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COMMENTS ON THE U.S. PROGRESS IN MAKING MEASUREMENTS RECOMMENDED BY THE BRUSSELS PANEL ON STANDARDS

This paper lists the recommendations resulting from the May 8-12, 1967, IAEA sponsored Brussels Panel on Standards, along with remarks giving U.S. implementation on the requested measurements.

1. Neutron Flux Determination	Remarks
a) Improved techniques should be developed so that the H(n,n) cross section can be used to obtain the neutron flux to the following accuracy: Energy range 100 keV - 2 MeV $\pm$ 0.5-1.0% " " 2 MeV - 5 MeV $\pm$ 1.0% " " 5 MeV -15 MeV $\pm$ 2.0%	Nothing being done.
b) Knowledge of the differential cross section for hydrogen should be improved in step with the improved techniques and the ratio $\sigma nn(180^{o})/\sigma nn/4\pi)$ should be obtained at all energies > 5 MeV to $\pm$ 1%.	See Section 3.
c) The branching ratio of ^{7}Be should be determined to $\pm$ 0.5% or better so that flux measurements accurate to better than $\pm$ 1% can be made.	Dr. A. B. Smith of ANL has data on hand (results thought to be good to $\pm$ 1%).
d) The spectra of radioactive photoneutron sources should be investigated by both experiment and calculation.	Has been work on levels in antimony which indicates a low lying level at 37 keV instead of a level thought to exist at 18 keV. Monte Carlo calculations to predict the Sb Be spectra are dependent on the 18 keV level but not the 37 keV level.

(1. continued)

e) New measurements to an accuracy of $\pm$ .2% of the ratio (σ_{Mn}/σ_H) at thermal neutron energy should be undertaken.

There is a paper circulating around ANL which indicates that the lack of control of the PH value of the solution is reason for not obtaining an accuracy of $\pm$ 0.2% for the ratio of (σ_{Mn}/σ_H) for thermal neutrons. This paper is being circulated by Dr. de Volpi of ANL.

f) In order to reduce effect of Coulomb scattering targets should be developed in which the tritium is absorbed in thin layers of material, for instance about 100 $\mu g/cm^2$ of Ti or preferably 30 $\mu g/cm^2$ of ^6Li.

Nothing being done.

g) Further development of the associated particle counting technique is encouraged and in particular there is need for improvement in the knowledge of
   i) the distribution of tritium and deuterium in targets
   ii) the stopping power in target materials for low energy d, α, ^3He particles
   iii) Coulomb scattering in target materials.

Nothing being done.

h) It is recommended that the multiple scattering corrections for B plug detectors and ^6Li and ^{10}B loaded glass scintillators should be more carefully investigated by Monte Carlo techniques or other methods.

Work on the chemical composition, homogeneity, and isotopic analysis of the standard boric acid distribute by NES (known as Argonne II) is being carried out under the supervision of Drs. J. L. Hague and W. R. Shields. In addition work is being done on a new standard boron glass, the glass disks made a number of years ago having been found to have too great variability in boron content from disk to disk. A third effort in the area of boron chemistry is the determination of the composition of the small glass beads being developed in the NBS Reactor Radiation Division for fluence measurements in nuclear reactors. Once assay has been determined for a boron loaded glass several codes exist (05R at ORNL for one) for carrying out multiple scattering corrections.

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2. Standard Material and Foils for Neutron Measurement	Remarks
Investigation not completed.	
3. Neutron Standard Cross Sections	
$^{3}He(n,p)$	
a) To verify the $^{3}He(n,p)$ cross section inferred from $^{3}H(p,n)$ by direct measurements at a few discrete energies.	Nothing being done.
$^{10}B(n,\alpha)$ and $^{6}Li(n,\alpha)$	
a) Up to 100 keV more measurements of the absorption and elastic cross sections and the angular distributions are needed to bring the $^{10}B(n,\alpha)$ cross section to an accuracy of 1%.	
b) Measurements of the cross section $^{10}B(n,\alpha)$, the branching ratio $(n,\alpha_o)/(n,\alpha\gamma)$, and the angular distribution in the energy region from 100 keV to 1 MeV are required to achieve 5 percent accuracy in flux measurement by γ ray detection.	Work covering a large part of requirements b) and c) have been finished by Macklin and Gibbons of ORNL. The work is contained in Phys. Rev., Vol. 165, 1147 (1968). Article title is "The Study of $B^{10}(n,\alpha)Li^{7}$ Li^{7*} for En between 30 and 500 keV." Recent preliminary work by Dr. I. L. Morgan of the Texas Nuclear Corp. on the $B^{10}(n,\alpha\gamma)Li^{7}$ reaction is 40-50% larger than those obtained by Macklin and Gibbons from the inverse reaction and the α_o/α_1 ratios. Work by Dr. Morgan is continuing and Gulf General Atomic also is planning to measure the $(n_{\alpha o}/n\alpha\gamma)$ ratio.
c) Measurements of the inverse reaction $^{7}Li(\alpha,n)$ are recommended as a possible check of the $^{10}B(n,\alpha)$ cross section.	

(3. continued)

d) Between thermal and 100 keV, a 1% accuracy on the $^{6}Li(n,\alpha)$ cross section is desirable. It is suggested that new measurements of the total and elastic scattering cross sections be made and also measurements of the $^{6}Li(n,\alpha)/^{10}B(n,\alpha)$ ratio.	Work being carried out by H. Newson of Duke University and C. Hibdon of ANL on $Li^{6}(n,\alpha)$. Dr. R. Block will be making σ_t measurements on Li^{6} and Li^{7} in about two months. The metal samples are being prepared at ORNL for the RPI work. Also see e) below.
e) Further measurements of $^{6}Li(n,\alpha)$ cross section to 5% accuracy should be made using either the ^{235}U fission cross section or H(n,n) as a standard particularly in the energy region above 100 keV.	ORNL has long range plans to carry out this measurement. Dr. A. B. Smith is presently working on the Li^{6}/U^{235}, B^{10}/U^{235} and will obtain the $Li^{6}(n,\alpha)/B^{10}(n,\alpha)$ ratio. Results expected to be published in six or seven months.
$^{1}H(n,n)$	
a) New relative differential measurements between 5 and 20 MeV with $\pm$ 1% relative error are required.	Nothing being done.
b) New phase shift analysis calculations which are consistent with the newer total cross section data with $\pm$ 0.2% accuracy between 100 keV and 5 MeV are required.	Phase shifts were calculated from existing data by Dr. John C. Hopkins. The anisotropy is larger than previously reported. The results are contained in LASL document (LADC 8878). The title of the report is "A Calculation of the $^{1}H(n,n)$ differential cross section in the energy range 1 to 20 MeV. The anisotropy at 5 MeV is approximately 3%; the results in the paper are extremely important as they affect certain detector efficiency calculations.
C(n,n)	
a) Present data on C(n,n) are not good enough for use as a standard and further work is recommended.	The conclusions given by the Brussels document are in error here. Dr. A. B. Smith has σ_t data up to 1.5 MeV. Angular distribution data taken at

(C(n,n) continued)

	selected energies above 800 keV at ANL show distributions which are not symmetric about 90° in the C. M. system (also probably not under 800 keV). NBS also has very preliminary σ_t data.
$^{197}Au(n,\gamma)$	
a) The earlier activation measurements should be disregarded in future evaluations, and further measurements are required to resolve discrepancies in the intermediate energy range.	The Lockheed Palo Alto Research Laboratory is continuing their experiments on the $^{197}Au(n,\gamma)^{198}Au$ activation cross section.
b) The present status of the gold (n,γ) cross section indicates that it may be well worthwhile to look for structure in the energy region from 1 to 100 keV.	When the ORELA gets into operation, this measurement will be undertaken.
$^{235}U(n,f)$ and $^{239}Pu(n,f)$	
Above 10 keV further fission cross section measurements of ^{235}U and ^{239}Pu are required over the whole energy range to obtain 1% accuracy. A few spot measurements are required, together with accurate measurements of the shape of the cross section curves.	Measurements being made by A. B. Smith in the energy region from 30 keV to 1.5 MeV. These cross sections are also fallout of ORNL α measurements. Dr. Smith gets differences between his preliminary data and existing data.
Threshold Reactions	
a) $^{27}Al(n,\alpha)^{24}Na$ Since only one set of measurements has been made in the 8-13 MeV energy region, further work is desirable.	Nothing being done.
b) $^{32}S(n,p)$ New measurements are desirable from threshold to 15 MeV with a 5% accuracy.	Nothing being done.

(3. continued)

4. $\bar{\nu}^{252}Cf$

Further measurements on ^{252}Cf fission neutron spectrum and delayed neutron and γ contributions are desirable in order to meet the 0.25% accuracy asked for in the request lists.	Probably O.K. according to private communication from A. B. Smith (de Volpi of ANL has worked on this problem).