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INTERNATIONAL NUCLEAR DATA COMMITTEE

PROGRESS REPORT ON NUCLEAR DATA IN BRAZIL

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1. INTRODUCTION

Nuclear physics research in Brazil is concentrated mainly in the following research centers (main experimental facilities are indicate):

Institute of Physics, University of São Paulo (3.5 Mev Van de Graaff, 75 Mev electron LINAC, "Pelletron" tandem accelerator in construction): charged particle reactions, electron induced reactions, nuclear spectroscopy.

Instituto de Energia Atômica, São Paulo (5 Mw pool reactor) : neutron cross-sections, photonuclear reactions, neutron capture gamma-ray studies, nuclear metrology.

Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro (28 Mev electron LINAC): nuclear spectroscopy, neutron physics.

Catholic University, Department of Physics, Rio de Janeiro(4 Mev Van de Graaff in construction): nuclear spectroscopy.

Instituto de Engenharia Nuclear, Rio de Janeiro (Argonaut type reactor): nuclear spectroscopy, neutron spectroscopy.

Institute of Physics, University of Rio Grande do Sul,Pôrto Alegre (angular correlation equipment): nuclear spectroscopy.

2. DEVELOPMENTS IN THE ACQUISITION AND BUILDING OF FACILITIES FOR NUCLEAR PHYSICS MEASUREMENTS

2.1. "Pelletron" accelerator, Institute of Physics, University of São Paulo

This machine formed by a 4 Mv injector coupled to a 9 Mv Tandem, will provide continuous and pulsed charged particle beams of 22 Mev protons, 27 Mev alpha particles, and 200 Mev heavy ions. The building is finished and the accelerator is being assembled. The facility includes a IBM/360/44 computer, on-line data processing, scattering chambers, and instrumentation for gamma, neutron, and charged particle spectrometry. The initial operation is programmed for the second semester of 1971. Research will include mechanisms of nuclear reactions, nuclear spectroscopy, charged particle radioactive capture reactions, angular correlation, Coulomb excitation, neutron time-of-flight.

2.2. Electron Linear Accelerator, Institute of Physics, University of São Paulo

Variable energy up to 75 Mev; 1 μA unanalysed mean current; resolution of analysed beam 0.5%. This accelerator has been installed during 1969-70 and is already in operation. Research program includes electrodisintegration experiments, electrofission, photofission and delayed neutron studies; nuclear spectroscopy of radionuclides deficient in neutrons; electron scattering.

2.3. Electron Linear Accelerator, Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro

Energy: 28 Mev; 60 μA mean current; pulsed beam with pulses from 500 nsec to 3 μsec. This accelerator was designed and built by the Centro Brasileiro de Pesquisas Físicas Accelerator Development Group. It is in operation since 1968 and has been utilized for radionuclide production in nuclear spectroscopy studies. An uranium target is used for the production of pulsed neutron beams. Flight paths of 5, 10, 15, and 20 meters are in use for neutron time-of-flight spectrometry. Resonant neutron capture studies are in progress.

2.4. Van de Graaff Accelerator, Catholic University, Department of Physics, Rio de Janeiro

This is a High Voltage Eng. Model KN-4000 machine, with the following characteristics:

protons or deuterons: 0.5 to 4.0 Mev, 3 Kev resolution, 200 μA intensity

electrons: 1.5 to 3.0 Mev, 20 Kev resolution, 900 μA intensity.

The building for housing the accelerator is already finished and the accelerator is being assembled. Computer facilities, including IBM-1130

and IBM-7044 computers, are available. Future research will include ^{3}He induced reactions, (d,n) reactions, and Coulomb excitation.

2.5. Other Nuclear Instrumentation

2.5.1. Instituto de Energia Atômica, São Paulo

In operation at the IEA-R1 research reactor: neutron capture gamma-ray collimated beams for photonuclear studies including photofission, magnetic beta spectrometer for convertion electrons, neutron crystal spectrometer, neutron diffractometer, Be-filter/slow chopper/time-of-flight spectrometer.

400 Kv Van de Graaff, pulsed neutron source being used for fast and thermal neutron pulse propagation studies.

2.5.2. Instituto de Engenharia Nuclear, Rio de Janeiro, GB

A neutron crystal spectrometer has been built and is in operation at the J-9 beam port of the Argonaut type reactor. Four LiF (111) crystals assembled together are used as monochromator. The thermal neutron spectrum and the effective neutron temperature in this beam port has been measured.

2.5.3. Instituto de Pesquisas Radioativas, Belo Horizonte

A vertical neutron beam tube was installed in the IPR-R1 TRIGA reactor. At 100 Kw, the thermal neutron flux at the top terminal of the tube is 7.9×10^{5} n/cm^{2}.sec.

3. MEASUREMENT, ANALYSIS AND EVALUATION OF NEUTRON AND NUCLEAR CROSS-SECTIONS

3.1. Neutron Cross-Sections

Instituto de Energia Atômica, São Paulo IEA

The total cross-section and effective absorption coefficient of a germanium single crystal has been measured in the direction (111) using a crystal spectrometer in the energy range 0.01 ev - 1.0 ev. (R. Fulfaro)

The total neutron cross-section of polyethylene has been measured using a slow-chopper time-of-flight spectrometer and a crystal spectrometer in the energy range 0.0008 ev - 0.13 ev; the experimental data are compared with published calculated cross-sections and emphasis is given in the analysis of the results in the very low energy region. (S.B.Herdade, CRodrigues, L.Q.Amaral and L.A.Vinhas)

Neutron scattering cross-sections per hydrogen atom of methanol, ethanol, n-propanol, iso-propanol, n-butanol, ethanediol, and propanetriol have been determined at room temperature, in the range 0.0008 ev - 0.13 ev, by means of a slow-chopper T-O-F spectrometer. (C.Rodrigues, L.A. Vinhas,L. Q.Amaral and S.B.Herdade)

Cold neutron differential scattering data were obtained for methanol at room temperature. Experimental studies of the quasi-elastic and inelastic scattering of cold neutrons in n-propanol, iso-propanol, and t-butanol are in progress at the Be-filter/chopper/T-O-F facility. (L.Q.Amaral, C.Rodrigues, L.A.Vinhas and S.B.Herdade)

Measurement of neutron scattering cross-section per H atom of t-butanol above and below the melting point are in progress . (L.Q.Amaral, C. Rodrigues, L.A.Vinhas, S.B.Herdade and R.Fulfaro)

Institute of Physics, University of São Paulo

The ratio of the neutron capture cross-section of Sm, Eu, Gd, Tb, Dy, Ho, Er, Lu, and Ta, to that of In (assumed as standard) has been measured at the energies 30, 65, and 300 Kev. The reaction $^{7}Li(p,n)$ has been used as the neutron source, and a Moxon-Rae detector has been utilized to detect the gamma-rays. (Jacques Lépine)

3.2. Photonuclear Reaction Data and Electron Induced Reactions

Instituto de Energia Atômica, São Paulo (IEA-R1 research reactor)

The ratio $\Gamma n/\Gamma f$ has been determined for ^{238}U and ^{232}Th near threshold, using monochromatic neutron capture gamma-rays in the energy range 6 to 9 Mev. (O.Y.Mafra, S.Kuniyoshi, and J.Goldemberg)

The (γ,n) reaction cross-sections for Li, ^{6}Li, and ^{209}Bi has been measured using neutron capture gamma-rays in the energy range 5.43 Mev to 10.83 Mev. (M.F.Cesar, O.Y.Mafra, and J.Goldemberg)

The cross-section for the reaction $^{2}H(\gamma,n)$ reaction has been measured using gamma lines of different multipole character /^{72}Ga(2.504 Mev), and ^{24}Na(2.758 Mev)/. (M.F.Cesar, O.Y.Mafra and J.Goldemberg)

Angular distribution studies of fission fragments from $^{238}U(\gamma,f)$ reaction are in progress; solid state track detectors such as glass plates and "makrofol" are used. (S.Kuniyoshi, O.Y.Mafra, C.Renner, M.F.Cesar, and J.Goldemberg)

Institute of Physics, University of São Paulo.(Electron LINAC)

The ratio $\sigma(e,f)/\sigma(\gamma,f)$ of the electrofission to the photofission cross-section of ^{238}U and ^{232}Th is being determined in the energy range 20 Mev to 50 Mev. Studies of delayed neutrons emitted in the photofission of ^{238}U and ^{232}Th are in progress. (I.C. Nascimento, G.Moscati, J.Goldemberg)

3.3. Charged Particle Reactions

Institute of Physics, University of São Paulo

The values of Q_o for the following reactions have been determined: $^{20}Ne(d,\alpha)^{18}F$ (Q_o = 2790 ± 10 Kev), and ^{24}Mg (d,n)^{25}Al .
(L.C.S. Bouéres, H.A.Maia, L.C.Campello, O.Dietzsch)

The excitation curve in the range E_p = 1.0 - 2.0 Mev, and the spectrometry of ^{41}K are being studied for the reaction $^{40}A(p,\gamma)^{41}K$. (M. Melnikoff, J.P.de Souza and O.Sala)

Using nuclear emulsion techniques the following reactions in tin isotopes are under study: $^{112}Sn(d,p)^{113}Sn$, $^{122}Sn(d,p)^{123}Sn$, $^{124}Sn(d,t)^{123}Sn$. (T.Borello, O. Dietzsch, E.W. Hamburger, C.Q.Orsini)

4. NUCLEAR LEVEL SCHEMES AND RADIOACTIVE DECAY DATA

Instituto de Energia Atômica, São Paulo

Energy levels of ^{28}Al have been studied by the reaction $^{27}Al(n,\gamma)^{28}Al$ using a Ge(Li) detector. Twelve new lines have been identified and suggest the existence of 2 levels near the ground state: 0^+(790 ± 20) Kev and 1^+(830 ± 15) Kev. (M.A.N. de Abreu)

The total internal conversion coefficient of ^{203}Tl 279 Kev transition was measured to be 0.233 ± 0.003, with systematic error less than 0.5%, using the $4\pi\beta(PC)$-γ coincidence system and the variation of the efficiency parameter technique. (L.P.Moura)

The half-life of the 514 Kev level of ^{85}Rb has been determined by measuring the delayed coincidence between the X-rays and the 514 Kev γ-rays in the decay of ^{85}Sr, with the result: 1018 ± 80 nanosecond. (L.P.Moura)

The fission track method was used to determine the decay constant λ_F for spontaneous fission of ^{238}U. Samples of natural uranium in contact with mica remained sealed for 4.216 years. The decay constant was found to be $\lambda_F = (7.30 \pm 0.16) \times 10^{-17}$ year^{-1}. (M.P.T.Leme, C.Renner and M.Cattani)

Institute of Physics, University of Rio Grande do Sul, Pôrto Alegre

The mean life of the 50 Kev level of ^{233}Ra has been measured by means of γ-γ coincidences between the 236 kev and the 50 Kev transitions with the result $\tau_{1/2}$ (50 kev) = 580 ± 50 psec. (R.Livi, F.C. Zawislak)

The γ-γ angular correlations for 12 cascades in ^{131}Cs have been measured; the values 1/2 and 5/2 have been confirmed for the spins of the levels 620 kev and 133 Kev, respectively, and the spin 3/2 has been atributed to the 124 Kev level. (A.Maciel, A.Vasquez, M.H.P. Correa, and J.D.Rogers).

Institute of Physics, University of São Paulo

The energy levels of negative parity of the odd isotopes of copper have been studied. (J.A.Guillaumon Filho, I.D.Goldman)

Also concluded:

Time dependent angular correlation measurements for the first 2^+ state of ^{150}Sm recoilling into vacuum. (T.Polga, W.M.Roney, H.W.Kugel, R.R. Borchers)

The magnetic hyperfine interaction of the first (2^+) state of ^{142}Ce in Iron. (H.W.Kugel, T.Polga, R.Kalish and R.R.Borchers)

Department of Physics, Catholic University, Rio de Janeiro

The energy level scheme of ^{142}Nd has been studied from the β disintegration of ^{142}Pr, and β^+ disintegration of the chain ^{142}Sm - ^{142}Pm. (F. Smolka, A.G.de Pinho, and J.M.F.Jeronymo)

Other recent work:

The 1/2 ground states of ^{127}Cs and ^{129}Cs.

Enhanced low-energy E2 transitions in the odd. A isotopes of Sb, I, Cs and Pr.

Levels of the odd mass isotopes of Sb and I and the unified model.