

International Atomic Energy Agency

INDC(ROM)-021/G
INDC/P(90)-7

INDC

INTERNATIONAL NUCLEAR DATA COMMITTEE

PROGRESS REPORT FOR ROMANIA FOR THE PERIOD 1989/90

**S.N. Rapeanu
Institute of Atomic Physics
Bucharest, Romania**

NDS LIBRARY COPY

August 1990

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

F O R E W O R D

This progress report contains the main nuclear data obtained during the years 1989/1990 in the institutes of the Institute of Atomic Physics from Romania. It has been prepared to promote exchange of nuclear data information between Romania and the other member states of the International Atomic Energy Agency. The emphasis in the works here reported has been on calculations, measurements and evaluations of nuclear data for application. The individual reports are not intended to be complete or formal. Consequently they should not be quoted and reproduced without the permission of the authors.

C O N T E N T S

1. Study of the 14.7 MeV Neutron Reaction Mechanisms in the Mass Range $A \approx 50^*$, M.Avrigeanu, M.Ivascu and V.Avrigeanu.
2. Double Differential Nucleon Emission Spectra Calculations within the Computed Code STAPRE-H, M.Avrigeanu.
3. Cluster Emission Rates of Nuclei Far from Stability, D.N.Poenaru, W.Greiner, I.Cata.
4. Integral Cross Sections Measured around 14 MeV, I.Garlea, C.Garlea, N.-H.Rosu, V.Raducu.
5. Neutron Diffraction on Liquid Heavy Water at Various Temperatures, S.N.Rapeanu, I.Padureanu, M.Ion, Zr.A.Kozlov.
6. Inelastic Neutron Scattering on Liquid Heavy Water at Various Temperatures, I.Padureanu, S.N.Rapeanu, Gh.Rotarescu, A.G.Novikov, N.K.Fomichev.
7. Inelastic Neutron Scattering on Zirconium Hydride at Various Temperatures, S.N.Rapeanu, I.Padureanu.
8. Experimental Investigation of Pion Emission in Nuclear Fission, M.Ivascu, D.B.Ion, I.Berceanu, I.Brancus, A.Buta, A.Damian, M.Duma, C.Grama, I.Lazar, I.Mihai, H.Petrascu, M.Petrascu, R.Ion Mihai.
9. S and P Determination using Activation Method at the IPNE Cyclotron, B.Constantinescu, G.Pascovici, D.Plostinaru

STUDY OF THE 14.7 MeV NEUTRON REACTION MECHANISMS IN
THE MASS RANGE $A \approx 50$ *)

M.Avrigeanu, M.Ivascu and V.Avrigeanu

Institute for Physics and Nuclear Engineering, Bucharest

A test of the generalized GDH pre-equilibrium emission model and Hauser-Feshbach statistical model predictions across the valley of stability, in the mass region $A \approx 50$, has been performed. Both the absolute cross section values and the "stepness" of the isotope trend have been obtained in good agreement with the experimental data. It can be emphasized that the present agreement as well as the one got for the (n,p) , (n,α) and $(n,2n)$ reaction excitation function data [1] have been found with no further change of the model parameters. By using the calculated cross sections, the isotope effect of the fast neutron reactions (n,p) , (n,α) , $(n,2n)$ and $(n,n'p)$ has been discussed. The applicability of the generalized Q_{gg} -systematics of the deep inelastic collisions between complex nuclei to fast neutron reactions is presently investigated.

- [1] M.Avrigeanu, M.Ivascu, V.Avrigeanu, Z.Phys.A - Atomic Nuclei, 335, 299 (1990)

*) *Work performed under the Research Contract Nr. 3802/R4/RB with the International Atomic Energy Agency, Vienna*

DOUBLE DIFFERENTIAL NUCLEON EMISSION SPECTRA
CALCULATIONS WITHIN THE COMPUTER CODE STAPRE - H

M.Avrigeanu

Institute for Physics and Nuclear Engineering, Bucharest

Further inter-comparisons between definite experimental data and different theoretical and model approaches should be pre-

sently carried out, the use of double - differential cross sections (DDCS) being recommended. Therefore, the computer code STAPRE-H - successfully used to describe pre-equilibrium emission (GDH model) and statistical angle-integrated energy spectra (e.g. [1,2]) - is being developed to include the angular distribution calculation by using the approach of Blann et al. [3]. The nucleon-nucleon scattering event in nuclear matter with the influence of the Fermi motion and the Pauli principle is taken into account in this respect. Blann's predictions for the nucleon pre-equilibrium emission angular distributions, including entrance and exit channel refraction, as well as the Kalbach-Mann systematics predictions [4] are presently given by STAPRE-H. DDCS for the pre-equilibrium emitted nucleons from $n + {}^{56}\text{Fe}$ process at 14.8 MeV incident energy, given by the two calculation methods, have been comparatively analysed. The agreement between the respective results is improved as the emission energy increases. Further DDCS analyses are following.

- [1] M.Avrigeanu, D.Bucurescu, M.Ivascu, G.Semenescu, V.Avrigeanu, J.Phys.G Nucl.Phys. 15, L241 (1989)
- [2] M.Avrigeanu, V.Avrigeanu, J.Phys.G: Nucl.Phys. 15, L261 (1989)
- [3] M.Blann, W.Scobel, E.Plechaty, Phys.Rev. C 30, 1493 (1984)
- [4] C.Kalbach, F.M.Mann, Phys.Rev. C 23, 112 (1981)

CLUSTER EMISSION RATES OF NUCLEI FAR FROM STABILITY

D.N.Poenaru^{a,b}, W.Greiner^b, I.Cata^a

^aInstitute of Atomic Physics, Bucharest, Romania

^bInstitut für Theoretische Physik der Universität, Frankfurt am Main, F.R.Germany

The first prediction of the halflives relative to spontaneous cluster emission from nuclei had been made within analytical variant of the supersymmetric fission model (ASAFM). Since 1980 it was frequently used in a systematic search for new decay modes.

The experimental results obtained until now [1,2,3,4] (^{14}C emission from $^{222-224,226}\text{Ra}$; ^{24}Ne emission from ^{230}Th , ^{231}Pa , $^{232,233}\text{U}$; Ne and ^{28}Mg emission from ^{234}U ; ^{28}Mg emission from ^{236}Pu ; Mg and ^{32}Si emission from ^{238}Pu) are in good agreement with the theory [5].

The atomic masses of the three partners (parent, daughter and emitted nuclei), allowing to calculate the released energy, are important input quantities of the model. The computed halflife is very sensitive to any error affecting these masses. Consequently we prefer the measured masses or those obtained from systematics (Wapstra et al. 1988) whenever available.

New mass tables have been published recently [6]. We took eight of them (Comay et al., Jänecke and Masson, Masson and Jänecke, Möller and Nix, Möller et al., Satpathy and Nayak, Spanier and Johansson, Tachibana et al.) in order to estimate cluster emission rates for parent nuclei far off the β stability and for superheavies [7].

In spite of the mass differences from table to table, one can draw some reliable conclusions concerning cluster emission rates in three regions of nuclides.

Measurable branching ratios relative to α -decay could be found not only around the line of β stability, but also on the neutron deficient side, where ^{12}C , ^{16}O , ^{28}Si and other cluster radioactivities of some Ba ($A = 114-116$), Ce ($A = 118-125$), Sm ($A = 127, 128$), isotopes, respectively, have a chance to be detected.

Cluster emission from superheavies cannot explain why these nuclei have not been found. Nevertheless, around $Z = 110$, $N = 176$, there should be an island of ^{78}Ni emission with the corresponding daughter ^{208}Pb . Also some ^8Be and $^{12,14}\text{C}$ emissions are expected from neutron deficient superheavy nuclei.

Neutron rich parents with $Z = 58-78$ are stable to α -decay, but they could emit fragments with high neutron excess.

The lifetime of various isotopes of a given element decreases with the "distance" from the β stability line (when the neutron number decreases in the proton rich region, or when it increases in the neutron rich region), but in the same direction the competition of other decay modes become stronger.

NEUTRON DIFFRACTION ON LIQUID HEAVY WATER AT
VARIOUS TEMPERATURES

S.N.Rapeanu, I.Padureanu, M.Ion, Zh.A.Kozlov^{*)}

Institute for Physics and Nuclear Engineering, Bucharest

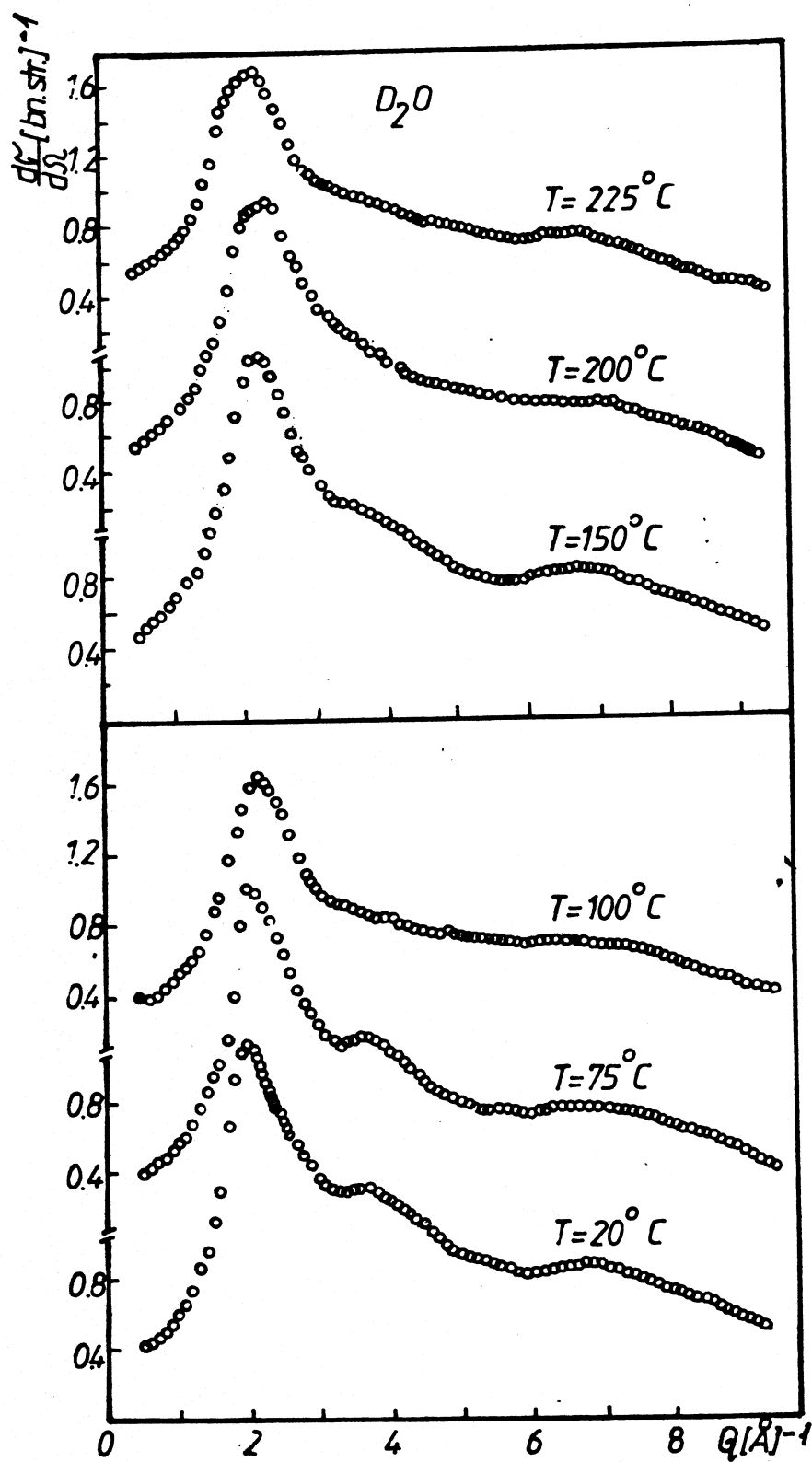
ROMANIA

^{*)} Joint Institute of Nuclear Research, Dubna, USSR

The neutron diffraction measurements on Liquid D_2O have been extended up to $225^\circ C$. The measurements were performed on a neutron diffractometer set-up at the VVR-S reactor, IPNE-Bucharest. The sample of D_2O with 99.85 per cent concentration consisted of seven quartz tubes, each having an inner diameter of 2.5 mm. Each tube was filled up with D_2O in such a manner that it was in liquid state from $20^\circ C$ up to $225^\circ C$. The incident neutron wave-length of 1.158 \AA allowed to perform measurements in the range of the wave vector transfer up to 9.5 \AA^{-1} . The results were processed in order to get the differential cross section, $d\sigma/d\Omega$ in units of barn sterad.⁻¹ in the usual manner including the correction for container scattering, self - attenuation and multiple scattering. The analytical corrections for incoherent scattering and inelasticity effects have also been calculated. The calculated multiple scattering did not exceed 15 per cent. The differential cross section as a function of momentum transfer, obtained after applying the experimental corrections, is plotted in the figure below.

A systematic change of the scattering spectra is observed. The main features of the curves are the single main diffraction peak located around 2 \AA^{-1} , the shoulder in the range $2.25 \div 4.5 \text{ \AA}^{-1}$ and a large maximum at $(6 \div 9 \text{ \AA}^{-1})$. The most obvious effect is the shift of the position of the main diffraction peak $Q_0(T)$ at higher Q values as the temperature is increased. In the temperature range up to $225^\circ C$, a significant rearrangement of the molecular structure is observed. In addition, a changing of the molecular parameters was observed and there is an evidence for the braking of hydrogen bonds [1].

We hope that the molecular structure factor, $S_M(Q)$, the structure function, $D_M(Q)$, the fullpair correlation function, $G(r)$ and pair correlation function, $g(r)$ for liquid heavy water will give an important information about the complex modifications with the increasing temperature in this molecular liquid.



- [1] S.N.Rapeanu, I.Padureanu, M.Ion, Zh.A.Kozlov, Rev.Roum., 35 185-195 (1990).

sulted from the impact of the trajectories with a vertical plane $80 \times 90 \text{ cm}^2$ which contains the target in the centre. From this figure can be seen that none of the trajectories intersect the target. Thus it was established an upper limit for the pion emission in ^{235}U fission $\Gamma_{\pi}/\Gamma_f < 5 \cdot 10^{-11}$.

REFERENCES

1. D.B.Ion et al, Ann.of Phys. (N.J.) 171, 237 (1986)
2. M.Ivascu et al, Rev.Roum.Phys. 33, 105 (1988)
3. D.Bucurescu et al, IPNE NP-58, 1987
4. M.Petrascu et al, St.Cerc.Fiz. 38, 694 (1986).

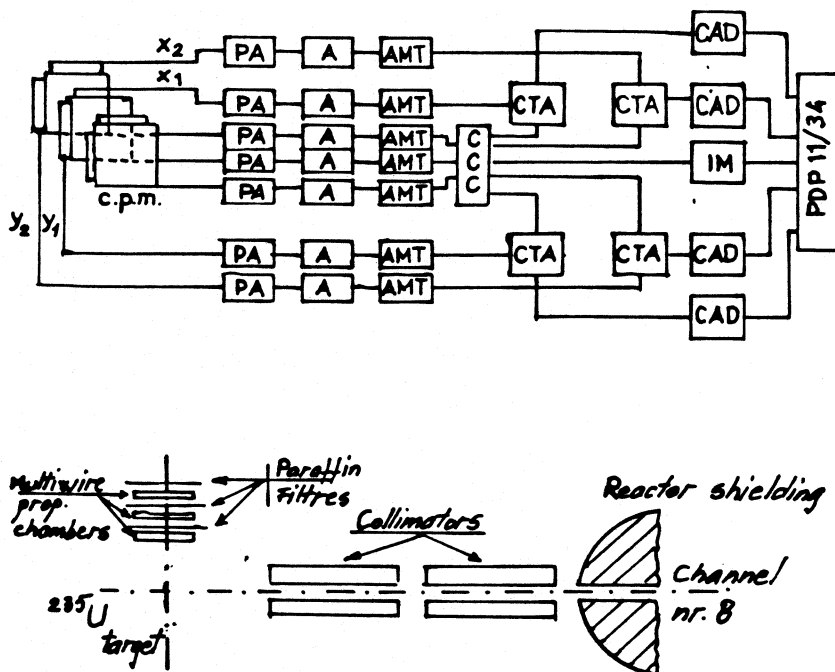


FIG. 1

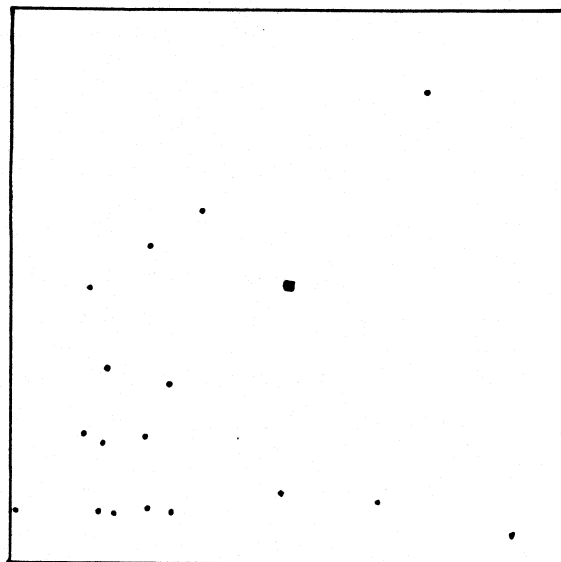
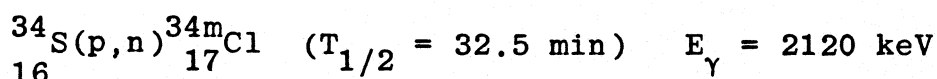


FIG. 2

S and P DETERMINATION USING ACTIVATION METHOD AT THE
IPNE CYCLOTRON

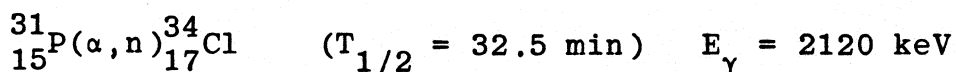
B.Constantinescu, G.Pascovici and D.Plostinaru
Institute for Physics and Nuclear Engineering, Bucharest

We have developed a nuclear nondestructive method of S and P analysis in polymers, which use proton and alpha-particle activation. So, for S we have used the reaction :



A 100 nA 14 MeV proton beam was used for in air irradiation (10-15 min) through a 100 μ Al foil. The samples (various polymers) were measured 15 min after the end of irradiation using a 70 cm³ Ge(Li) detector in a lead shielded area. Ammonium sulphide (NH₄)₂SO₄ mixed with polyethylene standards were used. The sensitivity for polymers is about 30 ppm.

For P we have used the reaction :



in the same irradiation (100 nA 22 MeV alpha particle beam) and measurement conditions. Triphenylphosphine (C₁₈H₁₅P) mixed with polyethylene standards were used. The sensitivity is about 5 ppm.