International Atomic Energy Agency

INDC(AUS)-5/G

INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

Progress Report to INDC from Austria

May 1980

G. Winkler, Editor

June 1980

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

Reproduced by the IAEA in Austria
June 1980
80-2690

INDC(AUS)-5/G

PROGRESS REPORT TO INDC

FROM AUSTRIA

May 1980

G. WINKLER, Editor

This report contains abstracts about work performed at

Institut für Radiumforschung und Kernphysik der Österreichischen Akademie der Wissenschaften, Wien

Atominstitut der Österr. Universitäten, Wien

Institut für Experimentalphysik der Universität Wien

Institut für Theoretische Physik und Reaktorphysik der Technischen Universität Graz

Institut für Radium-
forschung und Kern-
physik der Österr.
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INSTITUT FÜR RADIUMFORSCHUNG UND KERNPHYSIK DER
ÖSTERREICHISCHEN AKADEMIE DER WISSENSCHAFTEN, WIEN

1. Precise absolute measurement of the $^{27}Al(n,\alpha)^{24}Na$ cross section with 14.68 MeV neutrons

G. Winkler, V.D. Huynh *

The reaction $^{27}Al(n,\alpha)^{24}Na$ is in discussion as a potential candidate for a neutron cross section standard, especially in the 14 MeV region, and may serve as a fluence monitor in fusion reactor studies. The cross section for this reaction has been remeasured in this energy region with an accuracy of about 2.5%, using the associated particle method to determine the neutron fluence, and measuring the induced ^{24}Na gamma-activity by means of an absolutely calibrated 5" x 5" NaI(Tl) well-type detector. The results obtained are consistent with previous results of Vonach et al. (Z. Phys. 237 (1970) 155) and a recent result of Ryves et al. (J. Phys. G: Nucl. Phys., Vol. 4, No. 11 (1978) 1783) within the error limits.

2. Measurement of differential elastic and inelastic scattering cross sections with 14 MeV neutrons on Barium and Chromium **

G. Winkler, K. Hansjakob und G. Staffel

The elastic scattering of 14 MeV neutrons has been measured at angles from 20° to 130° with an accuracy of about 10%,

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** Work supported by the European Community through Euratom

the high energy part of the inelastic neutron spectrum has been measured as a function of θ and E_n' in the region of $\theta = 20^\circ - 130^\circ$ and $E_n' = 4 - 12$ MeV with an energy resolution ≤ 0.5 MeV, on elemental Barium and Chromium, using time-of-flight techniques. The cross sections for forming the first 2^+ level of ^{138}Ba and ^{52}Cr and the 3^- level of ^{52}Cr (4.56 MeV) have been measured. The results are compared with optical and statistical model calculations. The knowledge of the neutron interaction with Barium is important due to its use in reactor shielding, Chromium is expected to be an important structural material in fusion reactors.
(Bull. Am. Phys. Soc. 24, No. 7 (1979) 866; Proc. of the Internat. Conf. on Nuclear Cross Sections for Technology, Knoxville, Oct. 22-26, 1979). A detailed publication is in preparation.

3. Measurement of the spectrum averaged cross section for the reaction $^{63}Cu(n,\alpha)^{60}Co$ in the ^{252}Cf spontaneous fission neutron field and in the ^{235}U thermal neutron induced fission neutron field *

G. Winkler, V. Spiegel **, D.L. Smith ***, C.M. Eisenhower **

The threshold-reaction $^{63}Cu(n,\alpha)^{60}Co$ is of special importance in reactor dosimetry for long-term fast flux integration. Absolute measurements of neutron spectrum averaged activation cross sections have been performed

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* Work supported partly by the U.S. Department of Energy
** National Bureau of Standards, Washington, D.C.
*** Argonne National Laboratory, Argonne, USA

employing the ^{252}Cf irradiation facility of the National Bureau of Standards, and the ^{235}U cavity fission neutron field in the 30 cm diameter spherical cavity located at the center of the NBS Research Reactor graphite thermal column, with ^{235}U discs as a converter. The ^{235}U cavity fission neutron field was calibrated by flux transfer from the ^{252}Cf neutron field using Indium foils. The results are to be compared with calculated results obtained from recent measurements of the $^{63}Cu(n,\alpha)$ excitation function from threshold to 10 MeV carried out at the Argonne National Laboratory (G. Winkler, D.L. Smith, J.W. Meadows, to be published in Nucl. Sci. and Eng.)

4. The excitation function for the reaction $^{207}Pb(n,n'\gamma)^{207m}Pb$ from threshold to 6 MeV *

G. Winkler

Work is in progress processing experimental data for the excitation of the 0.8 s isomeric state at 1.633 MeV in ^{207}Pb. The decay of this isomer is a source of delayed gamma-rays in lead shielding in a fast neutron field, a very sensitive tool in activation analysis work, and useful as a reference for the cross section determination for other reactions with short-lived reaction products. The experimental data were taken at the 8 MeV Tandem-Dynamitron-Accelerator at the Argonne National Laboratory, using a slow-pulsed accelerator technique. The gamma-ray activity induced in natural lead samples was measured by means of a Ge(Li)-detector, the neutron fluence was determined with a fission chamber containing a ^{238}U deposit. The results are to be compared with optical-statistical model calculations.

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* Work supported by the U.S. Department of Energy

5. Measurement of cross sections for the $^{90}Zr(n,2n)^{89}Zr$ and $^{58}Ni(n,2n)^{57}Ni$ reaction from threshold to 20 MeV

A. Pavlik, G. Winkler, H. Vonach

Work is in progress to determine the excitation function for the reactions $^{90}Zr(n,2n)^{89}Zr$ and $^{58}Ni(n,2n)^{57}Ni$, which are important for fast neutron reactor dosimetry using activation techniques. Irradiations were carried out at the 7 MeV Van de Graaff Accelerator of the CBNM, Geel, using the $T(d,n)^{4}He$ reaction as source reaction. The neutron fluence was determined employing a proton recoil telescope and using known angular distributions. Additionally in the energy range 13.5 - 14.8 MeV measurements were made relative to the well known $^{27}Al(n,\alpha)^{24}Na$ reaction cross section. Activity measurements were done with a 5" x 5" NaI(Tl) well-type detector.

6. Evaluation of neutron induced cross sections for $^{58,60}Ni$, ^{56}Fe, ^{55}Mn and ^{52}Cr

W. Reiter, B. Strohmaier and M. Uhl

For incident neutrons with energies between 10 and 30 MeV the differential elastic and total cross sections as well as the cross sections for reactions with neutrons, protons and alphas as emitted particles are evaluated mainly by model calculations. The production spectra for the above named particles and for photons are calculated, too.

7. **Evaluation of the cross sections for the reactions $^{24}Mg(n,p)^{24}Na$, $^{64}Zn(n,p)^{64}Cu$, $^{63}Cu(n,2n)^{62}Cu$ and $^{90}Zr(n,2n)^{89}Zr$**

S. Tagesen, H. Vonach and B. Strohmaier

An extensive literature search on the indicated neutron dosimetry reactions has been performed. If necessary, data have been renormalized taking into account recent changes of reference data, e.g. neutron angular distributions or branching ratios etc.. From the revised data sets excitation functions including a consistent set of variances and covariances have been calculated.
Full details and results have been published in "Physics Data" Nr. 13-1, 1979, ISSN 0344-8401.

8. **Evaluation of the cross-sections for the reactions $^{19}F(n,2n)^{18}F$, $^{31}P(n,p)^{31}Si$, $^{93}Nb(n,n')^{93m}Nb$ and $^{103}Rh(n,n')^{103m}Rh$.**

B. Strohmaier, S. Tagesen and H. Vonach

Following the evaluation procedure outlined in a previous publication (1979, see above) 4 additional excitation functions have been evaluated. A method is described to consistently combine experimental reaction cross sections and theoretically calculated excitation functions to provide reliable cross section estimates including variances and covariances also in energy regions, where no experimental data exist.
Method and results will be published shortly in "Physics Data".

9. Application of a small cylindrical multiwire proportional chamber for measurements of differential cross sections on $^{50}Cr(n,\alpha)^{47}Si$ and $^{93}Nb(n,\alpha)^{90}Y$

C. Derndorfer, F. Fischer, P. Hille, G. Stengl, H. Vonach

Measurements of energy- and angular distributions of (n,α)-reactions were performed on a newly developed apparatus, consisting of a small cylindrical multiwire proportional chamber (32 wires) and a central CsI(Tl)-scintillator, which allows simultaneously the measurements at all angles and energies and the background. A first analysis of the data was performed. The preliminary results of the total cross sections are:

$^{50}Cr(n,\alpha)^{47}Si$	95.0 ± 10 mbarn
$^{93}Nb(n,\alpha)^{90}Y$	9.1 ± 2.5 mbarn

The angular distribution indicates a strong contribution of the precompound process for both reactions studied. Presently the reactions $^{50}Cr(n,p)^{50}V$ and $^{93}Nb(n,p)^{93}Zr$ are being investigated.

10. Measurement of the secondary neutron spectra from the interaction of 14.1 MeV neutrons with 17 elements

H. Vonach, A. Chalupka, F. Wenninger, G. Staffel

The angle-integrated secondary neutron spectra from interaction of 14.1 MeV neutrons with 17 elements in the range Ti to Bi were measured over the secondary neutron

energy range 0.25 - 6 MeV with special emphasis on obtaining reliable and accurate neutron production cross sections in the low energy region (0.25 - 1 MeV). An overall accuracy of 5 - 7% was obtained over most of the investigated energy ranges. The results are in good agreement with the predictions of statistical model calculations and in the neutron energy range above 1.5 MeV also with most other recent measurements; in the low energy range there are still large discrepancies between the results of different measurements.
Preliminary results are given in table 1.
The work will be presented at the Brookhaven Symposium on neutron cross-sections from 10 - 40 MeV, May 12-14, 1980 and published in the proceedings of that symposium.

Table 1. Angle integrated secondary neutron-production cross-sections $\frac{d\sigma}{dE_n'}$ for 14.1 MeV neutrons.

E_n' (MeV)	σ_{nM} (mb/MeV)				
	Ti	Cr	Fe	Ni	Cu
0.25-0.50	399±28	415±21	420±20	319±16	604±26
0.50-0.75	465±22	491±22	523±25	378±16	730±34
0.75-1.00	499±23	473±22	502±24	381±16	699±34
1.00-1.25	454±21	433±20	466±23	346±15	619±30
1.25-1.50	410±19	379±18	394±19	297±13	531±26
1.50-1.75	359±16	340±15	349±17	257±11	445±21
1.75-2.00	321±14	303±14	305±15	224± 9	378±19
2.00-2.25	292±13	285±13	281±14	202± 9	335±17
2.25-2.50	253±12	243±12	237±12	168± 8	285±15
2.50-2.75	222±11	225±12	228±12	169± 8	256±14
2.75-3.00	202±11	191±10	190±10	140± 7	221±14
3.00-3.25	171± 9	169± 9	175± 9	120± 6	180±11
3.25-3.50	148± 8	159± 9	158± 9	119± 6	163±10
3.50-3.75	149± 8	149± 8	150± 8	110± 6	151±10
3.75-4.00	129± 8	134± 8	130± 7	100± 5	140± 9
4.00-4.50	117± 7	109± 6	113± 6	89± 4	110± 7
4.50-5.00	91± 6	91± 6	102± 6	80± 4	95± 7
5.00-5.50	73± 5	70± 5	82± 5	63± 4	73± 6
5.50-6.00	60± 5	55± 5	66± 5	52± 3	53± 6
	Zn	Zr	Nb	Mo	Ag
0.25-0.50	422±10	1208±36	1256±66	1185±39	1669±96
0.50-0.75	519±23	1256±53	1360±60	1418±64	1689±83
0.75-1.00	510±23	1136±49	1252±57	1243±58	1450±74
1.00-1.25	448±20	960±42	1043±49	1030±49	1146±60
1.25-1.50	376±17	815±36	895±42	848±41	923±49
1.50-1.75	324±14	681±29	782±36	710±33	786±41
1.75-2.00	286±13	538±24	655±31	585±28	617±33
2.00-2.25	254±12	462±21	568±27	506±24	545±30
2.25-2.50	224±11	362±19	459±24	415±22	406±24
2.50-2.75	199±10	291±17	380±21	361±19	380±22
2.75-3.00	175± 9	230±15	317±18	293±16	289±20
3.00-3.25	146± 8	173±13	257±15	237±13	224±15
3.25-3.50	131± 7	150±12	212±14	202±12	199±14
3.50-3.75	122± 7	139±12	196±13	168±11	177±13
3.75-4.00	105± 7	114±11	161±12	141±10	145±12
4.00-4.50	85± 5	84± 9	109± 8	115± 7	108± 9
4.50-5.00	74± 5	61± 9	87± 8	87± 7	91± 9
5.00-5.50	60± 4	31± 9	65± 8	70± 6	73± 9
5.50-6.00	46± 4	31± 9	68± 8	50± 6	66± 9

Table 1. cont.

E_n' (MeV)	σ_{nM}(mb/MeV)				
	Sn	Ba	Ta	W	Au
0.25-0.50	1495±44	1500±62	2151±118	2123± 70	1958± 72
0.50-0.75	1675±69	1443±72	2458±123	2508±115	2364±118
0.75-1.00	1566±67	1465±70	2186±113	2347±111	2243±116
1.00-1.25	1305±56	1292±62	1750± 92	1844± 89	1922±101
1.25-1.50	1062±46	1051±52	1360± 72	1469± 72	1586± 84
1.50-1.75	878±37	834±43	1069± 56	1139± 55	1346± 70
1.75-2.00	700±30	688±38	833± 45	887± 44	1120± 59
2.00-2.25	608±27	561±35	671± 37	704± 36	870± 47
2.25-2.50	463±22	420±32	505± 30	527± 30	685± 39
2.50-2.75	362±19	365±33	403± 23	425± 26	619± 33
2.75-3.00	300±17	287±33	278± 18	289± 25	484± 28
3.00-3.25	233±14	262±28	230± 15	243± 19	369± 22
3.25-3.50	180±13	215±28	193± 13	207± 17	289± 18
3.50-3.75	177±13	174±28	154± 12	161± 17	249± 17
3.75-4.00	145±12	202±28	142± 11	126± 15	213± 15
4.00-4.50	109± 9	165±21	93± 8	102± 12	147± 11
4.50-5.00	88± 9	97±22	82± 2	53± 12	114± 11
5.00-5.50	66± 9	57±20	59± 8	50± 13	82± 10
5.50-6.00	30± 8	26±12	55± 8	54± 12	40± 10
	Pb	Bi			
0.25-0.50	1447±62	1701±58			
0.50-0.75	1809±79	1873±80			
0.75-1.00	1885±83	1932±84			
1.00-1.25	1705±76	1845±80			
1.25-1.50	1595±71	1691±73			
1.50-1.75	1422±61	1520±63			
1.75-2.00	1244±54	1346±56			
2.00-2.25	1121±49	1189±51			
2.25-2.50	899±43	999±46			
2.50-2.75	741±38	817±40			
2.75-3.00	526±31	648±34			
3.00-3.25	424±26	514±28			
3.25-3.50	380±24	409±24			
3.50-3.75	304±22	324±21			
3.75-4.00	232±20	277±20			
4.00-4.50	183±15	219±15			
4.50-5.00	136±15	161±14			
5.00-5.50	83±14	97±13			
5.50-6.00	65±15	75±14			

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Nuclear Safeguards

H.BÖCK

1. A fuel element scanning device has been designed and tested at the Atominstitut which allows to measure the fission product gamma spectrum of a single TRIGA reactor fuel along its axis. Together with an intrinsic Ge-detector and a portable multi-channel analyser the system allows the fast and accurate determination of the fuel element burn-up. This equipment is also used as demonstration and testing unit for IAEA safeguard inspectors.

2. The application of solid-state track detectors for the determination of delayed neutrons in a reactor coolant circuit was investigated and tested successfully at the Atominstitut (see also IAEA Research Contract 2050/RB and Kerntechnik Bd. 34 (1979) Lfg 3, p.105)

Reactor Safety

H.BÖCK

1. The temperature and radiation behavior of Pt- and Rh-self-powered neutron detectors was investigated at the Atominstitut (see Nucl. Instr. Meth. 164 (1979) 205).

2. A self-powered neutron detector with improved sensitivity was developed and tested at the "Atominstitut" using a thin layer of 93% enriched uranium as sensitive emitter. As a result the detector is about 50 times more sensitive than any other commercial available self-powered neutron detector (see also IAEA Symp. on Nuclear Power Plant Control and Instrumentation, Cannes 1978).

The fast neutron emission spectrum of ^{252}Cf

F.BENSCH, H.JASICEK

The fast neutron emission spectrum of ^{252}Cf has been investigated by means of two proton-recoil spectrometers. By means of a large counter tube of 900 mm length the neutron distribution between 0.9 MeV and 10 MeV was determined. Monte-Carlo calculated response functions were applied to unfold the measured proton-recoil distributions. Using a smaller, 466 mm long counter tube the energy interval between 1 MeV and 3 MeV was examined in a search for neutron fine-structure groups. No such groups could be established. The numerical results are presented in a preliminary form. The final results have been submitted for publication to "Journal of Nuclear Science and Engineering".

Properties and applications of radioactive photoneutron sources

F.BENSCH

Some spherical photoneutron sources have been investigated in the "Atominstitut der Oesterreichischen Universitaeten" (^{124}Sb-Be, ^{72}Ga-Be, ^{72}Ga-D_2O, ^{228}Th-Be, ^{228}Th-D_2O, ^{24}Na-Be, ^{24}Na-D_2O, ^{140}La-Be, ^{116}In-Be, ^{56}Mn-Be) by experiments ($MnSo_4$-bath for source strength determination, proton-recoil proportional counter tubes for the measurement of the neutron distribution) and/or by Monte-Carlo calculations to find data on intensity and emission spectra of the sources. Preliminary results are presented.

A rapid transportation facility for irradiation with thermal and fast neutrons

F.BENSCH, F.GRASS, A.SALAHI, K.ZILLNER

A rapid vertical transportation system for irradiation with thermal and fast neutrons is designed and partly constructed for inserting samples into the central thimble of the TRIGA Mk II reactor at the "Atominstitut". Fast neutrons of the energy 14 MeV will be produced by a ^{6}LiD hollow cylinder. Using the pulse irradiation possibility of the TRIGA reactor, the 14 MeV neutron flux density is expected to be in the order of 10^{12}/s. The transportation time is to be below 30 ms to enable determination of short-lived nuclides down to 15 ms.

Transmission of polarized neutrons through oriented targets

K.P.SCHNEIDER, H.W.WEBER, C.STASSIS*

At the polarized neutron facility of the TRIGA-MARK II reactor a nuclear orientation experiment was set up which consists of a ^{3}He-^{4}He-dilution refrigerator and an asymmetric superconducting split pair providing magnetic fields up to 1.5 T. The transmission of polarized neutrons was measured to determine the polarization-dependent cross-sections. In order to achieve a high degree of nuclear orientation single crystals of the ferromagnetic and monoisotopic substances Ho and Tb were used. Results were obtained on the total cross-sections, the polarization dependent scattering and absorption cross-sections, the transmission cross sections into the + and - channels, and the coherent scattering cross-section.

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(Experimental work done at Los Alamos Scientific Laboratory,
Los Alamos NM. 87545, USA).
Responsible scientist: Manfred DROSG.
Reporting date: April 16, 1980
General remark: Only those projects are mentioned that originated in Vienna and are not official projects of LASL. Therefore they usually are not included into LASL's Progress Report to INDC.

I. Production of monoenergetic neutrons

1) General: Two invited review talks on production of monoenergetic neutrons between 2 keV and 60 MeV were given at the IAEA consultants' Meeting in Debrecen, Hungary, March 1980. The reactions $^{1}H(t,n)^{3}He$, $^{1}H(^{7}Li,n)^{7}Be$, $^{2}H(d,n)^{3}He$, $^{2}H(t,n)^{4}He$, $^{3}H(p,n)^{3}He$, $^{3}H(d,n)^{4}He$, $^{7}Li(p,n)^{7}Be$, $^{9}Be(p,n)^{9}B$, $^{45}Sc(p,n)^{45}Ti$ and $^{51}V(p,n)^{51}Cr$ were covered including referenced literature until January 1980. Zero-degree neutron production cross sections of the t-H, d-D, t-D, p-T and d-T reaction were evaluated up to neutron energies of 40 MeV (in some cases to even higher energies) and data on secondary neutron emission (break-up data) are collected. The need for improved evaluations of the $^{3}H(p,n)^{3}He$ reaction around 3 MeV and of the $^{2}H(d,n)^{3}He$ reaction around 0.25 MeV charged particle energy is shown. These two papers will be published as Proceedings of this Meeting by IAEA, Vienna. Previous work, dealing with neutron production by the hydrogen isotopes only, was published in Nucl.Sci.Eng.67, 19o (1978)./It gives not

only experimental data but also an evaluation of the differential cross sections between 6 and about 20 MeV charged particle energies.

2) Experimental work:

a) $^{3}H(p,n)^{3}He$: The first complete angular distributions of this reaction have been measured, at 2.5 and 4.0 MeV proton energy. This was done using the $^{1}H(t,n)^{3}He$ reaction to obtain the backward yields. These distributions are 17% more strongly peaked in the backward direction than suggested by the previous extrapolated distributions. A new evaluation of the zero-degree excitation function including these new data gives about 1o% lower values near 3 MeV. An experimental verification of this finding appears to be necessary. The work done will be published as internal report LA-8215-MS of the Los Alamos Scientific Laboratory

b) Detector Efficiency: The relative neutron detection efficiency of a NE-213 scintillator was measured with a 0.3 MeV bias. Three pronounced peaks above 5 MeV neutron energy were traced back to carbon interactions. This work was published as internal report LA-7987-MS of the Los Alamos Scientific Laboratory in January 1980

c) Background neutrons: The percentage of background neutrons when using the p-T, d-D and t-H reaction for the production of monoenergetic neutrons between 1o and 14 MeV was measured. For the p-T reaction optimum conditions for the target construction (materials for the beam stop and the entrance foil) were investigated. Results were published in the report LA-6459-MS (1976)

II. Reactions of fast neutrons

1. Evaluation: Differential cross sections of the reactions $^{3}He(n,p)^{3}H$ (between 0.5 to 19 MeV), of $^{3}He(n,d)^{2}H$ (between 4.5 and 21.2 MeV) and of $^{4}He(n,d)^{3}H$ (between 22.06 and 36 MeV) were calculated using evaluated data of the inverse reactions. Besides it was shown that the total n-^{4}He cross section above

12 MeV (with exception of the resonance above 22 MeV) can be presented by the equation

$$\sigma_T = \exp(-0.9181 \ln E_n + 9.3860)$$

up to at least 150 MeV. These data and revised data for elastic neutron scattering from ^{3}He and ^{4}He are presented in the report LA-7269-MS (1978).
However, the new findings with regard to the p-T reaction around 3 MeV change the ^{3}He(n,p)^{3}H data around 2 MeV appreciably. In addition there are new total n-^{3}He cross sections from Karlsruhe, Germany, which are about 5% higher than the previous data. These new data remove the discrepancy between the total and the sum of the partial cross sections at 2.0 MeV and 3.5 MeV but introduce now a similar discrepancy at 6.0 and 7.9 MeV. The elastic scattering data at the two latter energies are from two different experiments so that the source of the discrepency is still uncertain.

2. ^{1}H(n,n)^{1}H: Incomplete (relative) angular distributions at 22.4, 23.7, 27.1 and 28.5 MeV were published in the report LA-7269-MS (1978). In addition it was shown, that the 18o degree cross sections which are needed for neutron counter telescope measurements are not too high when the YALE predictions are used, as was suspected before at energies around 25 MeV. The discrepancy was traced back to the presence of extraneous protons making the background subtraction incorrect. This was published in Nucl.Instr.Meth.<u>16o</u>, 143 (1979)

INSTITUT FÜR THEORETISCHE PHYSIK UND REAKTORPHYSIK DER TECHNISCHEN UNIVERSITÄT GRAZ

1. Investigation of the role of non-fission neutron sources as fissile fuel breeder in a fission reactor economy

M. Heindler

The expected supply of intense non-fission neutron sources suggests the possibility of enhancing the performance characteristics of existing fission converter reactors and of increasing the fissile fuel supply by neutron-induced transmutations. This potential is explored with an emphasis on the type of neutron sources and on their mode of integration with fission reactors. Particular emphasis is placed on the achievement of self-sufficiency of a converter reactor with respect to fissile fuel. As a general result, it appears that neutronically efficient converter reactors combined with relatively modest external neutron contributions can have a significant effect on the long-term fissile fuel logistics of a fission reactor economy.

2. Study of the potential role of dense plasma focus devices as fissile fuel breeders

M. Heindler

The concept of incorporating a dense plasma focus device in a nuclear energy system is examined. The basic function of this device is to supply neutrons to breed fissile fuel for fission reactors. It appears that, subject to further developments, the dense plasma focus seems suited to play an important role in the future development of advanced and integrated nuclear power plants.

3. <u>Assessment of the effect of an incorporation of non-fission breeders into a conventional fission reactor economy on the overall energy conversion efficiency</u>
M. Heindler

The effect of the implementation of fusion or spallation driven fissile fuel breeders into a conventional fission-converter reactor economy is studied with respect to the achievement of fissile fuel self-sufficiency. The results are given for three types of fissile fuel management: reprocessing, in situ reenrichment and once-through-then-out. The results show that a Q-value of 0.5 to 1 for the non-fission breeder seems to be optimal.

4. <u>Review study on the state of the art in advanced nuclear energy concepts including advanced fissile and fusile fuel cycles</u>
M. Heindler

Based on the presentations at the first international conference on advanced nuclear energy concepts held at Graz, in March 1978, and on information obtained during a study leave of one of the members of the institute in Canada and the USA, an attempt to summarize the progress made in the field of advanced nuclear energy system and fuel cycle concepts has been made.

5. Evaluation of a fissile fuel requirement and supply strategy for various conventional and synergetic nuclear energy concepts including fast-fission breeders, fusion-fission systems, spallation breeders etc.

M. Heindler

An accurate and easy to implement representation of the life-time fissile fuel requirement has been formulated which avoids the ambiguities of common figure-of-merit parameterization. The approach is based on the equivalent fuel concept and the fuel stockpile inventory concept. A comparison to detailed simulation of fast fission breeder reactor performance shows the merits of the trajectory concept and its consequences for a realistic fuel requirement and fuel breeding capacity assessment.
For synergetic nuclear energy systems generalized trajectories which characterize the fuel inventories and fuel breeding capacities of fusion-fission-symbionts are derived and analyzed. The resultant formulations are based on physically relevant processes and lead to mathematically tractable expressions. By analytical numerical test and a specific comparison, it is concluded that this formulation leads to more exact fissile and fusile fuel flow characterizations than are possible with conventional procedures.

6. Numerical and analytical investigations of high-energy high-angular momentum resonance cross sections

M. Heindler

A rigorous analytical formulation of temperature dependent high-energy and high-angular momentum resonance cross sections based on fundamental quantum mechanical considerations is established and subsequently investigated. It is found that in addition to more accurate calculational results, this formulation also reduces computational effort in comparison to less accurate alternatives and yields useful criteria for its applicability to a given set of resonance parameters.

7. Micro- and macrocoherence of fermions

E. Ledinegg

With the help of the Glauber's coherence definition the coherence relations for a fermion field are introduced. In extension of a previous paper collective Fermi operators are defined which have for the state vectors the property of production and annihilation operators a^+, a of uniformly correlated Fermi particles. For $n \to \infty$, where n is defined as the number of different occupation number spaces in which the Pauli principle is satisfied, the operators a^+ and a go over to Bose operators, whereas for n = 1 a^+, a represent Fermi operators. The derived coherence relations for the Fermion field show for $n \to \infty$ the same properties as for the photon field. Especially it is possible to construct Fermi fields with complete coherence, which are characterized by a Poisson distribution. Hence, there follows in analogy to the P-representation by Glauber the possibility to represent the coherence state of Fermions with complete coherent Fermi fields (microcoherent fields). With the help of correlation functions of order 2 it is also possible to define coherence times and lengths of partially coherent Fermi fields.

8. A diffusion-theoretical method to calculate the neutron flux distribution in multisphere configurations

F. Schürrer

For characterizing heterogeneous configurations of bebble-bed reactors the fine structure of the flux distribution as well as the determination of the macroscopic neutronphysical quantities are of interest. When calculating system parameters of Wigner-Seitz-cells the usual codes for neutron spectra calculation always neglect the modulation of the neutron flux by the influence of neighbouring spheres. To judge the error arising from that procedure it is necessary to determinate the flux distribution in the surrounding of a spherical fuel element. In the present paper an approximation method to calculate the flux distribution in the two-sphere model is developed. This method is based on the exactly solvable problem of the flux determination of a point source of neutrons in an infinite medium, which contains a spherical perturbation zone eccentric to the point source. An iteration method allows by superposing secondary fields and alternatively satisfying the conditions of continuity on the surface of each of the two fuel elements to advance to continually improving approximations.

9. Reactor-physical layout of critical experiments at the Siemens-Argonaut-Reactor Graz to study the water ingress in pebble-beds

F. Schürrer

The possible accident of the ingress of water into the core region is an essential safety problem of the gascooled high-temperature-reactor. The Institute for Theoretical Physics and the Reactor Institute of the Technical University Graz try to find out in cooperation with the Institute for Reactor Development of the Nuclear Research Centre Jülich, to what extent theoretical models (computer code system GAMTEREX) used for the layout of HTR's can be applied as well for the neutron physical determination of this kind of accidents. The present paper explains the layout of a critical assembly. The annular core of an Argonaut-Reactor is to work in the planned experiment as the driver zone of a pebble bed erected in the reactor centre. Important results of the reactor physical predeterminations are discussed.

10. Measurement of the fluctuation of fissile content in spherical fuel elements

W. Ninaus

For the evaluation of reaction rates of various detector materials in a small pebble-bed assembly (∿ 35 spherical fuel elements) it is generally assumed that the fissile fuel content is the same in all fuel elements. Since no detailed fissile content data were available, we have experimentally determined the relative deviation of the fuel mass. It can be expected that the relative deviation of 0,31 %, which has been found, will have a negligible effect on the determination of the reaction rates in the pebble-bed assembly.