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Progress Report to E.A.N.D.C.

from Sweden, December 1966

edited by

N. Starfelt

AB Atomenergi, Studsvik, Nyköping

A. Work done at the Research Institute of National Defence, Stockholm

1. $\bar{\nu}$-measurements in the fast neutron fission of ^{239}Pu, ^{236}U and ^{234}U

H. Condé, J. Hansén and M. Holmberg

Using a large liquid scintillator as the fission neutron detector measurements of the $\bar{\nu}$-values for ^{239}Pu, ^{234}U and ^{236}U relative to the $\bar{\nu}$-value for the spontaneous fission of ^{252}Cf are in progress. For ^{239}Pu the $\bar{\nu}$-value is being measured in the energy region 4-14 MeV while for ^{234}U and ^{236}U the spontaneous as well as the induced fission in the threshold region are being studied.

2. Measurements of (n, 2n) cross-sections

M. Holmberg and J. Hansén

The (n, 2n) cross section of ^{9}Be and D have been measured in the energy regions 2.0-6.5 MeV and 4.2-6.5 MeV, respectively. Preliminary results were given at the Paris Conference on Nuclear Data (October 1966), Paper CN 23/18.

3. Neutron resonance radiative capture cross sections in 2s1d shell nuclei

G. Nyström, I. Bergqvist

The possibility of measuring the radiative capture cross section by means of the time-of-flight technique with a 5" x 4" NaI(Tl) scintillator is being investigated. The neutrons are produced by the $^{7}Li(p,n)^{7}Be$ reaction. The pulsed proton beam from the 3 MV van de Graaff-generator has, after Mobley bunching, a duration of 1 ns. The over all time resolution of the system (over a decade of pulse heights from the γ-ray spectrometer) is 2 ns. Measurements have been performed for F, Na, Mg, Al, Si, P and S in the neutron energy range 10-60 keV. Cross section calculations are in progress.

4. γ-ray spectra from neutron resonance capture in 2s1d shell nuclei

B. Lundberg, I. Bergqvist

Experiments on the γ-ray spectra from resonance capture at neutron energies below about 150 keV in 2s1d shell nuclei are in progress. Time-of-flight technique with a 9" x 9" NaI(Tl) spectrometer is used. Measurements have been completed for the 64 keV resonance in ^{28}Si, 30 keV resonances in ^{31}P and ^{32}S.

5. Cross sections of gamma-rays from inelastic neutron scattering

I. Bergqvist, H. Condé and G. Nyström

N. Starfelt, AB Atomenergi, Studsvik, Nyköping

A Ge(Li)-detector (15 cm^3) will be used to study gamma-rays from inelastic neutron scattering mainly in the neutron energy range $4 < E_n < 8$ MeV. The detector will be used in a time-of-flight equipment. The set up also gives the possibility to measure angular distributions of the gamma-rays.

6. Neutron inelastic scattering from ^{232}Th in the energy region 1.0 - 2.0 MeV

M. Holmberg and L.G. Strömberg

The inelastic cross-sections for the levels between 1.1 and 1.8 MeV have been measured. These cross-sections are needed for the study of the competition between neutron reemission and fission in this energy range, where the fission cross-section shows strong variations. Further measurements with higher resolution are planned.

7. Angular distributions of neutrons from the $^{7}Li(p,n)^{7}Be$ and the $^{9}Be(p,n)^{9}B$ reactions near threshold

A. Bergström, S. Schwarz, L.G. Strömberg and L. Wallin

Angular distributions have been measured for neutrons from reaction threshold energy to about E_p = 500 keV above threshold. Theoretical analysis is being completed in terms of the R-matrix and the S-matrix descriptions of resonance nuclear reactions.

8. Multiple scattering of fast neutrons in Li- and B-glass scintillators

H.O. Zetterström, S. Schwarz and L.G. Strömberg

Nucl. Instruments and Methods: 42, 277 (1966) and 441, 208 (1966)

9. A relative measurement of the $^{10}B(n,\alpha)^{7}Li$ reaction in the energy range $1 < E_n < 500$ keV

S. Schwarz and L.G. Strömberg

As a sequel to the studies on the $^{6}Li(n,\alpha)^{3}H$ reaction the $^{10}B(n,\alpha)^{7}Li$ reaction will be studied in the keV range.

10. Absolute measurement of fast neutron flux with a large liquid scintillator

H. Condé and L.G. Strömberg

N. Starfelt, AB Atomenergi, Studsvik, Nyköping

A method of making an absolute measurement of the flux of fast neutrons has earlier been studied (Arkiv för Fysik 29, 45 (1965). An experiment is in progress to use the calibrated neutron beam to measure the absolute cross section for $^{6}Li(n,\alpha)$ in the neutron energy range $30 < E_n < 100$ keV.

11. On the properties of small organic scintillators as detectors of fast neutrons

S. Schwarz and H.O. Zetterström

Nucl. Instr. and Methods: 41, 93 (1966)

B. Work done at the reactor R1, Stockholm

1. Thermal neutron capture gamma rays at R1, Stockholm

R. Hardell, S.E. Arnell, Chalmers University of Technology

The equipment available for the determination of capture gamma spectra now comprises a 0.5 cm by 4 cm^2 Ge(Li) detector, a TC 130 FET preamplifier and a 4096 channel pulse height analyzer. To make accurate measurements of high energy gamma spectra possible the Ge(Li) detector has been surrounded by a bisected NaI crystal, 6 in. in diameter and 4 in. long. The closed geometry gives a high detection efficiency for the escaping annihilation quanta. For the detection of low energy gammas it is of interest to reduce and smooth the Compton distributions by using an anticoincidence mantle. The annular mantle of NaI described is used even for this purpose. Furthermore, a 5 in. diameter by 4 in. long NaI crystal with an 18 mm through hole for the entering gamma ray beam is used to detect backscattered radiation. This equipment has been successfully used for the improvement of unpublished spectra, previously obtained by this group, from neutron capture in ^{19}F, ^{20}Ne, ^{22}Ne, ^{36}Ar and ^{40}Ar.

2. Cold neutron scattering at R1

U. Dahlborg and K.E. Larsson, The Royal Institute of Technology

Measurements on pentane at low temperatures are performed and show some unexpected features. Further measurements are in progress to establish the effects with certainty.

The crystal spectrometer has been rebuilt to allow measurements by use of the inverted filter method. Higher order reflections are eliminated by beryllium filter inserted before the lead monochromator. A filter of beryllium oxide is placed in front of the detector. The range of energy transfers possible to study is $-1.0 \leq E \leq + 1.5$ MeV. A resolution of about 1 % at 4.7 Å should be possible to reach.

The measurements on n-propyl alcohol, C_3H_7OH, and a model to treat the data was published in Phys.Rev.

A final report on the results on solid and liquid aluminium compared to theoretical models was published in Arkiv för Fysik.

The study of the liquid-vapor transition in water is finished. The final analysis of the data is in progress.

Preliminary measurements on DNA show a dependence of the molecular orientation on the scattered neutron distribution. Further measurements are in progress.

C. Work done at reactor R2, Studsvik

1. Time-of-flight spectrometer at the reactor R2

K. Sköld, L. Karlén, G. Nelin, J. Sciesinski (guestscientist),
J-O. Burgman (Royal Institute of Technology, Stockholm)

Experiments on the diffusion of hydrogen in palladium have been finished during the period.

K. Sköld, G. Nelin: Neutron study of the diffusion of hydrogen in palladium. Solid State Communications, Vol. 4 (1966) 303

K. Sköld, G. Nelin: Diffusion of hydrogen in the α-phase of Pd-H studied by inelastic neutron scattering, (FFN-53).

A careful study of the differences in the atomic motions in water and ice close to the melting point has been undertaken. The analysis of the data is not completed but the results obtained so far indicate that the differences are much more pronounced than has been suggested from earlier experiments. Small amounts of KOH ($4 \cdot 10^{-3}$ mol %) in ice is known to have a drastic influence on the dielectric constant at low temperatures (T~150 ^{o}K). It has been suggested that this should be connected to changes in the thermal motions of the protons. A neutron study that we have performed showed, however, that the dynamics, in the range of frequencies (10^{11}-10^{13} s^{-1}) that are available with this technique, was not changed within the experimental accuracy when KOH was added.

The construction of a high pressure container for liquid samples has been completed and the arrangement has been tested. Experiments on H_2O and D_2O in the liquid state showed that the thermal motions are not affected by applying a pressure of 2000 atm. in spite of the fact that the volume is decreased by ~ 7 % on applying this pressure. This is perhaps due to the open structure of these hydrogen bonded liquids and a similar behaviour is not expected in, for example, hydrocarbons. NMR-studies on hydrocarbons have shown that the diffusion process is strongly pressure dependent but very little is known about the effects of increased pressure on other motions. Our first systematic study of liquids under pressure will be made on neopentane [$C(CH_3)_4$] which has earlier been investigated by NMR-methods.

The interpretations of the experimental results on liquid argon are completed and a final report will be published soon.

2. 3-axis crystal spectrometer

L. Almqvist, G. Nilsson, G. Raunio, R. Stedman

The greater part of the new double spectrometer is now installed. The massive shielding around the beam from the reactor is complete, and mechanical units are almost complete. The two-crystal monochromator which is an innovation in this spectrometer yields about the expected neutron intensity - exact figures have not yet been obtained, but at least we know that the device works satisfactorily.

The variation of frequency with wave vector and polarisation for phonons in lead has been mapped experimentally, and on the basis of this comprehensive survey the frequency distribution and the curve of the lattice specific heat as a function of temperature have been calculated.

R. Stedman, S. Nilsson: Dispersion relations for phonons in aluminium at a 80 and a 300 ^{0}K. Phys. Rev. 145 (1966) 492

3. β- and γ-ray spectroscopy

S.G. Malmskog and M. Höjeberg

The experimental study of hindered E1, E2 and M1 transitions by the delayed coincidence technique is continued. An equipment for accelerating low energy electrons has been incorporated into the Gerholm-type lens spectrometer. The system works satisfactory up to accelerating voltages of 20 kV. The following nuclei are being investigated:

In^{115} and In^{117} (together with A. Bäcklin)
Conversion electron spectra (double focussing spectrometer), γ-ray spectra (Ge-Li-detector) and half lives (double lens spectrometer) have been measured. A full report is being written.

Pm^{147} (together with A. Bäcklin)
Conversion electron and γ-ray spectra measured. A full report is under way.

Au^{199} (together with A. Bäcklin)
Measurements of conversion electron and γ-ray spectra are in progress.

Tb^{155} and Tb^{157} (together with A. Marelius, University of Uppsala)
Delayed E1-transitions have been investigated. A full report will soon be given.

$Ta^{182\ m}$

Delayed M1 and E2 transitions measured. A full report is in progress.

W^{185m}

γ-ray spectra measured. Further experimental work is in progress.

W^{183} (together with S. Wahlborn)

A calculation of γ-ray transition rates for the K-forbidden M1 and E2 transitions from the 453.1 keV level in W^{183} is performed. The result will be published in Nuclear Physics.

Pa^{233} (together with E. Falkström and L. Boreving, Chalmers University of Technology)

Project just started.

Tl^{205}

The half life of the first excited state has been measured. A report is under way.

Reports:

1. K.E.G. Löbner, S.G. Malmskog: Systematics of absolute gamma ray transition probabilities in deformed odd-mass nuclei. Nuclear Physics 80 (1966) 505

2. L. Broman, S.G. Malmskog: Possible odd parity state in ^{128}Xe. AE-240 (accepted for publication in Arkiv Fysik).

3. S.G. Malmskog: Half life measurements in ^{155}Gd. AE-242 (accepted for publication in Arkiv Fysik).

4. A. Bäcklin, S.G. Malmskog: On the properties of the $s_{1/2} \rightarrow d_{3/2}$ transition in ^{199}Au. FFN-42 (accepted for publication in Arkiv Fysik).

5. S.G. Malmskog: Absolute transition probabilities from the 453.1 keV level in ^{183}W. FFN-48 (accepted for publication in Arkiv Fysik).

6. A. Bäcklin, H. Solhed, S.G. Malmskog: Properties of levels in ^{149}Pm. LFF-26 (accepted for publication in Arkiv Fysik).

4. Nb^{93}-monitor

S. Hellström

The neutron doses necessary for the calculation of involved cross-sections have been determined from measurements of thermal, epithermal and threshold detectors, which were irradiated together with the Nb^{93}-foil samples.

To check the degree of burn-up of Nb^{94}, a sample with only Nb^{94}-activity was irradiated for a short time ($\sim$ 6 h) at a high neutron flux level ($\sim 5 \cdot 10^{13}/cm^3/sec$) and the change of activity measured.

A computer programme for the accurate evaluation of the induced activities has been tested.

5. Experiment with nuclear resonant scattering of gamma rays

S. Hellström, T. Wiedling

One of the channels in the reactor R2 has been supplied with a collimator for the extraction of the prompt gamma-radiation from (n,γ) processes in irradiated samples. A turnable NaI(Tl)-spectrometer has been constructed in order to afford measurements of the scattered γ-rays from scatterers of different elements, placed in the beam. The set-up has been tested by measuring the resonant radiation caused by γ-rays from a $Fe(n,\gamma)$-source upon Pb(7.28 MeV)- Ni(7.64 MeV)- and Cd(7.64 MeV)-scatterers. A report about the experimental features is in preparation.

6. γ-radiation from fission

H. Albinsson, Chalmers University of Technology and

J. Higbie

Preliminary experiments started last May. Most of them have dealt with testing the electronics and trying to increase the neutron flux. Unfortunately we have had bad luck with the fission foils, but the radiochemists have improved their technique and we have great hope to get perfect foils soon. The experience by other people is that the uranium layer should not be as thick as we have used and the new foils will have not more than 100 $\mu g/cm^2$, sometimes less than that. This seems to be of special importance in measurements where mass selection is required.

From time-of-flight spectra we have found the ratio of chance to true coincidences to be satisfactory. In order to increase the gamma counting

rate we have moved the NaI-crystal closer to the fission chamber. Investigations are going on to find out if it is important to shield the NaI-crystal against the prompt neutrons. The resolution in the gamma peak (FWHM) is 6.5 ns, but this can probably be improved.

7. The double-focusing beta-spectrometer at R2

A. Bäcklin and B. Fogelberg, University of Uppsala and The Swedish Research Councils' Laboratory, Studsvik, Nyköping, Sweden

The low energy internal conversion measurements of lines from $Ho^{165}(n,\gamma)Ho^{166}$ have been completed with measurements of the corresponding gamma transitions using a Ge(Li) detector and an external beam geometry. Internal conversion spectra have been recorded from $Dy^{161}(n_{th},\gamma)Dy^{162}$ between 70 and 1000 keV. The latter spectrum contains several hundreds of lines. The Dy measurement has revealed possible $K = 0^-$ and $K = 0^+$ bands in Dy^{162}. From a measurement of L-subshell conversion ratios from the reaction $Tm^{169}(n_{th},\gamma)Tm^{170}$, E2/M1 mixing ratios of a few transitions within and between the low-lying $K = 1^-$ and $K = 0^-$ bands in Tm^{170} have been determined.

From internal conversion measurements on the decays of Cd^{115g} and Cd^{117g}, multipolarities and mixing ratios have been obtained for some low lying levels in In^{115} and In^{117}. The data are compatible with a positive parity and a spin of 1/2 or 3/2 for a doublet of levels around 0.8 MeV in both isotopes. The reduced transition probabilities of transitions from these levels obtained from half life measurements (see C 3) is compatible with the assumption of a deformation ($\delta \approx 0.20$) of these levels.

Internal conversion lines have been measured from the decays of Pt^{199} and Nd^{147}.

Reports:

1. H.T. Motz, E.T. Jurney, O.W.B. Schult, R.H. Koch, U. Gruber, B.P. Maier, H. Baader, L. Struble, J. Kern, R.K. Sheline, T. von Egidy, Th. Elze and E. Bieber: The energy Levels of Ho^{166}, to appear in Phys. Rev.

2. A. Bäcklin, A. Suarez, O.W.B. Schult, B.P.K. Maier, U. Gruber, D.W. Hafemeister, E.B. Shera, W.N. Shelton and R.K. Sheline: Nuclear Spectroscopy of Dy^{162}, to be published.

3. A. Bäcklin and S.G. Malmskog: On the Properties of the $S_{1/2} \rightarrow d_{3/2}$ transition in ^{199}Au, to appear in Arkiv för Fysik.

4. A. Bäcklin, S.G. Malmskog and H. Solhed: Transitions, Lifetimes and Levels in ^{149}Pm, to appear in Arkiv för Fysik.

5. A. Bäcklin, B. Fogelberg and S.G. Malmskog: Possible Deformed Levels in Odd In isotopes. Preprint.

8. (n,γ)-studies by a crystal diffraction spectrometer

N. Ryde, S. Boreving, E. Falkström, and Ch. Tripathi, Chalmers University of Technology

The automated double-flat crystal spectrometer has earlier been described. In this instrument the resolution is determined by the crystals. In another arrangement a Ge(Li) detector is inserted between the crystals, the first crystal being used as a monochromator for the gamma rays. By this proceeding the Compton distributions are eliminated and the response function appreciably improved. The resolution is in this arrangement generally determined by the Ge(Li) detector. Maximum intensity of the diffracted gamma ray beam is ensured by using crystals of suitable material and of thicknesses appropriate for the energy region under investigation. The reactions studied so far are $^{103}Rh(n,\gamma)^{104}Rh$, $^{167}Er(,\gamma)^{168}Er$ and $^{40}Ca(n,\gamma)^{41}Ca$.

Reports

1. L. Andersson and S. Andersson: A Scanner with Arbitrary Voltage Characteristics for automatic single channel pulse height analysis. To be published in Journ. Scient. Instr.

2. L. Broman: A Spectrometer for Neutron Capture Gamma Ray Studies, LFF - 22, 1966.

D. Work done at the Van de Graaff laboratory, Studsvik

1. Van de Graaff generator

T. Wiedling

Since there is an interest in using heavy fast ions as probes in string effect experiments at our Van de Graaff laboratory a systematic investigation has been performed of the high-frequency ion source for production of heavy ions in different charged states. A H.F. ion source was choosen since our 6 MeV Van de Graaff accelerator is equipped with that type of ion source and since it would be most convenient to use the same ion source for the production of all the different ions used in the research programs at our laboratory. The relative yields of different charged ion states have been investigated for He, Ne, A, Kr, and Xe.

P. Tykesson: Jonisering av ädelgaser med högfrekvensjonkälla, (FFN-55) (in Swedish).

2. Fast neutron elastic scattering

B. Holmqvist and T. Wiedling

During this report period the fast neutron scattering experiments on the elements Fe, Co, Ni, Cu, and Ta have been extended up to 7 MeV energy using the D (D,n) reaction for the production of the neutrons. The experimental data have been analyzed by the use of the optical model with a potential of the form

$$V(r) = U\, f(r) + i\, Wg\,(r) + U_{so} \left(\frac{h}{\mu_\pi c}\right)^2 \frac{1}{r}\frac{d}{dr} /f\,(r)/\, \vec{\sigma}\cdot\vec{l}$$

Reports:

1. B. Holmqvist and T. Wiedling: An optical model study of neutrons elastically scattered by iron, nickel, cobalt, and copper in the energy region 1.5 to 4.6 MeV, (FFN-51).

2. B. Holmqvist and T. Wiedling: Inelastic neutron scattering cross sections of Cu^{63} and Cu^{65} in the energy region 0.7 to 1.4 MeV, Arkiv för Fysik, in press.

3. B. Gustavsson, B. Holmqvist, and T. Wiedling: A Monte Carlo program for calculation of neutron attenuation and multiple scattering corrections, Arkiv för Fysik, in press.

4. B. Antolkovic, B. Holmqvist, and T. Wiedling: Angular distributions of neutrons elastically scattered by natural copper in the energy region 1.5 to 4.6 MeV, Arkiv för Fysik, in press.

3. Study of neutron capture

I. Bergqvist, B. Lundberg, Research Institute of National Defence, L. Nilsson and N. Starfelt

The studies of the neutron capture process at neutron energies of several MeV have continued. Measurements with the 9" x 9" NaI crystal have been performed and the analysis of the experimental data is in progress. Experimental cross sections in several elements will be compared with calculations based on semi-direct and collective capture theories. A paper has been published in Physics Letters and preliminary results from later experiments have been reported at the Conference on Nuclear Structure and Elementary Particles, Oxford, March-April, 1966.

Reports:

1. I. Bergqvist, B. Lundberg, L. Nilsson, N. Starfelt: Gamma ray spectra from inelastic neutron scattering, Nucl. Phys. 80 (1966) 198.

2. I. Bergqvist, B. Lundberg, L. Nilsson, N. Starfelt: Gamma-ray spectra from the radiative capture of 7.4 MeV neutrons, Phys. Letters 19 (1966) 670.

3. B. Lundberg, N. Starfelt: Fast neutron capture gamma-ray spectra in Rb, Sr, Y, Zr and Nb, Arkiv Fysik, in press.

4. Studies of (d,pγ) reactions

I. Bergqvist, B. Lundberg, Research Institute of National Defence, L. Naucler, University of Lund, L. Nilsson and N. Starfelt

With the aim to achieve understanding of the reaction mechanism in neutron capture the corresponding (d,pγ) reactions are being studied. In these processes the neutron presumably is captured in a direct or semidirect reaction. With the use of a two-parameter multichannel analyzer it is possible to study simultaneously the gamma-ray spectra from neutron transfers to a wide range of excitation energies in the residual nucleus. The (d,pγ) reaction has been studied in Mg, Al, Ni, Cu and Ag. Further experiments with other targets are in progress.

5. Time-of-flight measurements of neutrons from (d,n) reactions

B. Erlandsson, University of Lund, A.T.G. Ferguson, Harwell, Z. Sawa, Research Institute for Physics, Stockholm, L. Nilsson, N. Starfelt

Neutron spectra and angular distributions for (d,n) reactions in ^{31}P, ^{42}Ca, ^{44}Ca, ^{50}Cr and ^{54}Fe have been measured. The experiments were

initiated by and carried out in collaboration with physicists from other laboratories.

The ^{31}P (d,n) ^{32}S reaction was studied to investigate isobaric analogue states which are identified by comparisons with positions, l-values and reduced widths obtained for levels in the analogue nucleus by the (d,p) reaction on the same target nucleus. DWBA calculations have been performed to give l-values and relative spectroscopic factors. A report on the work is under preparation.

In the study of the $^{42}Ca(d,n)$ ^{43}Sc reaction experimental angular distributions for neutron groups to a few low-lying states in ^{43}Sc have been measured. The corresponding DWBA-angular distributions are under way.

The (d,n) cross sections in ^{50}Cr and ^{54}Fe are small due to Coulomb barrier effects. The measurements for these nuclei have been repeated with pulse-shape discrimination technique, which resulted in a reduced background. A liquid scintillator, NE 203, was incorporated in our detecting system.

For the ^{44}Ca (d,n) ^{45}Sc reaction it appeared that the level density is too high to make measurements of angular distributions of single neutron groups possible.

6. Scattering of polarized fast-neutrons

O. Aspelund

The search for an intermediate structure in the energy dependences of the polarization patterns observed in polarized elastic fast-neutron scattering off nuclei in the lead region have so far resulted in the following experimental material:

Bi: 15 complete angular distributions of $(\frac{N_L}{N_R})$ between /.063 and 2.149 MeV.

Pb: 14 complete angular distributions of $(\frac{N_L}{N_R})$ between /.063 and 2.149 MeV.

Hg: 6 complete angular distributions of $(\frac{N_L}{N_R})$ between /.197 and 1.669 MeV.

A typical angular distribution contains observations of $(\frac{N_L}{N_R})$ at 8 nominal scattering angles between 30° and 189° (lab.syst.).

From this material the following conclusions may be drawn: On all polari-

zation patterns there is structure with half widths smaller than the gross structure of the optical model, but larger than the half widths of the Ericson fluctuations. However, only in the cases of Bi and Pb could the question of correlations at widely separated scattering angles be answered in the affirmative. The reason for this question being more easily settled in these nuclei than in the remaining ones is simply that the amplitudes of the polarization variations are larger for Bi and Pb than for adjacent nuclei in the periodic system. Characteristic half widths of the structure observed are 150 keV.

The analysis of the experimental polarization data observed in n + C^{12} elastic scattering between 1 and 2 MeV has been completed, and a report is practically ready for publication. - Theoretical work on the possible description of the energy variations of the phase shifts has been initiated. A comprehensive report on the multiple scattering code MULTPOL is ready for publication. As a part of our account of the kinematics of elastic fast-neutron scattering off spin-less nuclei we present a discussion of the possible depolarization of an arbitrarily polarized beam. The motivation for this discussion is our feeling that appropriate theoretical arguments should be presented for the necessity of the proper incorporation of polarization effects in successive scattering orders.

Reports:

1. B. Gustafsson, O. Aspelund: DETEC, a subprogram for simulation of the fast-neutron detection process in a hydro-carbonous plastic scintillator. AE-236 (1966).

2. O. Aspelund: Intermediate structure investigations in the lead region by means of polarized elastic fast-neutron scattering. AE Arbetsrapport FFN-52 (1966).

3. O. Aspelund: A general formalism for numerical evaluation of the polarization of fast-neutrons by means of finite-geometry measurements of the left-right ratio. Nucl. Instr. and Meth. 40 (1966) 291-304.

4. B. Gustafsson, O. Aspelund: DETEC, a subprogram for simulation of the fast-neutron detection process in a hydro-carbonous plastic scintillator. Nucl. Instr. and Meth., in press.

5. O. Aspelund: Angular distributions of the polarization in n+C^{12} elastic scattering. Proc. 2nd Int. Symp. Pol. Phen. Nucl., p. 474 (Birkhäuser Verlag, Basel-Stuttgart, 1966).

6. O. Aspelund: Intermediate structure investigations in the lead region by means of polarized elastic fast-neutron scattering. Contribution to the International Conference on Nuclear Physics, Gatlinburg 12-17 September 1966.

7. O. Aspelund: Polarized fast-neutron scattering off carbon in the lower MeV range. I. Experimental part. Available as manuscript only.

8. O. Aspelund, B. Gustafsson: Finite-geometry and polarized multiple scattering corrections of experimental fast-neutron polarization data by means of Monte Carlo methods. Available as manuscript only.

7. Neutron thermalization

L.G. Larsson, E. Möller

Measurements have been done of the decay constant of thermal neutrons in water, which has been poisoned with absorbers of the 1/v-type and of non-1/v-type in order to obtain integral parameters of the scattering law. The measurements cover the time period immediately after the thermalization, and the curves are intended to correspond to the case of an infinite medium by the use of a geometry for negligible leakage and a space-integrating detector of the gamma rays emitted by the capture in the absorber and the hydrogen. A numerical study has been performed of the flux distortion casued by the detector and its dependence on the concentration. Results from computations using data for the Nelkin kernel, obtained from the GAKER code, are in agreement with earlier calculations by Calame. Data obtained from Harwell for the Haywood kernel are being adapted to these calculations in order to yield results for the best presently available kernel. Further measurements are needed in order to obtain reliable experimental results.

Reports:

1. E. Möller: Measurement of the neutron slowing-down time distribution at 1.46 eV and its space dependence in water. Arkiv Fysik 31, 255 (1966).

2. E. Möller: Measurement of the time dependence of neutron slowing-down and thermalization in heavy water. Arkiv Fysik 31, 355 (1966).

3. L.G. Larsson, E. Möller, S.N. Purohit: Neutron scattering in hydrogeneous moderators, studied by the time dependent reaction rate method. AE-223 (1966).

4. E. Möller: An experimental study of the time dependence of neutron moderation in light and heavy water. Dissertation (1966).

8. Microanalysis and crystal studies

P. Hjerppe, E. Möller, L. Nilsson, N. Starfelt

Microanalysis of surface contaminations has been done by the use of charged particle reactions. Fluorine in zircaloy has been determined with an accuracy of about 0.01 $\mu g/cm^2$ by means of the $^{19}F(p,\alpha\gamma)^{16}O$ reaction and the depth distribution below the surface to a depth of 2 μm measured. Carbon, nitrogen and oxygen on and below a steel surface to a depth of 2 μm measured. Carbon, nitrogen and oxygen on and below a steel surface have been measured by means of (d,n) reactions and time-of-flight techniques, using 3 MeV deuterons from the van de Graaff accelerator. The sensitivity obtained is 0.1 $\mu g/cm^2$ and the depth resolution 4500 A.

Channeling studies have been performed in single crystals of aluminium and iron. Automatic equipment for the data accumulation using the RAMSES system and goniometers of the Aarhus type have been assembled and made work properly. A study of the channeling of molecule ions of hydrogen in aluminium has shown, that these ions can be used instead of protons when it is desirable to work with a lower ion energy than given by the minimum voltage of the van de Graaff accelerator. Studies of the positions of implantated impurity ions in a single crystal have been started.

Reports:

1. E. Möller, N. Starfelt: Microanalyse of fluorine contamination and its depth distribution in zircaloy by the use of a charged particle nuclear reaction. AE-237.
2. E. Möller, N. Starfelt: Channeling studies with hydrogen ions in monocrystalline aluminium, (FFN-54).
3. E. Möller, L. Nilsson, N. Starfelt: Microanalysis of light elements by means of (d,n) reactions, (FFN-58).

9. Applications of the Mössbauer effect

R. Wäppling

The measurements on FeP_2, FeP and Fe_2P have been completed and a report has

been issued. The 18-line spectrum of Fe_3P is very complicated but a measurement in an external magnetic field will probably make it possible to resolve the three different lattice positions of iron. Such a measurement is under way.

The effect of substitutions of Ru and Co in iron positions in Fe_2P-structure is being investigated.

The measurement on stainless steel after heat treatment has been interrupted temporarily due to a leak in the cryostat at the temperature of liquid helium but is to be continued as well as measurements on iron with low manganese contents.

A search for quadrupole interaction at an iridium nucleus in an iron lattice has been undertaken but due to activation difficulties no result was obtained. A new higher flux activation position in the reactor R2 will be in operation at the end of october and will probably remove the earlier difficulties.

Reports:

R. Wäppling, E. Karlsson, S. Rundqvist: Mössbauer spectroscopy on the phosphides of iron. (FFN-50).