Now $x_2'(\tau^-) \neq 0$ but $x_2'(\tau+) = 0$. This implies that

$$\Delta\phi = \phi(\tau+) - \phi(\tau^-) \neq 0$$

which in turn implies that $\Delta x_1' = x_1'(\tau+) - x_1'(\tau^-) \neq 0$.

The authors state that since $x_2'(\tau+) = 0$, the Hamiltonian $H = p_1 x_1' + p_2 x_2'$ is unaffected by p_2 and conclude that $\Delta H = H(\tau+) - H(\tau^-) \neq 0$ which is a contraction. This statement is not completely correct and the reasoning at this point should be as follows:

$$\Delta H = p_1(\tau)\,\Delta x_1' - p_2(\tau^-)\,x_2'(\tau^-) \quad .$$

From Eqs. (9) and (10)[1]

$$\Delta x_1' = -\gamma_1 \Delta\phi = \frac{\gamma_1 x_2'(\tau^-)}{\sigma_2 x_2(\tau^-) - \gamma_2} \quad .$$

So $$\Delta H = x_2'(\tau^-)\left[\frac{\gamma_1 p_1(\tau)}{\sigma_2 x_2(\tau^-) - \gamma_2} - p_2(\tau^-)\right]$$

and the condition for $\Delta H = 0$ is

$$p_2(\tau^-) = \frac{\gamma_1 p_1(\tau)}{\sigma_2 x_2(\tau^-) - \gamma_2} \quad .$$

Comparing this[1] with Eq. (24) we see that this is precisely the condition for B to be a switch point in the unrestricted space. This contradicts the earlier assumption and helps in the justification of the final conclusions of the paper.

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Remarks With Regard to an Article by Tassan

S. Tassan has recently published results of thermal-neutron spectrum measurements employing ^{176}Lu : ^{164}Dy and ^{176}Lu : ^{175}Lu activation ratios[1]. Concerning this article I would like to make the following remarks:

The usefulness of the article does not lie in the fact that it brings much new information on methods for measuring thermal-neutron-lattice spectra, but rather in the fact that it supports, to some extent, results and conclusions arrived at in a Technical Note published earlier in this journal[2].

The use of ^{164}Dy (combined with ^{176}Lu), and its advantage over other thermal-detector materials that have a higher resonance integral relative to their thermal cross sections, was already suggested in a 1964 Geneva Paper[3]. In the same year an experimental method for determining intracell thermal-spectrum distributions was described in detail by Smit[4]. It surpasses Tassan's method in that it also gives information on the spectrum's spatial variation inside fuel and moderator and not only averaged values for these regions, and thereby provides better material for a test of THERMOS-like codes.

It may very well be that the two latter publications were not known by Tassan at the time he wrote his article. However, in the period when he revised it (Revised March 1, 1966) the above-mentioned Technical Note appeared (January 1966) where reference was made to them. It surprises me that this has escaped both his attention and the editors', and that the article was published at all.

In the Technical Note the comparison between theory and experiment was pushed farther than in the article because, besides the Nelkin model, two other scattering models were tested. This led to accepting the improved Nelkin model, due to Koppel and Young (KY)[5], as the best of the three. This implies that if Tassan had compared his results with better THERMOS calculations using the KY model, the agreement would, on the average, have been better in the moderator but worse in the fuel.

Tassan noticed an approximately three times larger separation between calculated than between measured fuel and moderator ratios. A much weaker difference may be observed in some of the results of Smit and Stamm'ler (SS)[2] and in my opinion this large discrepancy should be mainly ascribed to uncorrected experimental errors. First, the presence of aluminum in the fuel introduces streaming effects that tend to soften the spectrum. Therefore its use should be minimized and copper catcher foils should be applied instead of aluminum. Even they will cause a disturbance and so will the remaining aluminum present in the Lu-Al and Dy-Al foils. Second, the presence of the foils in the moderator will cause a local spectrum hardening. In that respect Tassan's lutetium foils may have had more influence than the foils used by SS where the lutetium concentration was $2\frac{1}{2}$ times lower.

In connection with this kind of measurement it might be useful to draw the attention to two recent publications where improvements of Smit's method are presented as well as more experimental results and their analysis[6,7]. Although on the whole these results compare better with calculational methods than Tassan's, the agreement is not yet wholly satisfactory. A point that deserves closer investigation in this respect is the spectrum in the thermal column which has been assumed to be Maxwellian with the same temperature as that of the column.

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[1] S. TASSAN, "Thermal Spectrum Measurements in Slightly Enriched Uranium, Light-Water-Moderated Lattices by the Lutetium Activation Method," *Nucl. Sci. Eng.*, **26**, 271 (1966).

[2] J. SMIT and R. J. J. STAMM'LER, "On the Variation of the Lu: Dy Activation Ratio in Reactor Cells," *Nucl. Sci. Eng.*, **24**, 90 (1966).

[3] E. ANDERSEN et al., "Experimental and Theoretical Studies of Uranium Oxide Lattices Moderated by Mixtures of Light and Heavy Water," *Proc. 3rd Intern. Conf. Peaceful Uses At. Energy, Geneva*, III, 197 (1964).

[4] J. SMIT, "Analysis of Neutron Sepctra in UO_2 Lattices Moderated by Mixtures of Light and Heavy Water," KR-87, Kjeller, Norway (1964).

[5] J. U. KOPPEL and J. A. YOUNG, "Neutron Scattering by Water Taking into Account the Anisotropy of the Molecular Vibrations," *Nucl. Sci. Eng.*, **19**, 412 (1964).

[6] J. SMIT, "Measurement of the Spatial Variation of the Thermal Neutron Energy Spectrum in Reactor Cells," KR-103, Kjeller, Norway (1966).

[7] R. J. J. STAMM'LER, S. M. TAKAČ, and Z. J. WEISS, *"Neutron Thermalization in Reactor Lattice Cells: An NPY-Project Report,"* pp 82-84, 117, 121, Series No. 68, International Atomic Energy Agency, Vienna (1966).

Answer to Mr. Stamm'ler's Comments on Article on Thermal Spectrum Measurements

The remarks by R. J. J. Stamm'ler to my article[1] deserve some comment and explanation.

[1] S. TASSAN, *Nucl. Sci. Eng.*, **26**, 271 (1966).

The experimental work described in the article was performed at Brookhaven National Laboratory (BNL) in the Summer of 1961, shortly after the ^{164}Dy thermal-neutron activation cross section had been measured at the same laboratory[2], which made evident the advantage in the use of ^{164}Dy as the thermal-neutron flux detector for normalization of the ^{176}Lu activation. This was very likely the first use of the detector-pair Lu-Dy for thermal-neutron spectrum investigations. Due to various reasons, the experimental part of the article was written in early 1964, while the THERMOS calculation was not performed by H. Honeck until 1965.

At the time when the article was revised, the publication of the Technical Note by J. Smit and R. J. J. Stamm'ler[3] was known to me and, obviously, to the Editor of *Nuclear Science and Engineering*. I did not feel obliged to modify the text of my article to include a reference to such interesting work, since the two experiments had been carried out independently, and were in fact different applications of a rather obvious choice; i.e. the use of a detector with a low value for the ratio "resonance integral/thermal cross section" to normalize the Lu activation rate. In particular, my article[1] was concerned with the study of thermal-neutron spectrum variations in the fuel and in the moderator in a light-water-moderated lattice, as a function of the moderator-to-fuel volume ratio in the range from 1:1 to 4:1, while Smit and Stamm'ler[3] considered essentially moderator composition and temperature effects in a lattice with a moderator-to-fuel volume ratio of about 4:1.

The differential technique reported by Smit and Stamm'ler yields indeed more detailed information than the integral technique described by Tassan[1]. I do not believe, however, that this represents any basic improvement of the method, since both integral and differential techniques have been used for similar types of measurements over quite a number of years. In this respect, therefore, several well-known techniques may be chosen in association with the use of the Lu-Dy detector-pair, depending on the utilization of the data, the equipment actually available, etc.

Incidentally, S. Guardini and S. Tassan have recently tested satisfactorily the use of 2-mm-diam low-density Lu-Dy detector pairs for the determination of the fine structure of the thermal-neutron spectrum index variation across clustered fuel elements ("Ispra Internal Report," 1966); clearly this procedure presents some advantage over the technique described by Smit and Stamm'ler, since, for instance, it makes practically negligible the perturbation effects caused by the detectors themselves, but again the idea is obvious; the point is just to test the fact that one obtains, by careful work, experimental accuracies adequate for the further use of the data. Actually, it might well be that this procedure had been already adopted by others: I am not informed of it, but believe that the matter is of little importance.

As far as the discrepancy between measured and calculated values is concerned, it seems to me that the discrepancy in the data of Ref. 1, although being larger than that in the data of Ref. 3, has essentially a comparable order of magnitude.

It is certainly possible to ascribe the discrepancy observed in the data of Ref. 1 to experimental errors (as may be done in general for any experiment), but the arguments brought by R. J. J. Stamm'ler are in my opinion not quite pertinent, in the sense that they also apply to the work in Ref. 3; in particular, the neutron-streaming effect through the 0.001 + 0.001-in.-thick aluminum catchers covering the 0.005-in.-thick Lu-Al foil is less important than the same effect through the Lu-Al foil itself (and this effect is probably the same for the setup used in Ref. 3).

Also, the lutetium content of the Lu-Al foils used in Ref. 1 was nominally 4% (and not 10% as erroneously indicated in the text of the article), that is, the same as that of the detectors used in Ref. 3. The flux-hardening effect in the moderator was then comparable in the two cases.

Evidently there is still room for appreciable refinement both in the experimental techniques and in the methods for the analysis of the data of thermal spectrum index measurements (and not only using Lu-Dy detector-pairs), and a considerable amount of work in this line is being carried out at several laboratories, besides that quoted in Refs. 6 and 7 of Ref. 3.

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[2] R. SHER, S. TASSAN, E. WEINSTOCK, and A. HELLSTEN, *Nucl. Sci. Eng.*, **11**, 369 (1961).
[3] J. SMIT and R. J. J. STAMM'LER, *Nucl. Sci. Eng.*, **24**, 90 (1966).

Corrigenda

S. PEARLSTEIN and R. F. MILLIGAN, "Thermal Cross Section and Resonance Integrals of Cadmium-114," *Nucl. Sci. Eng.*, **26**, 281 (1966).

The authors request correction of the first entry of the first column of Table I of their manuscript. The uncertainty is ± 0.015 so the entry should read 0.300 ± 0.015 (barns).

M. M. R. WILLIAMS, "The Thermal-Neutron Milne Problem with a Two-Term Degenerate Kernel," *Nucl. Sci. Eng.*, **27**, 511 (1967).

The definition of η_{ij} in Appendix I, p. 518, should read

$$\eta_{ij} = \int_0^\infty M(E)\, \Sigma_i(E)\, \Sigma_j(E)\, \chi[u - \Sigma_0(E)]dE ,$$

where $\chi(u) = 1$ for $u > 0$, and zero for $u < 0$.

The η_{ij} are now functions of u and thus the value of the square bracket is

$$[\,] = \frac{1}{2} \int_0^{t_{max}} \frac{[a_{01}\, \eta_{01}(t) + a_{11}\, \eta_{11}(t)]\, t\, \tau - (1/t)\, dt}{(1 + St)\,[\mu + t\, \Sigma_0(E)]} .$$

In the text, this correction implies that all η_{ij} are to be included in the integrands of the kernels K, K^*, K^{**}, R^*, and R^{**} as the case may be.

The author is indebted to Dr. Jacek Arkuszewski, whose recent paper, *Nucl. Sci. Eng.*, **27**, 104 (1967) illustrates this point.