and r_{0-s0} parameters were found to be dependent on Bs. With this parametrization we were able to reproduce successfully the spin (parity) and the energies of the rotational band built on the 8μs isomeric state in ^{238}Pu and also to make a spin assignment for both isomer states in ^{237}Pu and ^{241}Pu.

HIGH-SPIN STATES IN ^{143}Dy

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The present work is a report on the level scheme of the ^{143}Dy nucleus obtained from a γ-ray spectroscopy measurement of the ^{54}Fe + ^{92}Mo reaction, at 240-MeV incident beam energy. The data were taken with the GASP array of the Laboratori Nazionali di Legnaro, consisting of 40 high-efficiency Compton-suppressed HpGe detectors with a 80-element BGO multiplicity filter, together with the multi-telescope Si-Ball (ISIS) for charged particle channel selection and the recoil mass spectrograph (RMS) CAMEL. The target used was an $\approx$ 1.0 mg/cm^2 thick ^{92}Mo foil. The experiment main purpose was the measurement of ^{141}Dy which is however very weakly populated in the reaction (see contribution of M. N. Rao *et al.* to this conference). The 2pn (^{143}Dy) channel is among the 6 most intense channels. There is no previous measurement of the high-spin states of ^{143}Dy. The assignment of the transitions to this specific channel was done by first sorting a γ-γ matrix gated on mass 143. The only other channel produced with mass 143 is ^{143}Tb, which is actually the strongest channel of the reaction (3p) and has several transitions known (see contribution of F. R. Espinoza Quiñones *et al.* to this conference). The charged particle data then allows for the assignment of a specific fold of protons and alfas, therefore unequivocally identifying the γ rays belonging to the 2pn channel. Several new transitions were assigned in this way to ^{143}Dy. The energies of the srongest lines are: 495, 384 724, 221, 753, 307 and 851 keV.
In the A$\approx$ 140 mass region, the $h_{11/2}$ subshell of both protons and neutrons is of importance to the high-spin state structure. Also the srong deformation driving $i_{13/2}$ neutron orbit has been observed to generate rotational bands in nuclei of this region (for example, the isotone ^{141}Gd [1]). The search for bands based on these configurations in ^{143}Dy is under way.

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The 4π Charged Particle Telescope Array of the Pelletron Laboratory

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The γ–ray spectroscopy of low-Z or very neutron deficient evaporation residues is difficult because of the strong competition among many open channels. Typically 2 to 5 particles are evaporated from a heavy-ion reaction, in varied combinations of protons, neutrons and alpha particles. A partial selection of specific channels can be made by detecting and identifying some or all of the evaporating particles. Indeed, the use of ancillary charged particle detectors can significantly improve the resolving power of γ–ray spectrometers. The γ–spectroscopy group of the Pelletron Laboratory has interest in the study of the A $\approx$ 100, 80 and 30 mass regions, which would benefit from the use of an evaporation–channel filtering device. The design of the 4π charged particle telescope array was based on ref. [1]. The system consists of 12 plastic phoswich scintillators, disposed in the geometry of a dodecahedron. Each telescope consists of a 0.1 mm thick fast scintillation decay time BC400 ΔE detector bonded to a 10 mm thick long decay time BC444 E detector. The detector faces have a diameter of 2 cm. The E and ΔE detectors are bonded toghether by the vacuum heat press technique [2] in order to avoid the presence of a dead layer. The target chamber also serves as a support for the detectors, and has the shape of a semi-regular polyhedron with 12 pentagonal and 20 triangular faces. It is built of aluminum and is divided in two hemispheres excavated inside in order to minimize γ ray absorption. The chamber has a diameter of 14 cm, and the whole system, including the photomultiplier tubes and bases fits in a sphere of 24 cm diameter. The γ-ray detectors are aligned with the triangular faces.

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DSAM LIFETIMES IN THE DOUBLY ODD NUCLEUS ^{134}Pr

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Information on highly deformed rotational bands in the doubly odd ^{134}Pr nucleus has become available quite recently [1,2]. One of these bands has been tentatively assigned a $\pi(h_{11/2})^3 \otimes \nu(f_{7/2},h_{9/2})$ configuration, while the other band is thought to have the $\pi(h_{11/2})^3 \otimes \nu i_{13/2}$ configuration. Thus one would expect the latter band to have a more deformed nuclear shape.
The present note reports on a Doppler broadened lineshape lifetime measurement in this nucleus. The rotational bands in ^{134}Pr were populated by bombarding a Au-backed ^{110}Pd target with 130 MeV ^{28}Si beam provided by the XTU tandem accelerator of the Legnaro National Laboratory. The GASP array, BGO inner ball and the multi-telescope particle detector ball (ISIS) were utilized in order to select the proton gated events. Data were of sufficiently good statistics to obtain clean gated spectra for the positive parity E2 band. The Doppler broadened lineshapes for a cascade of 6 transitions in this band were fitted for 5 of the 7 rings of detectors (36°, 60°, 90°, 120° and 146°) in the GASP array. The analysis of data was performed with the computer code LINESHAPE [3], assuming rotational-band side feeding for each of the levels of interest. The slowing down of the Pr recoiling nuclei was described with two sets of electronic stopping, viz., shell-corrected Northcliffe-Schilling and Ziegler's heavy-ion stopping powers.

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PRELIMINARY RESULTS FOR THE ^{137}La NUCLEUS

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With the view of extending the systematics of odd and odd-odd nuclei in the A = 130 - 140 mass region towards to the N = 82 closed shell, the nucleus ^{137}La was studied with in-beam γ-ray spectroscopy. The nuclei in the region Z $\approx$ 50 and N $\approx$ 80 are of interest because the Fermi surface is close to the top of the neutron intruder $h_{11/2}$ subshell and the proton one is at the bottom of this subshell, causing a competition between the neutron oblate and proton prolate driving forces. This competition can result in shape transitions from prolate (N = 73) to triaxial or oblate (N = 80) forms.

The isotopes Z = 57, ^{130,132,134,135,136}La [1,2,3,4], were studied by this group during the last years. At low spins these nuclei are γ-soft with moderate quadrupole deformation ($\beta_2 \approx 0.2$).
The ^{137}La nucleus has been produced in the ^{130}Te + ^{11}B fusion reaction at 49 MeV beam energy. The beam was provided by the Pelletron Tandem Accelerator of the University of São Paulo. The experiment was performed using the GBR [5] array consisting of 4 HPGe detectors and a multiplicity filter of 7 NaI scintillators (6 of 3"x3" and 1 of 4"x4"). Two detectors are Ortec GMX of about 20% efficiency with BGO Compton suppressors while the other two are Canberra REGe with 60% efficiency. Events were collected when at least 2 Ge detectors and 1 scintillator detector fired in coincidence. Approximately 12x10^7 γ-γ coincidence events were recorded. The data have been sorted off-line into a symmetrized matrix and is being analysed. The preliminary level scheme for ^{137}La obtained in this work was extended to much high energies as compared to the first scheme proposed by Kortelahti [6]. Several new structures were observed, one of them populating the already known 360ns ($I^\pi = 19/2^-$). Careful analysis of the data is being performed in order to clarify the character of these structures.

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SPECTROSCOPY OF HIGHLY NEUTRON DEFICIENT NUCLEI AROUND A≈ 140

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Data on the structure of nuclei in the neighbourhood of the proton drip line are scarce since these nuclei, situated far from the stability valley, are hard to produce and study. We have used the
^{54}Fe + ^{92}Mo reaction at 240-MeV incident beam energy, in order to investigate neutron deficient nuclei in the A ≈ 140 mass region.
The incident beam was obtained with the XTU tandem accelerator of the Legnaro National Laboratory, Legnaro, Italy. The multi-detector array GASP, consisting of 40 high-efficiency Compton-suppressed HpGe detectors and the 80-element BGO multiplicity filter, was used for obtaining gamma-ray double and triple coincidence spectra. The 40-telescope Si ball (ISIS) permitted information on the type and multiplicity of the charged particles emitted, while the recoil mass spectrograph (CAMEL) allowed mass identification.
The following 3 and 4 particle reaction channels were strongly populated: ^{143}Tb, ^{140,142}Gd, ^{143}Dy. Preliminary results on the high-spin states seen in ^{143}Tb in the present work are described elsewhere in this report. Several gamma transitions have been assigned to belong to the 2pn channel ^{143}Dy. Previous to this work no information was available on the spectroscopy of this nucleus. The 3pn channel leading to ^{142}Tb has a large predicted cross section. No data on high-spin states in this odd-odd nucleus is known in literature. Among the other nuclei predicted to be populated at this incident energy, by statistical model codes (CASCADE, PACE), with weaker cross sections, it has been possible to assign transitions in the odd-odd nucleus ^{140}Tb, from the αpn channel, also for the first time.
Of the 2-particle outgoing channels, transitions in the 2p (^{144}Dy) and the αp (^{141}Tb) channels are strong. The 2α channel is much weaker and efforts are underway to detect the αn channel leading to ^{141}Dy, with a predicted cross section of around 1 % of the total fusion cross section. The data analysis is in progress.

HIGH-SPIN STATES IN ^{143}Tb

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A STUDY OF SHAPE DIFFUSION IN HOT NUCLEI

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The velocity of the changes in shape of a hot nucleus is important in several types of nuclear reactions. In some cases, fission of hot nuclei seems to be hindered relative to neutron emission due to the inability of the nuclei to change shape with sufficient speed[1,2]. On the other hand, if shape changes are sufficiently fast, the spectrum of statistical giant dipole photons is expected to become narrower[3].

We estimate the speed of the shape changes assuming that the evolution in nuclear shape is a completely-damped statistical process. To calculate the shape diffusion coefficients of a hot nucleus out to the scission point, we generalize the microscopic model of shape diffusion of Bush, Bertsch and Brown[4]. As they do, we completely neglect collective motion and treat the dynamics of shape changes as a purely diffusive process. We use a double-centered assymetric oscillator potential to describe the nuclear shapes, in order to apply the model to highly deformed nuclei. We then assume the diffusive dynamics to be a result of the two-body residual transitions between states and calculate them using the static Nilsson one-body orbitals of the underlying oscillator potential. As the number of contributing transitions grows rapidly with the temperature of the system, we do not calculate them all but sample them using a Monte Carlo technique.

Preliminary results show that our results are are in slightly better agreement with the experimental data than those of Ref. [4], but that neither of the two can explain the data.

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RELATIVISTIC HARTREE-BOGOLIUBOV APPROXIMATION

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The experimental study of nuclei far from the valley of stability has motivated a great deal of interest in nuclear structure calculations of the observed nuclei. One difficulty of these calculations is their need to extrapolate the parameters used in the effective interaction from the stable region, where they are well determined, to the region of interest. Relativistic models, which describe the nucleus in terms of Dirac nucleons interacting by meson exchange, offer the hope of being more fundamental than the others and, thus, of permitting such an extrapolation with no substantial changes in parameters.

We have derived self-consistency equations for pairing mediated by meson exchange and have implemented these in a relativistic Hartree code for axially-deformed nuclei. We are currently using it to study several isotopic chains. Results obtained to date will be discussed.

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In the region below N = 82 and around Z = 64 the Fermi level is close to the $h_{11/2}$ orbital for both protons and neutrons. Consequently $11/2^-$ states occur at low excitation energy in odd nuclei of this region with collective structures built on these single particle states. In the case of doubly even nuclei the importance of the $h_{11/2}$ proton and neutron orbital is evident from the presence of two 10^+ states, often isomeric, at low excitation energy. In the N = 78 isotones of Sm and Gd, these two states have been identified as the alignment of 2 protons or 2 neutron holes in the $h_{11/2}$ subshell. The N = 78 odd nuclei also show a discontinuity around 3 MeV in the regular $\Delta I = 2$ sequence built on the $11/2^-$ proton single particle state. Two $27/2^-$ states are indeed observed involving, respectively, the alignment of two $11/2^-$ protons, giving a maximum spin of $27/2^-$, and of two $11/2^-$ neutrons, which gives rise to a multiplet whose maximum spin is $31/2^-$. Two different cascades are built on the $27/2^-$ states which can be related to the structure of the two core nuclei. Shape coexistence phenomena are therefore important at N = 78.

Some information on these structures in nuclei with Z larger than 64, for example, in ^{143}Tb and ^{144}Dy, where the $h_{11/2}$ proton configuration is even more dominant, is available in refs. [1-4].

The present work is a report of the results on the ^{143}Tb nucleus from a study of the ^{54}Fe + ^{92}Mo reaction at 240-MeV incident beam energy. The 3p channel was one of the strongest channels populated. The target used was an ≈ 1.0 mg/cm^2 thick ^{92}Mo foil. The GASP array consisting of 40 high-efficiency Compton-suppressed HpGe detectors with the 80-element BGO multiplicity filter together with the multi-telescope Si-Ball (ISIS) were used to identify the events associated with the formation of ^{143}Tb nuclei. The recoil mass spectrograph (CAMEL) allowed mass identification. A preliminary level scheme obtained from the present measurement will be presented. The data analysis is continuing.

At the incident energy used, the 2p channel leading to the N = 78 even isotone ^{144}Dy is also populated relatively strongly. We hope to obtain further information on this nucleus in order to interpret the different structures observed in terms of nucleon alignment.

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FIRST EXCITED 2^+ AND 3^- STATES IN ^{94,98}Mo: PREDOMINANCE OF THE PROTON CONTRIBUTION

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The molybdenum isotopes lie in a transitional region, only a proton pair above the $Z = 40$ zirconium isotopes which, between $N = 50$ and $N = 56$, display features which are indicative of proton shell closure, in particular very low B(E2 : $0_1^+ \rightarrow 2_1^+$) values. This behavior is, in Zr, suddenly disrupted, if further neutrons are added. It is, consequently, of interest to investigate in detail how the extra proton pair affects these characteristics.

B(EL) values are, in principle, only representative of the proton contribution to the transition, if changes in core polarization effects are disregarded. It is therefore important to measure B(ISL) values, to also characterize the joint contribution of protons and neutrons. The Nuclear Spectroscopy Group has, at the Pelletron-Enge-split-pole-spectrograph facility, developed a research program in which Coulomb-Nuclear Interference measurements with deuterons are employed to extract the ratio B(EL)/B(ISL), in a manner in which experimental scale errors are cancelled and some model errors diluted. DWBA predictions within a deformed optical model approach are applied, utilizing well tested global optical parameters for deuterons. The use of nuclear emulsion as detector is deemed as an essential ingredient in obtaining data at forward scattering angles, where the interference pattern determines the ratio. To test the reliability of the method, data at 13.2 MeV and 16.0 MeV were obtained for ^{94,98}Mo. The constrained χ^2_{min} analysis determines the value of the ratio as being essentially due to the 13.2 MeV data and shows that the mass deformation parameter, δ^N, is obtained consistently, at the few percent uncertainty level, by the data sets at the two energies, both for ^{94,98}Mo and for the 2_1^+ and 3_1^- excitations. The analysis shows B(E2) to be ~ 25 - 35% higher than B(IS2) for the 2_1^+ excitations and the correspondent transition to be somewhat more

collective in ^{98}Mo. No sign of proton subshell closure is, therefore, further seen.

A simple pairing description of ^{11}Li

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The recent interest on nuclei near the neutron and protons drip-lines which have been observed through the use of radioactive nuclear beams has raised a new challenge to the theorists. It remains to be cleared whether or not the well estabilished theories in the valley of stability can be apllied to halo nuclei. In this work, we treat the neutron rich nuclei ^{11}Li using the BCS approach slightly modificated by the inclusion of the self-energy term, usually not considered [1]. This leads to a new gap equation, which depends on the j^{th} single particle level,

$$\widetilde{\Delta_j} = G\sum_i(\Omega_i - \delta_{ij})u_i v_i.$$

Varying the pairing force strenght, we have calculated the binding energy of ^{11}Li using the calculated single particle neutron levels available. We have also calculated the first excited state energy through the use of the quasi-spin method [2]. We expect this extension to multi-level case to bring us some information about the structure of the ground state of ^{11}Li.

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Decay of $^{102}Rh^m$

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The decay of ^{102}Rh has been studied for five years through a Rh source, produced by the ^{nat}Rh(γ,xn) reaction using the Linear Acceleretor of LAL-IFUSP.

With single and coincidence gamma-ray spectroscopy measurements, the known ^{102}Rh decay has been verified, and a new gamma-ray with euergy 277.071(12) keV and intensity $1.4(3)\cdot 10^{-4}$ *transitions per* ^{102m}Rh *decay*, was observed and assigned to the transition between the 4^+, 1798.71 keV, and 3^+, 1521.64 keV, levels in ^{102}Ru.

It was confirmed that the longer lived, 6^+, level is the isomeric state. The intensity of the isomeric transition between the 6^+ and 2^- levels of ^{102}Rh was measured as $2.7(3)\cdot 10^{-3}$ *transitions per decay.*

Statistical Methods of analysis of the decay data were developed, taking into full account the experimental information and the data covariances.

The isomeric states excitation energies and eletromagnetic properties, were calculated within the single particle model. In this framework, it is possible to assign a configuration to the 2^- fundamental state but not to the 6^+ isomeric state.

Neutron Star Mass in Relativistic Mean-Field Theory

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Relativistic Mean-Field (RMF) Theory has been applied in recent years to a large number of problems in nuclear structure. It has turned out to provide a very simple mean to describe ground state properties of nuclear matter and of finite nuclei in the entire periodic table. In fact, the model is very successful around the saturation region, but this does not assure that the same is true at extreme conditions (very low or very high densities).

Various applications of nuclear physics depend on the behavior of nuclear matter under extreme conditions. The properties of neutron stars depend on the neutron matter equation of state at densities up to an order of magnitude higher than those observed in ordinary nuclei. This high-density behavior is essential for calculating the balance between the attraction of general relativity and the nuclear pressure; it determines under what conditions gravity will cause the collapse of a neutron star into a black hole.

In this work, we use several RMF models available in the literature to obtain the neutron matter equation of state. From this equation of state, we calculate the neutron star maximum mass predicted in these models, which compared to observational estimates, allows us to test their validity at extreme conditions. We use the Walecka $\sigma-\omega-\rho$–model, considering the most successful parameterizations for the coupling constants, with and without non-linear terms in the σ–field. Density dependent coupling constants approaches are also used.

Measurement of directional $\gamma-\gamma$ angular correlation in the beta- decay of ^{188}Re

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The energy levels of the nuclide ^{188}Os, populated in the beta-decay of ^{188}Re, are showing clearly the rotational bands. There are several 0^+ and 2^+ states and possible states 1^+ and 3^+. Some negative parity states are also present and definitively identified.

Nuclear reactions induced by HI have shown the existence of high spin states.

Angular correlation measurement are difficult because the predominance of gamma-ray transitions with 155 keV (2^+ - 0^+) [1].

In this work, at the automatic spectrometer Angular Correlation device of the "Laboratório do Acelerador

Física nuclear aplicada

Física nuclear aplicada — 02/09/97

THE USE OF THE FLOATING WIRE TECHNIQUE TO TEST TRAJECTORIES IN MAGNETS OF ACCELERATORS

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The floating wire technique represents a good alternative to determine trajectories in the absence of accelerator beams. The trajectory (r) of a charged particle (q) with a given momentum (p) in a magnetic field (B) is equivalent to the shape assumed by a flexible wire in the presence of the same field submitted to a proper tension (T) and carrying an adequate current (i), that has to be high enough, to make the wire become incandescent. The tension is applied by running the wire over a pulley and attaching it to a weight to compensate the magnetic force : T/i=Br=pq . Friction in the pulley is minimized by the use of compressed air in its bearings, whose flux must be properly controlled. Cheaper than platinum and gold and with high melting point, it was used a 50 μm diameter nickel wire, energized with 600 mA. This technique was used to corroborate the beam trajectories, calculated by the Ptrace code,in the end magnets [1] of the race-track microtron booster, the second stage of the 31 MeV cw electron accelerator under construction at IFUSP Linear Accelerator Laboratory. The radius of the first (9.8 cm), third (14.0 cm) and fifth (18.2 cm) orbits were measured using respectively masses of 613.3 mg, 876.3 mg and 1136.7 mg. The orbits established by the incandescent wire were registered with the aid of a non magnetic mechanical device specially designed to be inserted in the magnet gap. The Ptrace results and the floating wire measurements agreed within 0.1%.

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Resistivity Measurements of Glasses used in Detectors with Resistive Electrodes

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Resistive Plate Chambers (RPCs) have been studied for many years, specially because they were considered suitable detectors for the construction of a first level muon trigger at the LHC, as they feature very large areas with low cost, simplicity of operation and good time resolution. However, when operated in the spark mode, the RPCs have severe rate problems that make it unsuitable above 100Hz/cm^2. One critical parameter governing the rate capability and the behaviour of these chambers is the resistivity of the electrodes. Experimental results have shown that the changes of the resistivity with temperature, time and humidity are responsible for the unstable operation of the RPCs. In the present work we describe the studies carried out to measure the resistivity and its dependence on the temperature of glass tubes that have been used in construction of resistive proportional counters. This was done by painting on both sides of the glass cylinder with conductive paint. We applied a potential difference to these electrodes and measured the current. The experimental device was placed inside a temperature controlled chamber through which either ordinary air or a special gas mixture could be passed. The results obtained have shown that the resistivity has decreased from $1.6\text{x}10^{13}\Omega$.cm to $9.3\text{x}10^{11}\Omega$ in the temperature range from 18°C to 50°C. On the other hand, up to now, we observed that the influence of surface leakage current on the measurements is negligible. These results associated with our previous data of resistive proportional counters will provide us with a better understanding of the origin of rate effects present in all gaseous counters which use resistive electrodes.

Covariances in deconvolution of multichannel spectra.

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Deconvolution of spectra has been extensively used in experimental sciences in connection to gamma-ray spectroscopy [1], neutron, mass and beta spectra study, cross-section, energy distribution of annihilation radiation [2], microprobe scans [3], seismic tomography [4], among others. The basic aim of deconvolution procedures is to obtain the intrinsic distribution of a signal blurred by the response function of a detector system affected by statistical fluctuation. The main source of troubles in deconvolution algorithms is that small statistical fluctuations in the original data are strongly amplified and, frequently, give rise to an oscillatory behavior of the data, and to negative counts. In order to reduce fluctuations of the deconvolved spectra many regularization procedures have been developed.

Linear do IFUSP", a set of absorbers [2] was used.
The source of ^{188}Re ($t_{1/2} = 17h$) was produced by irradiation using a flux of 10^{12} n/cm^2s thermal neutrons.In the analyses of single spectrum it was not observed any impurities, except ^{186}Re ($t_{1/2} = 96h$).
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The construction of a complex level diagram: the ^{194}Pt case

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The level diagram of the ^{194}Pt nuclide was performed with important changes when compared with the previously accepted one. The complexity of the levels and the production of contaminants during the irradiation has required special caution in the analysis of the single and coincidence spectra. The presence of ^{194}Ir (171d) has introduced important interferences that have been considered in the analysis and conclusions. In one of the two cascades fed by ^{194}Ir, two transitions with an energy of 562 keV appeared, coincident between themselves. The table of Isotopes (8th edition) show a third 562 keV gamma-ray between the levels of 2185 and 1622 keV, but that last one was not observed in the present experiment. In our work, a transition with the same energy but between the levels of 1373 (5^-) and 811 keV (4^+) was definitely seen . The 5^- level was populated from the 1432 keV level (3^-), by a gamma-ray of 59 keV, deduced from a carefull analysis of coincidences. The gamma-ray of 224 keV was relocated by the introduction of a 1737 keV level, very well substantiated by the analysis, including the observation of a difficult doublet 363-364 keV. The present discussion is a indication of the kind of sophisticated logic used to determine level diagrams in nuclides with complex structure.

HIGH-SPIN STATES IN ^{79}Rb

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High-spin states in ^{79}Rb were populated via the fusion-evaporation reaction ^{63}Cu(^{19}F,p2n)^{79}Rb, using a 67 MeV ^{19}F ion beam from the University of Notre Dame FN tandem accelerator. The target consisted of a self-supporting Cu foil, enriched in the isotope of mass 63, with a thickness of 500 μg/cm^2. The gamma decay of the residual nucleus was observed with the Pitt multidetector array [1] consisting of six Compton-suppressed HPGe detectors and of 14-element BGO sum-multiplicity spectrometer (SMS). Data were collected in event by event mode and stored on magnetic tapes for later analysis. Approximately 5×10^7 events were collected. The ^{79}Rb data were obtained from a symmetric $\gamma-\gamma$ coincidence matrix with 4×10^7 events. Events were defined by requiring gammas in three or more SMS elements. Two positive-parity bands and two negative-parity bands have been observed in ^{79}Rb. We suggest an additional level at 11649.2 keV to the Yrast negative parity band, according to the observation of a 1690.4 keV gamma-ray assigned to the transition between the levels $(45/2)^- \rightarrow (41/2)^-$. The reaction feeds weakly another negative parity band observed in the present work that can be assigned to ^{79}Rb. A level scheme for ^{79}Rb based on the present results and previous works [2,3] is proposed. A Cranking-model analysis was applied to the observed rotational bands in ^{79}Rb.

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Relativistic Mean Field Calculations for Asymmetric Nuclear Matter

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The Walecka model has been widely used to describe nuclear structure properties. The several available parameterizations for the Relativistic Mean Field (RMF) have successfully described these properties in the experimentally available regions (at zero temperature, saturation density and small neutron-proton asymmetry). In the present work we consider the asymmetric nuclear matter composed by protons and neutrons, using several RMF parameterizations available in the literature, in order to study the reliability of these forces for the reproduction of nuclear average properties in special, those related to the neutron-proton asymmetry.
Analytical expressions for several parameters of the semi-empirical mass formula are obtained. The infinite nuclear matter properties are analyzed in terms

of the several characteristic nuclear matter parameters such as volume energy, a_v, saturation density, ρ_0, incompressibility, K, symmetry energy, J, as well as other higher order parameters, like, L, K' and K_{sym}. For the density dependent RMF parameterization the analytical expressions of these coefficients are obtained for the first time.

From the obtained results it is shown that non-linear forces reproduce reasonably well the semi-empirical results, while the density dependent approach provide an unexpected small value for the incompressibility although giving a better value for the symmetry energy. The advantage of this last approach is the elimination of non-linear terms (which are of difficult physical interpretation) and also to give a parameter free description of the nuclear interaction, since the density dependence of the coupling constants is fitted to Brueckner-Hatree-Fock calculations for nuclear matter. The fact that we get a too small incompressibility points out that the used dependence (the single one available in the literature) needs to be improved.

Density Dependent Relativistic Mean Field Calculations for Semi-infinite Nuclear Matter

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In the last years a density dependent Relativistic Mean Field (RMF) approach has been proposed and applied for the description of spherical and deformed nuclei. A motivation for this description is to avoid the introduction of non-linear, not well understood, self-interaction terms in the σ–field, which are needed in order to achieve a quantitative reproduction of nuclear surface properties.

The recent studies applying the density dependent approach to infinite nuclear matter have shown that a too low incompressibility is obtained, although a better value for the symmetry energy is obtained. On the other hand, the density dependent studies for deformed nuclei have shown that a poor description of deformation is obtained in this approach. These results were interpreted as an indication that the density dependence of the coupling constants available in the literature and used in these works cannot well reproduce nuclear surface properties.

In the present work we examine directly this point performing Thomas-Fermi density dependent relativistic mean field calculations for semi-infinite asymmetric nuclear matter. The $\sigma - \omega - \rho$-Walecka model is used and the characteristic surface parameters for symmetric and asymmetric nuclear matter are obtained. The results are compared with semi-empirical mass formulae parameters and also with the results of the usual linear and non-linear RMF parameterizations.

A RELATIVISTIC SEPARABLE POTENTIAL TO DESCRIBE PAIRING IN NUCLEAR MATTER

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In two recent works[1,2], we have extended the usual relativistic mean-field approximation to Quantum Hadrodynamics (QHD) for the study of the short range correlations in nuclear matter. These correlations have been found to be rather simply related with the pairing phenomenon between nucleons. This happens due to the domination of the of the scattering N-N T-matrix pole over the size of the pairing gap and, also, due to the connection between the pairing field at low baryon densities and the $^1S_0$ N-N bound/virtual state wave function. This simplicity suggests that a simple though precise formulation of the nuclear pairing phenomenon can be done by an approximation that adequately take these results into account.

In this work we propose a *separable approximation* for the pairing potential in nuclear matter, which correctly takes into account the high momentum contributions of the short range NN-correlations and is much easier to handle than the complete set of the relativistic Hartree-Fock-Bogoliubov(HFB)-field equations. The approximation is based on the properties of the relativistic pairing field in the zero baryon density limit (vacuum) and on the observed numerical correlation between the magnitude of the T-matrix pole and the size of the pairing field for finite baryon densities.

The determination of the separable potential depends on the precision which can be achieved for the determination of the components of the vertex-function field $\Gamma(k)$. We have compared the usual relativistic HFB-calculations for Δ with the corresponding separable potential results, and the calculations for various $(\sigma\omega)$-potentials indicate that the above prescription is adequate. The relativistic separable potential correctly yields either the gap parameter, Δ_g , or the two bigger components of the Δ field, Δ_0 and Δ_s, at all baryon densities.

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Usually, such regularization procedures have been studied from ad hoc observations of the obtained results in some practical and simulated cases. However, regularization methods give rise to biased estimates and artifacts. In the study of deconvolution procedure, not enough attempt has been paid to the covariance matrices. As pointed out in this work, information obtained from the structure of the covariance matrices can be useful in understanding the behavior of deconvolved spectra: the large fluctuations are related to the large elements on the diagonal of the covariance matrices; the oscillatory behavior of the deconvolved spectrum is consequence of the negative elements on both sides of the main diagonal of the covariance matrices; and the source of artifacts are due to the positive elements on both sides of the main diagonal. In this work some aspects of the deconvolution spectra procedure within the least squares method are analyzed, and taking into account, in every step, the covariance matrices.

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MEASUREMENTS OF SMALL-ANGLE GAMMA RAY SACATTERING FROM BREAST PHANTOMS AND WATER

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The angular distributions of photons scattered by three phantoms of varying compositions (30% glandular/70% adipose, 50% glandular/50% adipose and 70% glandular/30% adipose) and by water have been measured at a photon energy of 59.54 keV. The results clearly demonstrate the existence of differences between breast phantoms and water for small angle scattering (2°-6°) at this energy. The contributions of intermolecular effects to the scattering process were only present in water. These results allow a critical comparison with calculations of the coherent differential cross section using molecular and atomic form factors for water obtained from interpolated x-ray diffractometer data [1, 2]. A good agreement was obtained within the experimental uncertainties .

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Física nuclear aplicada – 02/09/97

RESULTS OF PRELIMINARY TESTS WITH THE RF BUNCHING SYSTEM

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In a first phase we have evaluated the Q factor in a offline setup for each circuit, after adjusting the drive and pick-up probes of each individual component in order to get the correspondent resonant frequency. Typically, unloaded Q values were about 500 for pre-buncher (for the three harmonics) and chopper and about 1500 for the phase detector. These values were reproduced after the installation in the accelerator beam line. Recently we have started to use beam time to check and calibrate the bunching system control eletronics. Using ^{16}O and ^{35}Cl beams we have generate time spectrum between the bunched beam and a surface barrier silicon detector mounted in the 30B scattering chamber. In these preliminary tests we have used just the prebuncher. The results of these tests show a good agreement with our predict values. We have obtained 70% of transmission for bunched particles. Regarding the time resolution, we have not explored the best conditions of the system, but we have estabilished a higher limit of 4 ns. This value was obtained for ^{35}Cl beam in the laboratory energy of 67.5 MeV. A final point was that voltage obtained with the pick-up probe for this time resolution measurement has checked well with the predicted value.

The 3/2+ (3.5 +- 1.0eV) excited state of ^{229}Th

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The existence of an excited (J*=3/2+) nuclear state within 100 eV in ^{229}Th is known since 1976 (L. A. Kroger and C. W. Reich, Nucl. Phys. A259, 29 (1976)). More recently, a more precise measurement has deduced a value of 3.5(1.0) eV for that state (R. G. Helmer and C. W. Reich, Phys. Rev. C 49, 1845(1994)). The adopted methodology was to measure the difference in many energies of closed spaced gamma-ray peaks.

The main purpose of this work is to verify that value and to reduce the experimental uncertainty by using some experimental and statistical procedures developed in our laboratory (V. R. Vanin et. al, to be published in Nucl. Instr. and Meth). A ^{233}U source of about 4.10^6 Bq was measured using Si(Li) and high purity Ge detectors. Since many gamma-ray transitions from the radioactive serie beginning in ^{233}U appear in the direct measurements, a coincidence measurement was performed, allowing a net identification of the spectra. The statistical method adopted in the treatment of the experimental data takes into account the covariance matrix.

THE K_0-INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS: AN EXPERIMENTAL CONTRIBUTIONS AND APPLICATIONS.

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The k_0 standardization for Instrumental Neutron Activation Analysis is a relatively new nuclear analytical method. Due to the great advantages of these technique, it is expanded in more than twenty countries with reactor facilities in the world, including some from Latin America. The Cuban experience in this field is resumed in this paper. The development of an original neutron flux murtipurpose multimonitor and the use of Certified Reference Material for k_0-factors experimental determination, are presented. An original experiment dependencies of the neutron flux parameter for k_0 standardization are discussed. The application in Cuban agriculture, sugar industry, geology and enviroment shows the great potentiality of these nuclear analytical method.

CHARACTERIZATION OF POLYCARBONATE NUCLEAR TRACK-ETCHED MEMBRANES BY GAS PERMEATION METHOD

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Despite existing available several methods to estimate pore size in the ultrafiltration range in membranes, these methods generally involve very small membrane areas, some analysis ambiguity and/or require sample modifications. The measurement of gas permeability as a function of the mean pressure across the membrane has been proposed as an excellent tool to characterize several types of microporous membranes. In this work, the gas permeation technique has been applied to analyse the commercial flat polycarbonate nuclear track-etched membranes (TEM's) Nuclepore, with pore size of 15nm, 30nm and 50 nm, in order to verify if this method is appropriate to characterize the TEM's which are being developed at IPEN. The production of these membranes is being developed using the IEA-R1 research reactor (2MW) and the fission track registration technique in Makrofol KG ($8\mu m$ thickness). The trend of the flux versus transmembrane pressure measured for various gases (N_2, Ar, He, Ne, O_2, CO_2), at a constant temperature (293K), was perfectly linear indicating therefore a constant permeability for the commercial membranes. Furthermore, the permeability showed a tendency of increasing when the molecular weight of the gases decreased. The inverse of the square root of the molecular weight of the gases versus the corresponding permeability was plotted and all gases showed a good linearity for the three membranes studied, following the Knudsen predictions.So, the results demonstrated that the permeation of gases through the Nuclepore track-etched membranes (TEM's) follows the Knudsen diffusion model at least for pore diameters in the interval from 50nm to 15nm. An estimation of the pore radius r(nm) for each membrane has been realized using the Knudsen equation and it was observed a large variation of permeability for different samples with the same pore size. The reason for such large variation among the same pore size membrane may be explained by the presence of multiple pores (clusters) in their surfaces. However for the lowest value of permeability, the pore diameter estimated in this work presented a good agreement with those obtained by SEM technique and with the values listed in the Nuclepore catalogue.

THE ACCELERATING STRUCTURE OF THE IFUSP MICROTRON

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This paper describes the project, construction and testing of the $\beta = 1$ structure of the IFUSP Racetrack Microtron (RTM) and presents the results obtained for the effective impedance, coupling factors and accelerating field distribution.

The $\beta = 1$ cw-accelerating structure, 1.04-m long, containing 17 accelerating and 16 coupling cavities, has been built at the Laboratório do Acelerador Linear do IFUSP (LAL). It has been tested, showing excellent parameters. The effective shunt impedance is 10% higher than expected, which is very promising, since this will allow the operation of the RTM using $\sim 9\%$ less RF power than initially planned.

The dynamic tuning system that uses moving plungers in the extreme cavities, developed at LAL, proved to be very efficient and fast in keeping the structure tu-

ned, even when submitted to conditions worse than the expected to occur during normal operation.
The machining and brazing of the pieces that compose the structure were both done at LAL and proved to be of excellent quality, since the structure performance was higher than the project specifications.

ISA-to-CAMAC Interface

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The Linear Accelerator Laboratory data acquisition system is based on CAMAC crates interfaced to a PDP-11 computer, an old computer that is being retired. The experiments planned at LAL require counting rates of up to 10k events/s, each event demanding to read a few bytes from different CAMAC modules. We assessed experimentally the capabilities offered by off-the-shelf CAMAC controllers with standard GPIB and SCSI interfaces. Such systems reached maximum acquisition rates of about 6k events/s of 2- byte events. Significant dead-time is then expected to occur at low event rates. This low performance was attributed to the channel programming in the SCSI interface and to talker-listener arbitration in the GPIB interface. We did not test CAMAC controllers with Ethernet interfaces because of the low performance declared by the manufacturers, which may follow from the complexity of the Ethernet protocol. To fulfill our needs, we are designing a new CAMAC controller with ISA interface, intended to be microcomputer driven. The ISA protocol is more simple than the SCSI and GPIB, speeding up the communication process. The Crate Controller is designed to have I/O addresses to receive CAMAC commands (NAF), to read from and to write to the dataway, and to provide the LAM pattern. Interrupt capabilities include a programmable LAM mask. The first step, already achieved, was to develop 16-bit ISA boards with interrupt capabilities. The next was to extend the ISA-bus to 1.5 m. The extender consists of a twisted-pair cable (64 pairs) and two boards, one located at the mother board and the other at the remote end. We tested it by running a PC with the disks and mouse interfaces outside the main-board housing. We are now assembling the module.

RESULTS OF A BRAGG DETECTOR BUILT FOR THE AMS PROGRAM

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The main technical problem in ultra-high sensitive Accelerator Mass Spectrometry (AMS) measurements is the presence of isobaric contamination on natural samples. This is the case of AMS for isotopes lighter than Cl. Samples of interest on ^{10}Be have ^{10}B, the ones for ^{26}Al have ^{26}Mg and finally the ^{36}Cl samples have quite a significant amount of ^{36}S. In all these cases the chemical separation of the contamination is very difficult (AMS deals with isotopic abundances of the order of 10^{-14} to 10^{-15}). The detection system has to be able to separate elements that differ by one unit of charge. Normal particle detection techniques are based either on the mass number (A) or charge number (Z) determination. The resolution has to be good enough to separate the elements in the mass region of interest. The Brazilian AMS Program is concentreded on the determination of ^{10}Be, ^{26}Al and ^{36}Cl, so the detection system has to able of separate up to Z=20. In order to improve the ability to separate isobars and different elements within δZ=1, we have designed and built a Bragg detector. The first tests showed very good results and we hope to get an even better resolution improving the gas system control. In this contribution the results of the tests will be presented.

Performance of a Proportional Counter with Resistive Cathode under X-Ray Irradiation

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In this work the rate effects associated with the gain of detectors with resistive electrode under x-ray irradiation are considered. To study these effects it was decided to use a classical proportional counter geometry, with an alkaline glass cylindrical tube as the cathode, rather than parallel plate devices. Indeed, the generality of the information obtained is not affected and the cylindrical proportional counter geometry has several advantages to gather detailed experimental data and to compare it with simple electric field calculation. A self consistent set of data is presented for rate effects, from a few tens of Hz up to several hundreds of Hz, using several geometries and gas mixtures, different anode wires, cathode radii and thickness of the resistive electrode. Although a few sources of systematic errors can be identified, all the observed experimental data can be quantitatively explained. Indeed, the measured gas amplification, from a few tens up to 5×10^4 and for the range of counting rates quoted above, depends

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We perform a classical dynamics study of the one- and two-proton transfer reactions for the $^{12}C + ^{197}Au$ system, recently measured at the TANDAR laboratory [1]. These data are presented as a plot of the transfer probabilities versus the distance of closest approach, D_{Ruth}, calculated assuming a Rutherford trajectory. At large distances the experimental slope of the transfer probability decrease when the beam energy is increased, in apparent contradiction with the standard semiclassical interpretation of the transfer as a tunneling process at the distance of closest approach. Another notorious deviation from the standard picture are the unexpected values of the slopes for two-nucleon transfer compared to those from one-nucleon transfer reactions. This discrepancy between the data and the semiclassical predictions has been originally referred as the slope anomaly in the case of neutron transfer.

In this paper we reconcile the semiclassical picture with the trend of the slopes as a function of the beam energy. We assume that the nuclei move along classical trajectories under the influence of both, the Coulomb and the real part of the nuclear optical potential. The proton transfer is considered as a tunneling process around the point of closest approach. The absorption due to the imaginary part of the optical potential is also included. At the highest energies considered several trajectories correspond to a given scattering angle, each of them with a distinct distance of closest approach. The contributions associated to the different trajectories are added to obtain the proton transfer probability.

We show that the interplay between absorption and tunneling effects explains the observed energy dependence of the slopes in the transfer probabilities as a function of $D_{\rm Ruth}$ for both one- and two-proton transfer reactions.

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FROM WIGNER DISTRIBUTION FUNTIONS TO CLASSICAL DISTRIBUTION FUNCTIONS

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The main tool for the phase-space formulation of quantum mechanics are the phase-space distribution functions the best known of which is the Wigner distribution function ref. [1]. Although the quantum phase-space distribution function should be considered as simply a tool that facilitates making the connection of quantum mechanics with classical mechanics, in many situations the Wigner distribution function does a respectable job, it is often employed in the phase-space description of atom-molecules collision processes ref. [2,3]. There are also applications of the Wigner distribution function in Nuclear Physics such as the Wigner representation of the one-body time-dependent Hartree Fock approximation which reduces the description of the many-body nuclear dynamical problem to a phase-space distribution function ref. [4].

In this work we study a mapping ref. [5] wich relates the Wigner phase-space distribution function of a given stationary quantum mechanical wave function, solution of the Schrödinger equation, to a specific solution of the Liouville equation, both subject to the same potential. By making this mapping the elastic scattering of a particle by a potential is reduced to the classical limit whereas bound states are described by semiclassical distribution functions. These results were illustrated by considering scattering by a potential barrier and bound states in a square well ref. [5]. Here we study the mapped distribution obtained by considering a particle bound in the Pöschl-Teller potential ref. [6].

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Determination of reaction time scales from angular correlation measurements at small relative momenta

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In order to continue the study of the dynamics of light heavy-ion reactions, which has been done by our group, we are interested in obtaining time scales for these reactions. To do that, we are using a technique that consists of angular correlation measurements at small relative momenta. It has been a widely used tecnhique at low and high energies.

only on a local electric field as it should be expected. Efficiency results are a direct consequence of the gain behaviour.

Modernization of Second Generation Medical Tomograph on the Base of a Conventional PC.

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In this work we report the development of the X-ray Laboratory at CEFET-PR organized recently. Our activity now is focusing on the substitutiom of the medical tomograph control system based on old an old model PDP-11 by a conventional PC. We are also developing the data acquisition system and image reconstruction software.

As a first step it was necessary to get the mechanical control over the main second generation tomograph movements: rotation and translation. To achieve it we are using the signal diagrams which were presented in the technical manuals. To convert the logical signals (-/+12 V to 0 -:- 5 V) we had to construct a new interface board.

In principle the mechanical system gives us translation precision about 0,01 mm and rotation 0,5 degree. It means that after modernization will be fulfilled we can reach the spatial resolution comparable with a third or forth generation tomograph.

Right now our work is concentrated at the image reconstruction code and its filtering in order to obtain a better quality of tomographic images. Our image resolution involves now 512 x 512 pixels, but it could be increased to 1024 x 1024 easily.

PROGRAMA DE CONTROLE DE QUALIDADE EM RAIOS-X CONVENCIONAL

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A qualidade de uma imagem radiográfica está diretamente relacionada com a dose a que estão sujeitos os pacientes e os operadores dos equipamentos. Estão sendo estudados, no Setor de Radiodiagnóstico do Hospital de Clínicas da Universidade Federal do Paraná, os seguintes fatores envolvidos na produção de imagens:

1) Equipamentos de raios-X. Foram feitas medidas para garantir a autenticidade dos parâmetros de exposição (kV e mAs) e geométricos dos aparelhos.

2) Processadoras automáticas de filmes. Para garantir a qualidade do último passo da formação da imagem é feito o controle de temperatura e tempo de revelação, da câmara escura e dos parâmetros de resposta dos filmes, além de verificar a qualidade dos produtos químicos utilizados. Estão sendo ainda feitos testes de sensitometria para acompanhar diariamente o rendimento das processadoras.

3) Controle das radiografias rejeitadas. Estabelecer as causas de perdas das radiografias, permitindo avaliar o efeito da ação corretiva, mostrando também os setores que apresentam elevada taxa de rejeição.

4) Qualificação de pessoal. Foram ministrados cursos sobre processadoras automáticas de filmes e noções básicas de Radiologia para os técnicos do Setor.

Os procedimentos descritos acima tem como objetivo final a melhoria da qualidade das imagens permitindo diagnósticos mais precisos. Com isso diminui-se a dose e reduzem-se os custos de exames médicos. Todos os valores medidos estão dentro dos limites estabelecidos pelas normas internacionais (IEC 1221-2.1,2.3).

SURFACES AND JUNCTIONS OF Ge(HP) AND Si(Li)

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The final germanium and silicon detector performance depends greatly on the crystal surface quality state as well as on its junction. Thus, passivation techniques must be employed to protect the surface from environment influence [1]. In p-n junctions generation currents appear due to the electron-hole pairs produced at the generation-recombination centers in the depleted region of the detectors. If the detector's junction presents an interface Si-SiO_2 in silicon or Ge-GeO_x in germanium, there is an aditional current component due to the charges in this oxide ayer [2].

To recuperate detectors, sometimes it is necessary to regenerate its junction. In these case, we use warm-up and clean-up [3]. To produce uniformity in the junction interface we employ an annealing. If the detector presents some surface contamination, we must investigate and apply new passivation techniques, to eliminate the impurities. On germanium we used (HNO_3+HF), and diluted HF on silicon.

Results related to the recuperation of three detectors are presented, using the cited techniques. One Si(Li) detector recuperated its original characteristics, -1500V bias with 400eV resolution for the 30.97 keV ^{133}Cs $K_{\alpha 2}$ X ray. One Ge(HP) detector presented a resolution of 2.7 keV for the 1.33 MeV ^{60}Co γ radiation, with -3000V bias. The other Ge(HP)detector operated with -2600V and 1.94 keV resolution for the 59.54 keV ^{241}Am γ ray.

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Through that, we are going to obtain the correlation function, given by:

$$1 + R(q) = C \sum \frac{Y_{12}(p_1,p_2)}{Y_1(p_1)Y_2(p_2)}$$

where $Y_1(p_1)$ and $Y_2(p_2)$ are the number of particles with momentum p_1 and p_2, respectively, and $Y_{12}(p_1, p_2)$ is the number of coincidences between particles, whose momenta result in a specific relative momentum q; C is a normalization constant, chosen in such a way that $R(q) = 0$ for high values of relative momentum q.
One characteristic of this function that can be pointed out is the anticorrelation, which is like a half well at the small relative momenta region of the curve. It can be due to a predominance of Coulomb interaction. However, if the particles are alike, then the Pauli Exclusion Principle can also contribute to that behavior.
A correlaton function, which presents an anticorrelation, can be fitted by a Monte Carlo simulation code in which the time scale is a parameter of the fit.
To complement the work of our group, we are interested in studying correlations involving fission fragments or transfer products.
The experimental setup consists of a hodoscope composed by fourteen triple telescopes, each composed by one ionization chamber, one silicon detector and one CsI detector, closed packed, with an angular spacing of 4.5° between close neighbors. The telescopes provide identification of both heavy and light particles, with a good resolution.
We have performed measurements for the $^{16}O+^{10}B$ system at the bombarding energy of E=64 MeV, with the center of the hodoscope at 25° regarding the beam direction. The most forward telescope was at 18.3° and the most backward was at 31.8°.
The calibration of spectra and the program to obtain the experimental correlations are being done. We are also writing the Monte Carlo simulation code, which includes three-body kinematics and Coulomb interaction between the fragments and the residual nucleus.

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Time Scales for Fusion-Fission Reactions

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In the last few years our group has been studying the dynamics of light heavy-ions reactions (A_{CN}<20), specially the fusion-fission mechanism. In order to continue this kind of investigation we are interested in determining the time scales of fusion-fission processes in this mass region. These time scales can be evaluated when we examine the excitation functions of these systems. At excitation energies where several compound nucleus decay channels are available, the full width of levels is comparable to the separation between them. In this situation it is not possible to separate these levels and the cross section is strongly dominated by resonances, witch can interfere with each other. This interference is randomical, some times chaotical, and originates fluctuations on the cross-sections[1,2,3]. The compound nucleus life time (τ) is related to the average width of the levels (Γ), by:

$$\tau = \frac{\hbar}{\Gamma}.$$

The Ericson correlation function[4] $C(\varepsilon)$, is given by:

$$C(\varepsilon) = C(0)\frac{\Gamma^2}{\Gamma^2+\varepsilon^2},$$

where ε is the energy step and $C(0)$ is given by:

$$C(0) = \frac{1-y_d^2}{N_{eff}},$$

where y_d is the ratio between the cross section and the averaged one. N_{eff} is the number of effective channels that contribute to the experimental cross section.
This correlation function can be experimentally evaluated from the excitation function measured in small energy steps ans the time scales is evaluated from a fit.
The experimental setup consists of four particle detectors. Two of them are ionization chambers, to measure the energy loss in the gas and a silicon detector, to measure the residual energy. In these detectors it is possible to identify the atomic number (Z) of each particle. The other two are position sensitive detetors (PSD's) where it is possible to measure the position and the energy of the incident particle. We perform coincidence measurements between any ionization chamber and any PSD. The mass of the coincident particles can be evaluated by kinematic calculations. It is possible to apply high-voltage ($-100KV < V < 100KV$) to the target in order to change the beam energy in small steps (δE_{lab}~$20KeV$).
Measurements had been done for the system $^{16}O+^{10}B$ with E_{Lab}~$64MeV$ (δE_{Lab}~$50KeV$).

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Reações nucleares

Reações nucleares – 03/09/97

LONG-LIVED PRODUCTS OF THE SPALLATION OF ^{nat}Te AND ^{nat}Mo BY PROTONS

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With the exception of the nucleosynthesis in stars, the production of isotopes in the interstellar medium occurs mainly through the spallation of high-energy cosmic rays by protons and cold plasma bubbles, the main constituents of this medium. The spallation of the most abundant species into all the lighter ones is an ingredient of the propagation calculations of cosmic rays. The knowledge of those cross sections is then necessary to understand the observed cosmic-ray abundances and to make cosmic-ray age calculations. We have performed experiments of spallation of natural Te targets by 5.0- and 1.85-GeV protons and of a natural Mo target with 1.85-GeV protons at the LBNL Bevatron. The cross sections for the production of several radioactive isotopes with half-lives ranging from a few minutes up to tens of days were determined and published elsewhere [Phys. Rev. C **55**, 820 (1997)]. In order to determine those cross sections associated to long-lived products, we have brought the targets to the Laboratório do Acelerador Linear do IFUSP, to gamma-count them. The measurements were done with a high-purity Ge detector of 162-cm^3 active volume and usual nuclear electronics. The counting took ~10 days for each target, inside a 20-cm thick lead shielding, built with newly-cast, extra-clean lead. Measurements of background, efficiency and gamma absorption in the source were also made. The Te data revealed the presence of trace amounts of ^{60}Co (half-life 5.3 yr) and of ^{22}Na (half-life 2.6 yr) and measurable amounts of ^{102}Rh^m (half-life 2.9 yr) and ^{125}Sb (half-life 2.7 yr). The Mo target showed the presence of a trace amount of ^{22}Na and a measurable amount of ^{65}Zn (half-life 0.7 yr). Our results for the cross sections on Te are 4.0(2) mb for producing ^{102}Rh^m and 29(1) mb for ^{125}Sb. We are presently working on the determination of the spallation cross sections on Mo and on upper limits for the trace amounts mentioned.

Nuclear radii of proton-rich radioactive nuclides near the N=Z line

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There is a lack of experimental informations on properties of proton -rich, heavier (A=60-80) nuclei near to the N=Z line. They present a special interest due to their symmetries, which result in intriguing properties, as:
i- the strongest deformations in the nuclear chart are expected around the N=Z line due to the equal proton and neutron deformations, which enhance each other.
ii- the Nolen-Schiffer anomaly for N=Z mirror nuclei, which is related to the charge symmetry breaking interaction, mainly due to mixing of ω and ρ mesons, and which seems to increase for heavier N=Z nuclei.
iii-The spin-isospin independence of the nuclear force can be related to a SU(4) symmetry and results in a much enhanced proton-neutron pairing interaction and in a much stronger binding energy for N=Z nuclei. This effect also should decrease for heavier N=Z nuclei due to Coulomb and spin-orbit interactions.
From astrophysical point of view these drip-line or near drip-line nuclei are also interesting since probably they provide the pathway at higher mass for the so called rapid proton (rp) capture process.

Proton-rich radioactive nuclei with masses between A=60-80 near the N=Z line were produced via the fragmentation of a 73 MeV/nucleon ^{78}Kr primary beam on a ^{nat}Ni target at GANIL (Grand Accelerateur National d'Ions Lourds), Caen, France. The secondary beams have been analysed in the high precision magnetic spectrometer SPEG with complete identification of mass and atomic number of the incident particles. The nuclear reaction cross section of these secondary nuclei were measured on Silicon using the Direct Method, were the detector playes also the role of the target. A stack of several Silicon detectors were positioned in the focal plane of SPEG and allowed the measurement of the total energy spectrum with good resolution, where the elastic peak corresponds to particles without reaction in the Silicon (target and detector) and the events with energy loss correspond to nuclear reactions.
The reaction probability can be directly calculated from the spectra and related to the interaction radii of the secondary nuclei. The radii of the ^{62,63,64,65,66,67,68}Ga, ^{64,65,66,67,68,69,70}Ge, ^{66,67,68,69,70,71,72}As, ^{68,69,70,71,72,73,74}Se and ^{70,71,72,73,74,75,76}Br can be obtained from our data, which are being analysed at the Pelletron Laboratory.

Photofission and Multiple Nucleon Photoemission of ^{232}Th at Intermediate Energies

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The mean excitation energy $\bar{E}_x$ of ^{232}Th, following photoabsorption in the interval of $40-110MeV$; is determined from the nuclear photofissility measured at Saclay using a novel technique developed at this Laboratory. It is found that $\bar{E}_x$ of ^{232}Th is considerably lower than that obtained from INC-Monte Carlo calculations which, by their turn, describe fairly well the preequilibrium in heavier actinides. It is suggested that this fact could possibly be associated with a higher nuclear transparency of ^{232}Th. It is also shown that the accentuated disagreement between calculations and data from recently measured $^{232}Th(\gamma, xnyp)$ reactions, could be greatly due to the overestimation of the excitation energy of ^{232}Th. In this regard, an exemplifying calculation demonstrates that this overestimation of $\bar{E}_x$ reveals itself as a huge overestimation of the fission competition yield in the equilibrium stage.

THE DOORWAY EXPANSION METHOD APPLIED TO HEAVY-ION COLLISIONS INVOLVING A NEUTRON-RICH EXOTIC NUCLEUS

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We study heavy-ion collisions involving a neutron-rich exotic nucleus within a coupled-channel reaction model. The inelastic channel considered corresponds to the so called soft-giant dipole oscillation of the neutron halo against the core in the exotic nucleus. We use a generalization [1] of the Doorway Expansion Method (DEM) [2,3], that includes angular momentum coupling, to solve the resulting coupled-channel equations. We take the system ^{11}Li $+^{208}$ Pb at collision energies around the Coulomb barrier ($V_B \cong 26$ MeV), including in the calculation the ground-state and the first excited dipole state. We calculate the elastic and inelastic angular distributions, and the fusion cross sections and we study their dependence on the Q-value.

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ABSORPTION AND TUNNELING EFFECTS IN ONE- AND TWO-PROTON TRANSFER REACTIONS

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MEASUREMENTS OF THE PHOTOFISSION CROSS SECTION FOR ^{239}Pu IN THE ENERGY INTERVAL FROM 5.2 TO 10.8 MEV

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Photofission cross sections for ^{239}Pu, near the reaction threshold, have been measured using the nuclear track registration technique in Makrofol KG (10 μm) and an automatic discharge chamber for the fission fragment tracks counting. The experime nt has been carried out in an experimental facility installed at the tangential beam port (BH4/12) of the IEA-R1 research reactor (2MW) of the IPEN-CNEN/SP. The gamma rays used were those produced by thermal neutron capture in several materials targets wh en placed near the reactor core. These discrete and monochromatic gamma ray lines, with energy resolution of a few tens of electron volts, were monitored by a gamma ray spectrometer of Ge(Li)(5%, 25cm^3, ORTEC), positioned 824 cm far from the capture target. The efficiency calibration for this detector was performed, in the 2 to 11 MeV energy interval, using a sample of nitrogen as reference standard. For the present work, around than 30 gamma ray lines, with energies ranging from 5.2 to 10.8 MeV were employed. Details of the data analysis are discussed and the results are compared with previous measurements performed with different sources of gamma rays.

S AND D WAVES OF $E1$ TRANSITIONS OBSERVED IN TRITON ANGULAR DISTRIBUTIONS FROM THE REACTION $\gamma(^7\mathrm{Li},t)\alpha$

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The ground state of ^{7}Li ($J^\pi = 3/2^-$) is an example of a clustered nuclear system, consisting mostly of an α-particle and a triton, other components of the wave function playing secondary roles. The study of cluster properties in nuclei gained a new impetus due to new microscopic calculations based on the method of resonating groups and also on multicluster models. Those calculations adequately describe the main static characteristics of the nuclear systems and achieved remarkable progress in the description of the photodisintegration of binary clusters (like $\gamma + {}^7\mathrm{Li} \rightarrow t + \alpha$) and of the radiative capture of clusters (like $t + \alpha \rightarrow {}^7\mathrm{Li} + \gamma$).
Angular distributions of tritons emitted in the reaction $\gamma(^7\mathrm{Li},t)\alpha$ have been measured for $E_\gamma = 6.751$ MeV and 8.999 MeV and θ_t between 30° and 150°, using the monochromatic photon beam from neutron capture reactions of the IPEN/CNEN-SP 2-MW research reactor. The measured data were analyzed in the framework of a cluster approach for the ^{7}Li structure and confirmed the energy dependence of the $E1$ S and D scattering waves. The conclusion agrees with a recent measurement of the azimuthal cross section asymmetry.

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STUDY OF THE GENERATION AND DECAY OF FISSIONING HYPERNUCLEI

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We propose the delay fission investigation which will be the indication of hypernuclei production and decay within the atomic masses region near 200. The aim of the experiment is to measure the hypernuclei electroproduction cross section and Λ-hyperon lifetime inside of the heavy nuclei.
Proposed measurements demand the utilization of high energy electron beam facility with low angular emittance and high current. Other parameters such as high duty factor and compact beam spot dimensions at the target are also required. Actually these beam characteristics are offered by Thomas Jefferson National Accelerator Facility (CEBAF) only.
Despite the fact that hypernuclear physics has about 40 years of history, the experimental investigations have been made predominantly for hypernuclei within atomic mass number ≤ 20. Available data are rather scarce and have large uncertainties. This is due to the tremendous difficulty in the hypernuclei production and subsequently - due to the detection and identifying

problems of their decay products. Only two heavy hypernuclei - $^{209}Bi_{\Lambda}$ and $^{238}U_{\Lambda}$ have been experimentally observed and their lifetimes were measured with very low accuracy.
The hypernuclei lifetime is a fundamental quantity. Its knowledge is required to verify different concepts of the nuclear structure and hadron interaction. The investigation of hyperon decay in nuclei may provide the information about the influence of nuclear media on weak Λ-hyperon decay, quark structure of hypernuclear system and so on. One of the problems still existing is the search for long-lived hypernuclei whose existence may be due to the delaied decay of a Λ-hyperon in the strong intranuclear electromagnetic fields. It was predicted by Salam and Strathdee in connection with the expected symmetry restoration in such circumstances.
The delay fission cross section caused by hypernuclei production is about $(2.5 \pm 1.0) \times 10^{-5}$ of prompt fission cross section. The lifetime of delay fission is some picoseconds.
We propose to carry out the measurements of electroproduction cross sections for $^{197}Au_{\Lambda}$, $^{209}Bi_{\Lambda}$ and $^{238}U_{\Lambda}$ in the electron energy range $1 - 2GeV$ and their lifetime determination.
The measurements will be performed using the recoil-distance technique in projectile modification and solid state fission fragment detectors.

General Expressions for the Matrix elements of $SU(3)$ Wigner and Majorana Interactions

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The probabilities Q of creation inside the nucleus of pairs of necleons with definite quantum numbers of relative orbital motion in the unitary scheme approximation are considered. Explicit expressions for these probabilities in terms of genealogical coefficients are given. Three relationships between these quantities and the labels of unitary chain of subgroups of $U(2A-1)$, valid for any nuclear $SU(3)$ configuration were found. Two other ones, valid only for $SU(3)$ ground configuration, were also found. These relationships allow us to find the matrix elements of general $SU(3)$ invariant Wigner and Majorana Interactions in terms of labels of $SU(3A-1)$ in the unitary chain, for nuclei with A up to 40.

Shadow effect on a heavy-ion elastic scattering at very forward angles

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Recently some papers have reported that the interesting phenomena at very forward angles in a heavy-ion elastic scattering, the forward nuclear glory scattering, have been observed experimentally by means of the sum-of-difference cross section analysis. We have calculated the sum-of-difference cross section and the nuclear scattering amplitude for the α+^{90}Zr elastic scattering at some bomberding energies and have made a semiclassical analysis of them. We have shown that the angular distribution of the nuclear scattering amplitude in the very small angle region behaves like the zeroth order Bessel function with a specific frequency, which is a noticeable feature of the forward nuclear glory scattering, even if it never happens. We have also provide the semiclassical interpretation that the phenomenon like this can be also caused by the shadow effect of the nuclear rainbow scattering. On the other hand, we have indicated that it might be the evidence of the forward nuclear glory scattering that the amplitude of the sum-of-difference cross section at the very small angle is almost independent of the incident energy or at least has a very weak energy-dependence in case that the forward nuclear glory scattering occurs.

REACTION CROSS SECTION OF NEUTRON RICH NUCLEI

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The reaction cross section at intermediate energies for a variety of neutron rich isotopes with energies ranging from 50 to 70 MeV/nucleon is calculated. The Glauber and WKB approaches considered are described in details in ref. [1]. The imaginary optical potential is determined by knowing the profile function t(b), see ref. [2]. The Pauli-blocking "in-medium" correction in the optical potential were included. The real nuclear optical potential is determined by the double folding expression with no energy dependence. Both potentials, real and imaginary, depend on the nucleon densities. The densities are from the relativistic mean field theory. Comparison with experimental data is done.

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Spontaneous cold fission and cluster radioactivity half lives calculation

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In the last two decades cluster radioactivity and spontaneous cold fission phenomena have called attention both, from the experimental point of view [1,2], and the theoretical framework[3,4,5]. These processes are explained in terms of the models by including shell effects, and the results obtained in this context are in good agreement with the data.
After the observation of nuclear decay of ^{234}U in two symmetric nuclei with total kinetic energy very near of the available energy for the decay (Q-value), it has been detected others cold fission processes (^{230}Th[2], ^{240,242}Pu[2,7], ^{248}Cm[1,8] and ^{252}Cf[6,9]). Besides the cluster radioactivity process, the cold fission phenomenon has been considered as the newest source of information about the fission path from the sadle point to the scission. Theoretical approaches have tried to understand the alpha decay, exotic cluster emission and cold fission processes through an unifyed model[3].
In the present work we introduce half lives calculations of a large range of nuclei in order to predict possible new candidates to experimental research. We applied our previous unified model[4,5], discussing the use of different inertial coeficients on the result of half lives and yields of cold fission fragments.

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Kaon multiplicity calculation near threshold in photonuclear reactions

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Pions and kaons have been intensively studied in the last two decades in the relativistic heavy ions reactions context[1,2]. A renewed interest in the photoproduction of particles has appeared in order to explore the in-medium photon-nucleon interaction by using intermediate energy (0.5–2.0 GeV) monochromatic beams. It is observed that photonuclear reaction yields have been currently interpreted in the framework of a two-step interaction model. A rapid *intranuclear* cascade phase develops from binary intranuclear collisions, reabsorption of photoproduced pions, and scattering of recoil nucleons. During the second reaction stage the excited residual nucleus cools down by a mechanism of competition between fission and particle evaporation processes [?, 3]
Recently, we proposed a many body cascade calculation for the rapid phase which takes into account the dynamical evolution of the multiparticle collisional processes[4]. Results of this model showed that the pion

multiplicity is strongly sensitive to the multiparticle dynamics.

Kaons have already been recently observed as being produced in the γ -proton reactions[5,6,7]. An investigation for the γ-A reaction have been carried out in order to explore new informations about the effects of the nuclear medium in the photon absorption mechanism. The main observable of the present calculation is the kaon multiplicity and photonuclear kaon production cross section. The results obtained show that the Fermi motion and nuclear binding energy has a remarkable effect for kaon production near threshold.

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The Ion-Ion Potential and Neutron Transfer Processes in the $^{18}O + {}^{58,60}Ni$ Systems at Sub-Barrier Energies[a]

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Recently we have presented a realiable determination of the ion-ion potentials for the $^{16}O + {}^{58,60,62,64}Ni$ systems[1,2], at the large interacting radius ($9.5 \leq R \leq 11.5\ fm$),by measuring the elastic (1% precision) and inelastic (2^+) cross sections at sub-barrier energies. In the present work, we have extended those studies to the $^{18}O + {}^{58,60}Ni$ systems, and we have investigated: i) the influence of the neutron transfer processes in the determination of the ion-ion potentials using the coupled channel (CC) analysis of the data, ii) the comparison between the resulting CC ion-ion potentials and the theoretical calculations using the Double-Folded method and Shell-Model densities, iii) possible influence of the two neutron transfer process in the measured fusion cross sections for the $^{16,18}O + {}^{58,60}Ni$[3].

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Índice de Autores e Apresentações

Períodos

1 - Comunicações Orais - 14:00 - 15:30
2 - Painéis - 15:45 - 17:00

XX

REUNIÃO DE TRABALHO SOBRE FÍSICA NUCLEAR NO BRASIL

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CAPES

CLAF

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Autor	Dia	Período	Sala	Pág.
Oliveira, J. R. B.	2	2	.....	18
Oliveira, J. R. B.	2	2	.....	19
Oliveira, J. R. B.	2	2	.....	19
Oliveira, J. R. B.	2	2	.....	20
Oliveira, J. R. B.	2	2	.....	20
Oliveira, P. S. A. de	2	2	.....	30
Oliveira, P. S. A. de	2	2	.....	30
Oliveira, R. M.	3	1	.....	32
Oliveira, V. X. de	2	2	.....	15
Orr, A.	3	1	.....	32
Ostrowski, N.	3	1	.....	32
Pacheco, A. J.	3	2	.....	33
Pascholati, P. R.	2	2	.....	28
Paschuk, S. A.	1	2	.....	10
Paschuk, S. A.	2	2	.....	30
Paschuk, S. A.	2	2	.....	30
Paschuk, S. A.	3	2	.....	36
Passos, E. J. V. de	2	2	.....	14
Paterson, R.	2	2	.....	28
Pereira, D.	3	2	.....	39
Perso, P.	3	1	.....	32
Pessoa, E. F.	2	2	.....	27
Petrache, C.	2	2	.....	18
Petrache, C.	2	2	.....	20
Petrache, C.	2	2	.....	20
Petrache, C. M.	2	2	.....	19
Pina, S. de	3	2	.....	38
Pinto, A. E. de A.	2	2	.....	16
Pitz, H.	2	2	.....	16
Podolyak, Z.	2	2	.....	18
Podolyak, Z.	2	2	.....	19
Podolyak, Z.	2	2	.....	20
Podolyak, Z.	2	2	.....	20
Poletti, M. E.	2	1	.....	27
Policarpo, A. J. P. L.	2	2	.....	29
Policarpo, A. J. P. L.	2	1	.....	26
Poli, M.	2	2	.....	20
Poli, M.	2	2	.....	20
Poli, M. de	2	2	.....	18
Poli, M. de	2	1	.....	13
Portante, L.	2	2	.....	28
Porto, A. R.	2	2	.....	30
Porto, A. R.	2	2	.....	30
Pupin, J. C.	1	2	.....	11
Ramirez, G.	3	2	.....	39
Ranyuk, Y. M.	3	2	.....	36
Rao, M. N.	2	2	.....	18
Rao, M. N.	2	2	.....	18
Rao, M. N.	2	2	.....	19
Rao, M. N.	2	2	.....	19
Rao, M. N.	2	2	.....	20
Rao, M. N.	2	2	.....	20
Rego, R. A.	3	2	.....	37
Ribas, R. V.	2	2	.....	18
Ribas, R. V.	2	2	.....	18
Ribas, R. V.	2	2	.....	19
Ribas, R. V.	2	2	.....	19
Ribas, R. V.	2	2	.....	20
Ribas, R. V.	2	2	.....	20
Rios, P. B.	3	1	.....	32
Rizzo, P.	2	2	.....	30
Rizzutto, M. A.	2	2	.....	18
Rizzutto, M. A.	2	2	.....	18
Rizzutto, M. A.	2	2	.....	19
Rizzutto, M. A.	2	2	.....	19
Rizzutto, M. A.	2	2	.....	20
Rizzutto, M. A.	2	2	.....	20
Rizzutto, M. A.	2	2	.....	29
Robilotta, M. R.	1	1	.....	9
Robilotta, M. R.	1	2	.....	10
Robilotta, M. R.	1	2	.....	11
Rocha, C. A. da	1	1	.....	9
Rodrigues, H.	1	2	.....	12
Rodriguez, O.	3	1	.....	33
Rodriguez, O.	2	2	.....	17
Rodriguez, O.	3	2	.....	36
Rossi Jr, E. S.	3	2	.....	39
Rossi-Alvarez, C.	2	2	.....	18
Rossi-Alvarez, C.	2	2	.....	20
Rossi-Alvarez, C.	2	2	.....	20
Ruhle, G.	2	2	.....	30
Ruhle, G.	2	2	.....	30
Saladin, J. X.	2	2	.....	23
Sala, O.	2	2	.....	27
Salem-Vasconcelos, S.	2	2	.....	23
Sales, J. H. O.	1	1	.....	9
Santos, G. M.	2	2	.....	29
Santos, M. D. de S.	2	2	.....	29
Santos, M. D. de S.	2	1	.....	26
Santos, R. T. dos	2	1	.....	14
Santos, W. M. S.	2	2	.....	30
Saxena, A.	2	2	.....	18
Saxena, A.	2	2	.....	20
Saxena, A.	2	2	.....	20
Scanferla, T.	2	2	.....	19
Schelin, H. R.	2	2	.....	30
Schelin, H. R.	2	2	.....	30
Schelin, H. R.	3	2	.....	36
Schelin, H. R.	3	2	.....	37
Schnitter, U.	2	2	.....	27
Schnitter, U.	2	2	.....	29
Seale, W. A.	2	2	.....	18
Seale, W. A.	2	2	.....	19
Seale, W. A.	2	2	.....	20
Semmler, R.	3	2	.....	36
Semmler, R.	3	2	.....	36
Sherrill, N. A. B. M.	3	1	.....	32
Shostak, V. B.	1	2	.....	10
Silva, C. P.	3	2	.....	39
Silva, H. P. da	2	2	.....	30
Silva, H. P. da	2	2	.....	30