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PROGRESS REPORT
ON
NUCLEAR DATA ACTIVITIES
IN KOREA

(For the Period January 1973 to December 1973)

Mann Cho
Liaison Officer of INDC

Compiled by
Jung-Do Kim

KOREA ATOMIC ENERGY RESEARCH INSTITUTE
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NO

(1) OBSERVATION OF A NEW UNCLEAR REACTION - (2γ, n) REACTION

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The abstract on this subject was written in the Transactions of the Korean Physical Society, Spring Meeting, Seoul National University, April 27-28, 1973.

The (2γ, n) reaction, which no one has ever made, was observed using the monoenergetic and very intense thermal-neutron-capture gamma rays. At incident gamma-ray energies less than the threshold energies for the photoneutron reactions in Cu^{63}, the single-step reaction processes, (γ, n), in Cu^{63} were evidently forbidden but two-step reaction processes, (2γ, n), could possibly occur through intermediate states of well-defined energies and life-times. The spectra of the positron annihilation radiation following the photodisintegration processes were measured with two NaI(Tl) crystals in coincidence. Appreciable cross sections of 5.32 ± 0.51, 2.59 ± 0.31, 1.31 ± 0.13, and 2.85 ± 0.25 microbarns were obtained at energies of 6.072, 6.753, 7.724, and 8.997 MeV, respectively. First three excited levels were found with good agreement with known values.(1)

However, the excited level at 8.997 Mev was known as new. Several different experiments were performed to ensure these observed spectra were not due to (n, 2n) reaction in Cu^{63}. Analytic expressions for the mechanism of a two-step reaction process, (2γ, n), were derived using a distorted-wave theory. The measured cross sections agreed in magnitude with those predicted by this theory. It is suggested that the (2γ, n) reaction, and the analysis given here, promise to be a useful tool for the study of higher excited states.

(1) H. Verheul, Nuclear Data Sheets, B2(35) 1967. National Academy of Science, National Research Council (U.S. Government Printing Office).

(2) CALCULATION OF THE RESONANCE INTEGRAL FOR U-233 USING ADLER-ADLER MULTILEVEL FORMALISM

Chang Yul Chi and Chang Hyo Kim
Seoul National University
Mann Cho and Kun Joong Yoo
Korea Atomic Energy Research Institute

In this study we expressed the capture and the fission cross sections of U-233 covering the resolved resonance energy region below 60 eV in terms of Adler-Adler multilevel formula. We first confirmed that Adler-Adler representations for the reaction cross sections are quite satisfactory, demonstrating the good agreements between the experimental cross

sections and the theoretical ones. We then calculated an integral resonance absorption, the infinite dilution resonance integral of U-233, for the purpose of determining the temperature effect on the resonance absorption by this element. We also compared this calculations with the experiments, finding again good agreements between calculations and experiments.

Recently de Saussure and Perez developed a method which can transform a set of multilevel resonance parameters into an equivalent set of single-level pseudoparameters and a smooth backgrounhd. Using this method, we have obtained the single level pseudoparmeters of U-233. In this calculation we intended that these parameters would be useful for those reactor codes which are not suitable for multilevel parameters.

* A paper on this study will be submitted to the Journal of the Korean Nuclear Society soon.

(3) AN ANALYSIS OF INELASTIC NEUTRON SCATTERING BY LIQUID METHANE

Chang Hyun Chung and Won Kee Shin
Department of Nuclear Engineering, Seoul National University
Jin Soo Kim
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The paper on this subject was published in the Journal of the Korean Nuclear Society Volume 5, Number 4, p.265, December 1973 with an abstract as follows.

The incoherent neutron scattering cross section of molecular liquids is analyzed using a damping function model for correlation functions of molecular translations and rotations. The present approach is different from recent works in that the scattering function is evaluated directly, not through the intermediate scattering function. The damping fuction is determined from a simple relation between its long-wavelength limit and the generalized frequency distribution function, and translation-rotation couplings are assumed to be neglected. A physical model is used for the translational motions of center-of-mass of a molecule, including properly its short-time and long-time behaviors. A simple model for the rotational motions is suggested which relates the damping function to the Fourier transform of the dipole correlation function, or equivalently, the infrared vibrational absorption spectrum. Theoretical absolute scattering intensities are computed for liquid methane and shown to be in satisfactory agreement with both thermal and cold neutron measurements.

(4) THE PHOTOPROTON FROM $^{181}Ta(e, e'p)$ REACTION

B. N. Sung
Seoul National University

The abstract on this subject was written in the Transactions of the Korean Physical Society, Spring Meeting, Seoul National University, April 27-28, 1973.

The photoproton energy distribution from (e,e'p) reaction and (e,e'p) cross sections on ^{181}Ta have been measured with the bombarding energies 18.0, 19.0, 19.5, 20.0, 20.5, 21.0, 21.5 and 22.0 Mev at $\theta=90^{o}$ by using the electron linear accelerator and a broad range magnetic spectrometer with 100 solid state detectors. Two large proton groups in the proton energy distributions are found at E_p = 9.2 Mev and E_p=11.5 Mev in the cases of $E_e \rangle$ 20.0 Mev. The cross section shows a strong resonance at 20.0 Mev which is expected as T coherent state. The two main proton groups are resulted through this resonance. The modified Nilsson level scheme explained well these proton groups.

(5) REACTOR NEUTRON ACTIVATION ANALYSIS BY A SINGLE COMPARATOR METHOD

Chul Lee
Korea Atomic Energy Research Institute

The paper on this subject was published in the Journal of the Korean Nuclear Society Volume 5, Number 2, p.137, June, 1973 with an abstract as follows.

A method of activation analysis, based on the irradiation and counting of an iron wire which contains manganese impurity as the single comparator, has been elaborated by critical evaluation of nuclear data involved in activation and activity measurement. The variation of effective cross section is investigated as a function of the spectral index and other parameters such as a measure of the proportion of epithermal neutrons in the reactor spectrum. The errors induced by shifts in the neutron spectrum in the irradiation positions are discussed. The known amount of each element is irradiated simultaneously together with the single comparator, and the obtained values are compared with the known amount of each element. The results show that in general the random errors are not greater than those obtained by using the conventional relative method, but the systematic errors were up to about 20%.

This method is applied to the determinations of fourteen rare earth elements in monazite as well as other seven elements in the standard kale powder. The satisfactory reproducibility of the present method makes possible the determination of the elements with an accuracy attainable with the conventional relative method.

(6) SIMULTANEOUS DETERMINATION OF MERCURY, BROMINE, ARSENIC AND CADMIUM IN BIOLOGICAL MATERIALS BY NEUTRON ACTIVATION ANALYSIS*

Chul Lee, Nak Bae Kim and Euy Byung Park
Korea Atomic Energy Research Institute

The paper on this subject was published in the Journal of the Korean Nuclear Society Volume 5, Number 4, p.279, December, 1973 with an abstract as follows.

A method for the simultaneous determination of mercury, bromine, arsenic and cadmium in biological samples is described. Following neutron activation and a simple distillation of volatile compounds, mercury and bromine were determined by gamma-ray spectrometry. Arsenic and cadmium were further separated by cation exchange separation and determined similarly. Determination limits for mercury, bromine, arsenic and cadmium were 0.001 μg , 0.003 μg, 0.001 μg and 0.02 μg, respectively. The method has been applied to the determination of mercury, bromine, arsenic and cadmium in rice and fish samples. Analysis of a standard kale powder yielded the values of 0.046 $\mu g/g$ for mercury, 24.5 $\mu g/g$ for bromine 0.17 $\mu g/g$ for arsenic and 0.50 $\mu g/g$ for cadmium.

* This work was supported in part by IAEA under contract number 1136/RB.

(7) A STUDY OF FAST LI-FRAGMENTS FROM 28 GeV PROTON INTERACTION IN NUCLEAR EMULSION

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The paper on this subject was published in the New Physics (Korean Physical Society) Volume 13, Number 2, p.45, June, 1973 (in Korean) with an abstract as follows.

It was found that majority of the Li-fragments were emitted by nuclear evaporation process, but that also there was a small number of fast Li-fragments ($>$ 60 MeV) not explained by this process. In the present paper, these fast ones which were emitted in the stars (due to Ag or Br) and induced by 28 GeV protons, are described. The angular distribution and energy spectra of those fragments were determined and analized.

It seems that the fast Li-fragments are not be produced by the evaporation process or by the direct collision processes by the primary. It is probable that they may be ejected when the nucleons and pions-sets in flight during the cascade phase of the disintegration collide with the groups of nucleons. Consquently there is the possibility of the presence of nucleon clusters in the nuclear periphery.

(8) THE DECAY OF ^{11m}Ag: GAMMA-RAY INTENSITY STANDARDIZATION AND A SEARCH FOR WEAK TRANSITIONS

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The paper on this subject was published in the Journal of the Korean Physical Society. Vol. 6, No. 1, P.1, March, 1973 with an abstract as follows.

The relative intensities of the gamma-ray transitions from the decay of ^{110m}Ag have been carefully re-determined by using a true coaxial Ge(Li) detector with active volume of 20 cc. The values obtained for relative intensities are listed in the following in parentheses: 446.790±0.020(3.72±0.11), 620.305±0.015(3.00±0.09), 657.720±0.010(100), 677.590±0.015(11.39±0.57), 686.965±0.020(6.86±0.41), 706.650±0.020(16.85±0.39), 744.245±0.020(4.42±0.19), 763.930±0.020(23.38±0.67), 817.995±0.015(7.73±0.25), 884.655±0.015(79.53±1.83), 937.445±0.020(37.46±0.83), 1384.230±0.020(26.91±0.38), 1475.710±0.015(4.40±0.10), 1504.955±0.020(14.50±0.31), 1562.235±0.020(1.33±0.04). Apart from these well-known transitions, additional gamma-rays with weak intensities were observed at 626.22±0.20, 995.628±0.050 and 1334.808±0.050 KeV and their relative intensities were evaluated as 0.18±0.04, 0.19±0.03 and 0.20±0.03 respectively. Our measured results on a search for weak transitions well agree with one

of the two data sets (transition energies at 133.97, 566.0, 667.2, 753.0, 785.0 and 1443.0 keV in Data 1; transition energies at 626.22, 997.18 and 1334.16 keV in Data 2) previously reported and suggest that the observed weak gamma-rays are not attributable to the decay of ^{108m}Ag.

(9) AN IMPROVED PROTON RECOIL TELESCOPE DETECTOR FOR FAST NEUTRON SPECTROSCOPY

Moon Kyu Chung and Hee Dong Kang
Korea Atomic Energy Research Institute
Tong Soo Park
Kyung pook National University

The paper on this subject was published in the Journal of the Korean Nuclear Society Volume 5, Number 3, p. 191, September, 1973 with an abstract as follows.

For fast neutron spectroscopy in MeV region, a recoil proton telescope detector was designed and constructed so as to increase in detection efficiency without appreciable deterioration in energy resolution by adopting a special type of recoil proton radiator which is a combination of a ring-shaped vertical radiator and a cone-shaped horizontal radiator at a certain geometry. A neutron stopper was built in the detector system to minimize the background due to direct exposure of the Si(Li) detectors to primary incident

neutrons. The detection efficiency and the energy resolution calculated at various neutron energies and geometries are given and these characteristics of the detector system were tested by 14.1 MeV neutrons. As the calculation predicted, the relative detection efficiency in case of the combined radiator system is almost 2.2 times of that for a single, ring-shaped vertical radiator system. The calculated energy resolution is 3.7% FWHM, whereas the measured resolution was 3.9% which means resolution broadening of approximately.30% was was resulted by introducing a combined radiator system into the telescope. Increase in background less than 40% was also observed.

(10) APPLICATION OF A SINGLE FLAT CRYSTAL DIFFRACTION SPECTROMETER TO THE DECAY SCHEME STUDY-OF ^{110m}Ag

M. K. Chung and S. W. Cho
Korea Atomic Energy Research Institute

The abstract on this subject was written in the Transactions of the Korean Physical Society, Spring Meeting, Seoul National University, April 27-28, 1973.

To search for the unreported weak gamma-ray transitions in the decay of ^{110m}Ag, a single flat crystal diffraction spectrometer in combination with the large volume coaxial Ge(Li) detector was constructed and applied to the

verifying of the existence of small photo peaks which are usually hidden in the intense Compton background.

Apart from 15 well-known transitions, our measurements indicate the existence of additional gamma-rays with weak intensities at 626.22, 995, 628 and 1334.808 keV. By careful study of the spectra of ^{110m}Ag sample sources with different cooling times these weak transitions are proved to be from the decay of ^{110m}Ag and are not to be attributed to the decay of ^{108m}Ag.

(11) THE STUDY ON THE GAMMA-RAY TRANSITIONS FOLLOWING THE DECAY OF In^{116m}

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Seoul National University

The abstract on this subject was written in the Transactions of the Korean Physical Society, Fall Meeting, Ulsan Institute of Technology, October 26-27, 1973.

The decay of In^{116m} to Sn^{116} has been studied. Both singles and $\gamma - \gamma$ coincidence techniques were employed with the use of Ge(Li) detector. The energies and the relative intensities of all the known transitions were observed. Besides the known transitions, the unreported gamma-rays with weak intensities were observed. Two of them are

new transitions with energies of 277.799 keV and 688.664 keV which feed from 2390.82 keV(4+) level and 2800.83 keV (4+) level to 2111.93 keV(2nd 2+) level respectively. In connection with the two other gamma-rays observed at 2226 .522 keV and 303.297 keV, the possible existence of an unobserved level at 2226.522 keV(2+) will also be discussed.

(12) A STUDY OF SCHIELDING IN SLABS USING THE BEAM OF CP-5 REACTOR

Suk Yun Kim
Department of Applied Physics, Inha University

The paper on this subject was published in the New Physics (Korean Physical Society) Vol. 13, No. 1, P. 6, March 1973 (in Korean) with an abstract as follows.

Reactor shielding can only be evaluated trough direct measurement and extensive numerical calculation. In this paper, some results of numerical calculation (flux and heat generation of fast, thermal neutron and gamma-ray) are presented. The calculations are based on the data obtained in the slab shielding experiment using the beams in the ANL Lid Tank, Shielding Facility of CP-5 Reactor.

(13) A STUDY OF THE DOSIMETRY OF SCATTERED GAMMA-RAYS FROM A COLLIMATING LEAD CASTLE*

Jae Shik Jun
Korea Atomic Energy Research Institute

The paper on this subject was published in the Journal of the Korean Physical Society, Vol. 6, No. 1, P. 13, March, 1973 with an abstract as follows.

Collimated gamma-ray beams from Cs-137 and Co-60 sources contained in a lead castle are commonly used for calibration of various health physics instruments. Such beams, however, carry not only primary radiations, but also include scattered components from the collimating lead castle. To determine the energy, relative amount, and exposure rate of the scattered radiations, a scintillation spectrometer of a $1\frac{3}{4}$ dia. X2" long NaI(Tl) well-type crystal (well size; $\frac{2"}{3}$ dia. X$1\frac{1"}{2}$long) was used with a 100 channel pulse height analyzer.

For the calculations of the exposure rate due to scattered photons, a simple spectrum-dose conversion method was applied instead of correcting the spectrum by response matrix. Prior to the conversion procedure, the value of the conversion operator, G(E), was calculated as a function of photon energy, using the values of photofraction and interaction ratio determined for the scintillator used in this study. The results show that the relative contribution of the scattered photons to total exposure rate is - 2.25% regardless of the distance

from the source to the detecting position and that the scattered photons contributing to the collimated beams consist mainly of backscattered photons of an energy given by $E_b = E_o/(1+2E_o/0.51)$.

* Part of this experiment was carried out at Laboratorio di Dosimetria e Standardizzazione, Centro Studi Nucleari della Casaccia, Rome, Italy during the period of 1966 to 1967 under the auspices of an IAEA Fellowship.

(14) DOSIMETRICAL ANALYSIS OF REACTOR LEAKAGE GAMMA-RAYS BY MEANS OF SCINTILLATION SPECTROMETRY

Jae Shik Jun
Korea Atomic Energy Research Institute

The paper on this subject was published in the Journal of the Korean Nuclear Society Volume 5, Number 4, P. 291. December, 1973 with an abstract as follows.

Exposure rates due to leakage gamma-rays from operating reactors TRIGA Mark II and III were measured in a horizontal plane by means of scintillation spectrometry using a 3" X 3" cylindrical NaI(Tl) detector associated with a 400 channel pulse height analyzer under varied conditions of reactor operation.

In determining exposure rate due to the leakage gamma-

rays at each point of measurement, Moriuchi's spectrum-exposure rate conversion theory was applied instead of using conventional responce matrix method which necessitates very complicated procedures to convert a spectrum into exposure rate.

The results show that a basic pattern of "typical" spectrum of the reactor leakage gamma-rays is neither affected by thermal output of the reactor, nor influenced by overall attenuation in radiation intensity. It was indicated that the attenuation of the leakage gamma-rays in air in terms of exposure rate as a whole follows an exponential law, and the total exposure rate due to the leakage gamma-rays at a certain point is nearly proportional to thermal output of the reactor. The complexity in spectrum measured for a movable core reactor, TRIGA Mark III, was analyzed through spectrum resolution, and proper judgement of the leakage gamma-rays in a complex spectrum was discussed.

(15) GAMMA-RAY DOSIMETRY WITH THIN PLASTIC FILM

Young Soo Yoo and Seung Gy Ro
Korea Atomic Energy Research Institute

The paper on this subject was published in the Journal of the Korean Nuclear Society Volume 5, Number 3, P. 233, September, 1973 with an abstract as follows.

Thirty two different kinds of domestic plastic films for use in measuring high gamma-ray dose have been collected and their dosimetric characteristics investigated with the help of a Co-60 gamma radiation source.

Among them a rigid polyvinyl chloride (PVC) film of 0.06mm in thickness which is manufactured by Lucky Chemical Co., Korea, seem to be the most suitable one for this purpose. Ths relation between optical density at 3100Å and radiation exposure in this PVC film was linear in the range of 0.6×10^6R to 1.3×10^7R, and also the film showed a good reproducibility within 9% under the standard experimental condition. The effect of absorbed dose, oxygen content of surrounding atmosphere and irradiation temperature have also been studies for this film. It appeared to have a good property in the dosimetrical point of view.

(16) MEASUREMENT OF NEUTRON ENERGY SPECTRUM FROM AN ^{241}Am-F NEUTRON SOURCE USING BONNER SPHERE NEUTRON SPECTROMETER

Seung Gy Ro and Jae Shik Jun
Korea Atomic Energy Research Institute

The abstract on this subject was written in the Transactions of the Korean Physical Society, Spring Meeting, Secul National University, April 27-28, 1973.

The neutron energy spectrum from an ^{241}Am-F laboratory neutron source with the dimension of 4.85cm high by 2.24cm in diameter has been measured using a Bonner sphere neutron spectrometer which is a ^{6}LiI(Eu) thermal neutron detector coupled with various polyethylene spheres of 2, 3, 5, 8, 10, and 12 in. in diamerter.

Assuming that the entire spectrum consists of the Maxwellian thermal, uncollided and slowing-down components and that the former two components are invariable while the latter one is of the $1/E^{\alpha}$ form with a spectral parameter α which is variable, the relative intensities of three spectrum components were determined with three different sizes of polyethylene spheres. A determination of the parameter α can be simply made from the ratio of counting rates in two different spheres. However, the value obtained from five independent determinations of α with six spheres, which is agreeable with each other within the experimental error and consequently will be more rigorous compared to that obtained from the above two spheres, was finally taken in this study and is about 1.2. The result for the spectrum measurement is presented in the graphical form.

(17) DETERMINATION OF THE ALPHA PARTICLE TRACK RESISTRATING EFFICIENCY OF POSI-FILM

Seung Gy Ro and Jae Shik Jun
Korea Atomic Energy Research Institute

The abstract on this subject was written in the Transactions of the Korean Physical Society, Fall Meeting, Ulsan Institute of Technology, October 26-27, 1973.

Photographic posi-film which is commercially available has been found to be a possible alpha particle detector in the course of looking for a suitable material to be applied to the neutron dosimetry, and its track registration efficiency for alpha particles has been detormined. In order to dotermine the efficiency, the posi-film foil has been determined. In order to determine the efficiency, the posi-film foil bas been irradiated to alpha particles emitted from a thin ^{241}Am source entering the detector foil perpendicular to the surface. The irradiated foil has been etched in a 1.3 g/cm^3 NaOH solution for 1 hour at about 60°C, and the diameter of the etch-pits was measured under an optical microscope. Therefrom, the efficiency was calculated on the basis of Fleischer's and Tuyn's theories. The result seems to be $(78.8 \pm 4.7)\%$, and to be agreed well with the value of $(75.8 \pm 2.5)\%$ obtained by measuring the critical angle for the track registration.

(18) PROTECTIVE EFFECT OF ACETYLBENZOYLACONINE AGAINST GAMMA-RADIATION

Philip S. Moon
Korea Atomic Energy Research Institute

The paper on this subject was published in the Journal of the Korean Nuclear Society Volume 5, Number 2, P. 83, June, 1973 with an abstract as follows.

The protective effects of acetylbenzoylaconine, 2-aminoethylisothiouronium bromide hydrobromide, β-mercaptoethylamine HCL, and L-thiazolidine-4-carboxylic acid were studied on the white male mice, aged 5-6 weeks. The toxicity test of acetylbenzoylaconine revealed that the LD_{50} was 2.5mg/kg of body weight. After the administration of test substances, mice were irradiated with whole body dose of 800 rad by the Co-60 source. Observing the number of surviving mice for 30 days, the survival coefficients for the test groups were calculated and with these the protective coefficients against radiation injury, PCR, were also calculated. The PCR values are 2.24, 2.95, 2.78, and 1.23 for acetylbenzoylaconine, 2-aminoethylisothiouronium bromide hydrobromide, β-mercaptoethylamine HCL, and L-thiazolidine-4-carboxylic acid respectively. These values reveal that the acetylbenzoylaconine has protective potency against radiation injury on white male mice.

(19) PENUMBRA EFFECT ON INTEGRAL ABSORBED DOSE IN Co-60 TELETHERAPY

Philip S. Moon
Korea Atomic Energy Research Institute

The paper on this subject was published in the Journal of the Korean Nuclear Society Volume 5, Number 2, P. 87, June, 1973 with an abstract as follows.

Due to the Co-60 source size, the penumbra in Co-60 teletheraphy poses a serious problem, even if the extended collimators are used, Here an empirical formula for the calculation of integral absorbed dose in the penumbra region was derived. Through a numerical calculation, the penumbra effect on integral absorbed dose was investigated. The longer the source-to-skin distance, the larger the integral absorbed dose of penumbra region, and the larger the source diameter, the larger the integral absorbed dose of penumbra region. It was also found that in some case the integral absorbed dose in penumbra region becomes several times larger than the integral absorbed dose of treatment region itself if the source-to-skin distance becomes greater. Therefore, one must consider the penumbra effect in Co-60 teletherapy.