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On the thermal flux distribution in a hollow spherical nuclear reactor (**)

1 - Introduction

In [1] we have studied the nuclear behaviour of a new spherical nuclear reactor, bare or reflected outside the core, which has an inner cavity. The idea of such a reactor rose in order to approximate more and more the behaviour of the infinite slab as the radius of the cavity increases; in fact, it is well known that, in the absence of the reflector, the ratio $\gamma =$ maximum flux/average flux is maximum ($\gamma = 0.637$) for the infinite plane slab and it is equal to 0.304 only for the sphere. Moreover in [1] we wanted to realize a reactor characterized by an uniform distribution of the fuel elements, which were disposed in radial direction. Such a situation undoubtedly presents some constructive difficulties even if it is surely possible to solve the relative technical problems somehow, so much so that a solution is suggested in [1].

In the present note, also with a view to having fewer constructive difficulties, we consider a hollow spherical reactor, that be the envelope of the fuel elements disposed now vertically on a grid plate having the shape of an amphitheatre such as to envelop the lower half-sphere (of radius R), that delimitates the core; the fuel elements have a cylindrical shape and a variable height in such a way as to envelop the two spheres (whose radii are R_0 and R, $R_0 < R$) that delimitate the core, thus the central zone of some of them must be empty; for example, the fuel element in the center of the reactor is empty in the zone

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with $r < R_0$ and has its active part in the two zones with $r \in (R_0, R)$, r being the radial distance. However the grid plate can be an usual one, if all the fuel claddings have the same height and the fuel is disposed in them as we have already said.

The high values of γ, we can obtain also in these reactors, allow us to have a good homogeneity for the working of the fuel elements.

Moreover we consider the inner cavity always filled with reflector material, that on the contrary is absent in [**1**]; an outer reflector may be in the zone with $r \in [R, R+T]$. We study the nuclear behaviour of the reactor also when both the reflector and the moderator (always of the same material) change: H_2O, graphite, $D_2O + 0.16\,\%\,H_2O$ and D_2O are considered.

The values of γ, we have obtained, are greater than those derived in [**1**], but now the critical radius R increases in comparison with the cases examined in [**1**].

With a view to giving a first idea on the nuclear behaviour of this new reactor, we consider the reactor homogeneous and thermal. On the other hand, the presence of three different zones in the reactor surely does not simplify the problem; see to this purpose Boffi and Premuda's work [**2**] relative to a conventional spherical reactor.

2 - Determination of the neutron flux distribution

2(a). *Fundamental relations.* – Let the reactor core have the geometrical shape of a spherical bark, delimitated by two spheres of radii R_0 and R (with $0 < R_0 < R$) and surrounded by reflector material both inside and outside. We suppose that the inner reflector fills the whole spherical cavity, while the outer one has the shape of a spherical bark of thickness T, that includes the extrapolated distance of the reflector; moreover we suppose that the two reflectors and the moderator are made of the same material.

Denoting by Φ_0, Φ and Φ_1 the neutron flux in the inner reflector, in the core and in the outer reflector respectively, and considering the neutron diffusion equation relative to the steady-state of the reactor supposed homogeneous and thermal, we have the following three equations (see [**3**], [**5**], [**4**])

$$\Delta^2\Phi + B^2\Phi = 0 \qquad \text{when } r \in [R_0, R]\,, \tag{2.1}$$

and

$$\Delta^2\Phi_i - k^2\Phi_i = 0 \qquad \text{with } i = \begin{matrix} 0 & \text{when } r \in [0, R_0]\,, \\ 1 & \text{when } r \in [R, R+T]\,, \end{matrix} \tag{2.2}$$

where B^2 is the buckling of the critical reactor, r is the distance from the center of the reactor and

$$k = 1/L_r \tag{2.3}$$

is the inverse of the thermal diffusion length of the reflector.

Solving (2.1) and (2.2) in the same fashion as was done in [1] (1), we get the following solutions

$$\Phi(r) = \frac{1}{r}\left[A_1 \sin(Br) + A_2 \cos(Br)\right], \tag{2.4}$$

and

$$\Phi_i(r) = \frac{1}{r}\left(a_i \exp[kr] + b_i \exp[-kr]\right) \qquad (i = 0, 1). \tag{2.5}$$

First of all we observe that the neutron flux must not become infinite in the center of the reactor, and then in the expression of $\Phi_0(r)$ we must have

$$b_0 = -a_0 \neq 0, \tag{2.6}$$

hence it follows that

$$\lim_{r \to 0} \Phi_0(r) = 2a_0 k, \tag{2.7}$$

therefore, being $\Phi_0(r)$ a continuous function of r, we have also

$$\Phi_0(0) = 2a_0 k. \tag{2.8}$$

Moreover, putting

$$C_0 = \frac{\Phi_0(0)}{k} \qquad (C_0 > 0), \tag{2.9}$$

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(1) We recall that (2.1), as well as (2.2), in spherical coordinates becomes

$$\frac{d^2\Phi}{dr^2} + \frac{2}{r}\frac{d\Phi}{dr} + B^2\Phi = 0.$$

(2.5) with $i = 0$ can now be written in the following form

$$\Phi_0(r) = \frac{C_0}{r} \sinh(kr)\,, \qquad r \in (0, R_0]\,. \tag{2.10}$$

It is interesting to note that $\Phi_0(0) \neq 0$, whatever the value of R_0 may be.

The relation (2.5), also when $i = 1$, can assume a form like (2.10). In fact, from the boundary condition that the neutron flux reach zero at the extrapolated distance of the outer reflector, i.e.

$$\Phi_1(R + T) = 0\,, \tag{2.11}$$

we obtain that

$$b_1 = -\, a_1 \exp[2k(R + T)]\,; \tag{2.12}$$

hence, putting

$$C_1 = -\, 2a_1 \exp[k(R + T)] \geqslant 0 \qquad (C_1 = 0 \Leftrightarrow T = 0)\,, \tag{2.13}$$

we get at last

$$\Phi_1(r) = \frac{C_1}{r} \sinh[k(R + T - r)]\,, \qquad r \in [R, R + T]\,. \tag{2.14}$$

2(b) *The critical equation.* – Now we must lay the other boundary conditions relating to the surfaces between the different zones of the reactor; they are the continuity of the flux and the neutron current density at the interfaces, i.e.

$$\begin{aligned} \Phi(R_0) &= \Phi_0(R_0) \qquad \text{and} \qquad D\left[\frac{d\Phi}{dr}\right]_{r=R_0} = D_0\left[\frac{d\Phi_0}{dr}\right]_{r=R_0}\,, \\ \Phi(R) &= \Phi_1(R_0) \qquad \text{and} \qquad D\left[\frac{d\Phi}{dr}\right]_{r=R} = D_1\left[\frac{d\Phi_1}{dr}\right]_{r=R}\,. \end{aligned} \tag{2.15}$$

In these, recalling that the moderator and the two reflectors are made of the same material, the diffusion coefficients D, D_0, D_1 are equal (see on page 125 of [**3**]); thus, with some calculi, from (2.15) we get the following system

$$
(2.16)\qquad
\begin{aligned}
&A_1 \sin(BR_0) + A_2 \cos(BR_0) - C_0 \sinh(kR_0) &&= 0\,,\\
&A_1 B \cos(BR_0) - A_2 B \sin(BR_0) - C_0 k \cosh(kR_0) &&= 0\,,\\
&A_1 \sin(BR) + A_2 B \cos(BR) - C_1 \sinh(kT) &&= 0\,,\\
&A_1 B \cos(BR) - A_2 B \sin(BR) + C_1 k \cosh(kT) &&= 0\,,
\end{aligned}
$$

linear and homogeneous in the unknowns A_1, A_2, C_0 and C_1. These quantities cannot be zero, therefore the determinant of their coefficients must be zero. This condition gives the critical equation of the reactor, that can be put in the form

$$
(2.17)\qquad [B^2 \tanh(kR_0)\tanh(kT) - k^2]\sin[B(R-R_0)] = \\ = kB[\tanh(BR_0) + \tanh(kT)]\cos[B(R-R_0)]\,,
$$

which, observing that we cannot have in it

$$
(2.18)\qquad \sin[B(R-R_0)] = 0
$$

for the right-hand side cannot vanish simultaneously (being at least $R_0 \neq 0$), assumes the simpler form

$$
(2.19)\qquad \cot[B(R-R_0)] = \frac{1}{kB}\,\frac{B^2\tanh(kR_0)\tanh(kT) - k^2}{\tanh(kR_0) + \tanh(kT)}\,.
$$

From this equation we can deduce the critical dimension R of the reactor in terms of the other quantities in (2.19); thus we get

$$
(2.20)\qquad R = R_0 + \frac{1}{B}\cot^{-1}\Big[\frac{1}{kB}\,\frac{B^2\tanh(kR_0)\tanh(kT) - k^2}{\tanh(kR_0) + \tanh(kT)}\Big] + \frac{n\pi}{B}\,,
$$

where n is an integer number such that the neutron flux is positive in the core, i.e. for any $r \in [R_0, R)$. On the other hand it is easy to verify that $\Phi(r)$, which, on the ground of (2.4) and $(2.16)_{1,2}$, may be written in the form

$$
(2.21)\qquad \Phi(r) = \frac{C_0}{Br}\{k\cosh(kR_0)\sin[B(r-R_0)] + B\sinh(kR_0)\cos[B(r-R_0)]\}\,,
$$

vanishes at

$$\bar{r} = R_0 + \frac{1}{B} \cot^{-1} [- \frac{k}{B \tanh (kR_0)}] + \frac{m\pi}{B} , \tag{2.22}$$

where m is integer.

This relation coincides with the expression (2.20) of R when $T = 0$, i.e. in the absence of the outer reflector. We observe now that R decreases as T increases, thus, when $T \neq 0$, the first value of $\bar{r}$ (for $m = 0$) is greater than the value of R given by (2.20) with $n = 0$; moreover we cannot have $n > 0$ in (2.20), for otherwise R would be greater than the first value of $\bar{r}$ and this would cause the neutron flux to become zero and then negative within the core. Thus we can state that in (2.20) we have

$$n = 0 . \tag{2.23}$$

It is very interesting to consider the following limits

$$\lim_{R_0 \to +\infty} (R - R_0) = \frac{1}{B} \cot^{-1} [\frac{1}{kB} \frac{B^2 \tanh (kT) - k^2}{1 + \tanh (kT)}] , \tag{2.24}$$

$$\lim_{T \to +\infty} R = R_0 + \frac{1}{B} \cot^{-1} [\frac{1}{kB} \frac{B^2 \tanh (kR_0) - k^2}{\tanh (kR_0) + 1}] , \tag{2.25}$$

that characterize two situations which happen in practice when the values of R_0 and T are high enough to can assume respectively

$$\tanh (kR_0) \cong 1 \qquad \text{and} \qquad \tanh (kT) \cong 1 , \tag{2.26}$$

that is when R_0, $T = 2 \div 3 L_r$.

If the values of R_0 and T are such that (2.26) hold simultaneously, then the situation expressed by the following limit

$$\lim_{\substack{R_0 \to +\infty \\ T \to +\infty}} (R - R_0) = \frac{1}{B} \cot^{-1} [\frac{B^2 - k^2}{2kB}] \tag{2.27}$$

occurs.

We note, at last, that it is easy to verify both that the thickness of the core $R - R_0$ decreases as R_0 increases and that R decreases if T increases, when we hold the other parameters in (2.19) fixed.

2(c). *Some remarks about the flux distributions.* – Whatever the value of R_0 may be, from (2.9) and (2.10) it follows that

$$\Phi_0(0) \neq 0 \qquad \text{and} \qquad \Phi_0'(0) = 0 \; ; \tag{2.28}$$

moreover $\Phi_0(r)$, being

$$\Phi_0'(r) > 0 \qquad \forall r \in (0, R_0] \, , \tag{2.29}$$

is an increasing function from $\Phi_0(0)$ to $\Phi_0(R_0)$ and it is concave upward, being

$$\Phi_0''(r) > 0 \qquad \forall r \in [0, R_0] \, , \tag{2.30}$$

as one may easily verify with the calculus.

The neutron flux in the outer reflector is expressed by (2.14), from which we find that

$$\Phi_1'(r) < 0 \qquad \forall r \in [R, R+T] \, , \tag{2.31}$$

therefore, being from (2.2) with $i = 1$ (see the note [1])

$$\Phi_1''(r) + \frac{2}{r}\,\Phi_1'(r) = k^2\Phi_1(r) > 0 \, , \tag{2.32}$$

we have also

$$\Phi_1''(r) > -\frac{2}{r}\,\Phi_1'(r) > 0 \qquad \forall r \in [R, R+T] \tag{2.33}$$

and then $\Phi_1(r)$ is a decreasing function from the value $\Phi_1(R)$ to zero in $[R, R+T]$, where it is concave upward.

It remains to examine the neutron flux in the core. From (2.29) and (2.31) we deduce at once (see (2.15))

$$\Phi'(R_0) > 0 \qquad \text{and} \qquad \Phi'(R) < 0 \, , \tag{2.34}$$

hence in $[R_0, R]$ the function $\Phi(r)$ at first increases, then it has a maximum value at $r = r^*$ and after decreases down to the value $\Phi(R)$. We have only one maximum point r^*: in fact in $\Phi(r)$ had two (or more) maximum points, the function $\Phi(r)$ ought to have a minimum point between them, thus would exist an interval $\mathcal{I}$ over which the function would increases and be concave upward; but this cannot be for where $\Phi'(r) > 0$, on the ground of (2.1) written in the form

$$\Phi''(r) + \frac{2}{r}\Phi'(r) = -B^2\Phi(r) < 0, \tag{2.35}$$

there results

$$\Phi''(r) < -\frac{2}{r}\Phi'(r) < 0\,, \tag{2.36}$$

and not $\Phi''(r) > 0$.

Thus $\Phi(r)$ has only one maximum point in (R_0, R) and it has a point of inflection in a neighbourhood of R that may coincide also with $r = R$. The exact calculus of this maximum point is a very hard problem, therefore we have used a numerical method, solving the equation $\Phi'(r) = 0$ in (R_0, R) with the « regula falsi » [**6**], as we shall see later on.

3 - Neutron flux flattening

The ratio

$$\gamma = \bar{\Phi}/\Phi_{\max} \tag{3.1}$$

expresses the so called flux flattening in the core. To evaluate it we must calculate the maximum value of the flux

$$\Phi_{\max} = \Phi(r^*) = \frac{C_0 \cosh(kR_0)}{Br^*}\{k \sin[B(r^* - R_0)] + \\ + B \tanh(kR_0) \cos[B(r^* - R_0)]\}\,, \tag{3.2}$$

where r^* is its maximum point, and the average value of the flux

$$\bar{\Phi} = \frac{1}{V}\int_V \Phi \, \mathrm{d}V \,, \tag{3.3}$$

where

$$V = \frac{4}{3}\pi(R^3 - R_0^3) \tag{3.4}$$

is the volume of the core.

With some calculi we get the following expression

$$\gamma = \frac{3r^*}{B^2(R^3 - R_0^3)} \cdot \Bigg(\frac{[\frac{k}{B} + BR \tanh(kR_0)] \sin[B(R - R_0)]}{\frac{k}{B}\sin[B(r^* - R_0)] + \tanh(kR_0)\cos[B(r^* - R_0)]} + \frac{-[kR - \tanh(kR_0)]\cos[B(R - R_0)] + kR_0 - \tanh(kR_0)}{\frac{k}{B}\sin[B(r^* - R_0)] + \tanh(kR_0)\cos[B(r^* - R_0)]} \Bigg) . \tag{3.5}$$

4 - Numerical calculus

As in [**1**], we have studied the nuclear behaviour of the reactor in function of the various parameters we have in the deduced formulae. We have considered four different moderators (and reflectors): H_2O ($L_r = AL = 2.88$ cm), graphite ($L_r = 52$ cm), a mixture of D_2O and H_2O with 0.16 % of H_2O ($L_r = 116$ cm) and at last D_2O ($L_r = 171$ cm).

For each of these four reactors, with the use of the computer we have varied R_0 from 25 cm to 300 cm with variations of 25 cm, B from 0.005 cm^{-1} to 0.100 cm^{-1} with variations of $P = 0.005$ cm^{-1}, while the values of T are different for the four moderators.

The programme in FORTRAN IV is the following.

```
      READ(2,1)AL,P,EPS,PG
      WRITE(3,1)AL,P,EPS,PG
 1    FORMAT(2F12.4,F12.6,F12.7)
      AK=1./AL
      DO 10 J=1,12
      R0=25*J
      R03=R0**3
      AK0=AK*R0
      T0=TANH(AK0)
      DIF0=AK0-T0
      DO 10 I=1,7
      T=50*I+50
      TK=TANH(AK*T)
      T0K=T0*TK
      S=T0+TK
      DO 10 K=1,20
      B=P*FLOAT(K)
      AB=AK/B
      BT0=B*T0
      X=(B*AL*T0K-AB)/S
      Y=PG/2.-ATAN(X)
      R=R0+Y/B
      RV=R**3-R03
      V=4.*PG*RV/3.
      X1=R0
      X2=R
      F1=AGB(X1,B,R0,AB,BT0,AK,T0)
      F2=AGB(X2,B,R0,AB,BT0,AK,T0)
 2    X3=X1-F1*(X2-X1)/(F2-F1)
      F3=AGB(X3,B,R0,AB,BT0,AK,T0)
      IF(F3)3,9,6
 3    XE=X3-EPS
      FE=AGB(XE,B,R0,AB,BT0,AK,T0)
      IF(FE)4,8,5
 4    X2=XE
      F2=FE
      GO TO 2
 5    X3=(X3+XE)/2.
      F3=AGB(X3,B,R0,AB,BT0,AK,T0)
      GO TO 9
 6    XE=X3+EPS
      FE=AGB(XE,B,R0,AB,BTO,AK,TO)
      IF(FE)5,87.
 7    X1=XE
      F1=FE
      GO TO 2
 8    X3=XE
      F3=FE
 9    AR=B*(X3-R0)
      FIMED=3.*((AB+BT0*R)*SIN(Y)-(AK*R-T0)*COS(Y)+DIF0)/(B*RV)
      FIMAX=B*(AB*SIN(AR)+T0*COS(AR))/X3
      APP=FIMED/FIMAX
      WRITE(3,91)R0,T,B,R,V,X3,F3,FIMED,FIMAX,APP
 91   FORMAT(1X,2(F5.0,1X),F7.4,1X7(E12.4,1X)),
 10   CONTINUE
      STOP
      END
      FUNCTION AGB(A,B,R0,AB,BT0,AK,T0)
      C=B*(A-R0)
      AGB=-(AB+BT0*A)*SIN(C)+(AK*A-T0)*COS(C)
      RETURN
      END
```

In it, in particular, the values of T vary from 100 cm to 400 cm with variations of 50 cm and are related only to the cases corresponding to $L_r = 116$ cm and $L_r = 171$ cm; values less than these are used in the other two cases, for a thickness $T = 2 \div 3L_r$ is almost equivalent to an infinite outer reflector.

Moreover, in this programme, after fixing three values for R_0, T and B, we calculate the critical size R given, on the ground of (2.20) and (2.23), by

$$R = R_0 + \frac{1}{B}\left[\frac{\pi}{2} - \tanh^{-1}\frac{(B/k)\tanh(kR_0)\tanh(kT) - k/B}{\tanh(kR_0) + \tanh(kT)}\right], \tag{4.1}$$

and the volume V of the core (see (3.4)). Then, we derive the maximum point r^* of the neutron flux in order to calculate γ. To do this, we consider the function

$$f(r) = -\left[\frac{k}{B} + B\tanh(kR_0)r\right]\sin[B(r-R_0)] + [kr - \tanh(kR_0)\cos[B(r-R_0)], \tag{4.2}$$

being, on the ground of (2.21),

$$\frac{d\Phi}{dr} = \frac{C_0\cosh(kR_0)}{r^2}\cdot f(r), \tag{4.3}$$

and then the only maximum point of $\Phi(r)$ in $[R_0, R]$ (see sect. **2**(c)) is given also by the equation

$$f(r) = 0\,, \qquad r \in [R_0, R]\,. \tag{4.4}$$

From (2.34) it follows that

$$f(R_0) > 0\,, \qquad f(R) < 0 \tag{4.5}$$

and moreover $f(r)$ vanishes in $[R_0, R]$ only for $r = r^*$; thus the « regula falsi » may be used. In this method we have put EPS $= 10^{-6}$.

At last, the programme gives the following quantities

$$\begin{aligned}\text{FIMED} &= \bar{\Phi}\cdot\frac{B}{C_0\cosh(kR_0)} \\ &= \frac{3}{B(R^3 - R_0^3)}\cdot\Big[\Big(\frac{k}{B} + BR\tanh(kR_0)\Big)\sin\big(B(R-R_0)\big) - \\ &\quad - \big(kR - \tanh(kR_0)\big)\cos\big(B(R-R_0)\big) + kR_0 - \tanh(kR_0)\Big]\end{aligned} \tag{4.6}$$

and

$$\text{FIMAX} = \Phi_{\max} \frac{B}{C_0 \cosh(kR_0)} = \frac{B}{r}\Big[\frac{k}{B}\sin\big(B(r^* - R_0)\big) + \tanh(kR_0)\cos\big(B(r^* - R_0)\big)\Big]\,, \tag{4.7}$$

hence we have

$$\gamma = \text{APP} = \text{FIMED}/\text{FIMAX}\,. \tag{4.8}$$

5 - Results

In the presence of the inner reflector, the flux in the core is more flattened but the critical size increases in comparison with what occurs when the inner cavity is empty [**1**]. To have an idea of such variations we relate some results for the two different reactors, which we suppose both moderated and reflected with graphite. Then, to have an immediate comparison among the values of γ relative to the conventional geometries, we consider only the case with $T = 0$ cm, i.e. in the absence of the only outer reflector, and we fix $R_0 = 25$ cm, that is the least value we have considered; as B (in cm^{-1}) assumes the following values

$$B = 0.010,\ 0.030,\ 0.050,\ 0.070,\ 0.090$$

in [**1**] R (in cm) and γ become

$$R = 314.6,\ 108.2,\ 69.9,\ 54.8,\ 47.1\ ; \qquad \gamma = 0.312,\ 0.360,\ 0.412,\ 0.453,\ 0.483\,,$$

while now, i.e. in the presence of the reflector only in the inner cavity, we have

$$R = 316.3,\ 109.4,\ 70.6,\ 55.3,\ 47.4\ ; \qquad \gamma = 0.327,\ 0.373,\ 0.421,\ 0.460,\ 0.489\,.$$

The values of γ are, as in [**1**], greater than those relative to the conventional geometries and increase both with R_0, for any fixed B, and with B, for any fixed R_0; then they increase considerably with the thickness of the outer reflector, for any fixed pair of values for R_0 and B.

As regards the critical size R, we see that it decreases as B increases, for any fixed R_0; consequently the thickness $R - R_0$ decreases considerably and γ becomes very high.

All this holds, whatever the reflector material, we have supposed to be the same as the core moderator material, may be, i.e. for any L_r.

Then, if we vary L_r, it results that, as its value increases, R decreases and consequently the value of γ increases, whatever the values of the other parameters may be. To show this and to give an idea of the peculiarities of the reactor we are considering, we relate the following numerical results.

Let us consider the case when $R_0 = T = 100$ cm. The values of R (in cm) and γ, corresponding to the following values of B (in cm^{-1})

$$B = 0.010,\ 0.030,\ 0.050,\ 0.070,\ 0.090\ ,$$

if $L_r = 2.88$ cm (H_2O) are

$R = 408.4, 198.9, 157.1, 139.1, 129.2$, $\gamma = 0.528, 0.631, 0.674, 0.703, 0.727$;

if $L_r = 52$ cm (graphite) become

$R = 321.7, 139.3, 115.2, 107.9, 104.8$, $\gamma = 0.641, 0.897, 0.957, 0.977, 0.986$;

if $L_r = 116$ cm ($D_2O + 0.16\,\%\, H_2O$) result

$R = 278.1, 126.0, 109.6, 104.9, 103.0$, $\gamma = 0.669, 0.926, 0.971, 0.985, 0.991$;

if $L_r = 171$ cm (D_2O) are

$R = 267.6, 123.6, 108.7, 104.4, 102.7$, $\gamma = 0.671, 0.930, 0.973, 0.986, 0.991$.

Other results may be deduced from the enclosed figures, in wchich the values of T are about $2L_r$ to have an idea of the greatest savings, we may have by the use of the outer reflector. In these figures we show the variations of R, of the maximum point r^* of the flux and of γ with B, which ranges in a very large set (from 0.005 to 0.100 cm^{-1}), for some fixed values of R_0.

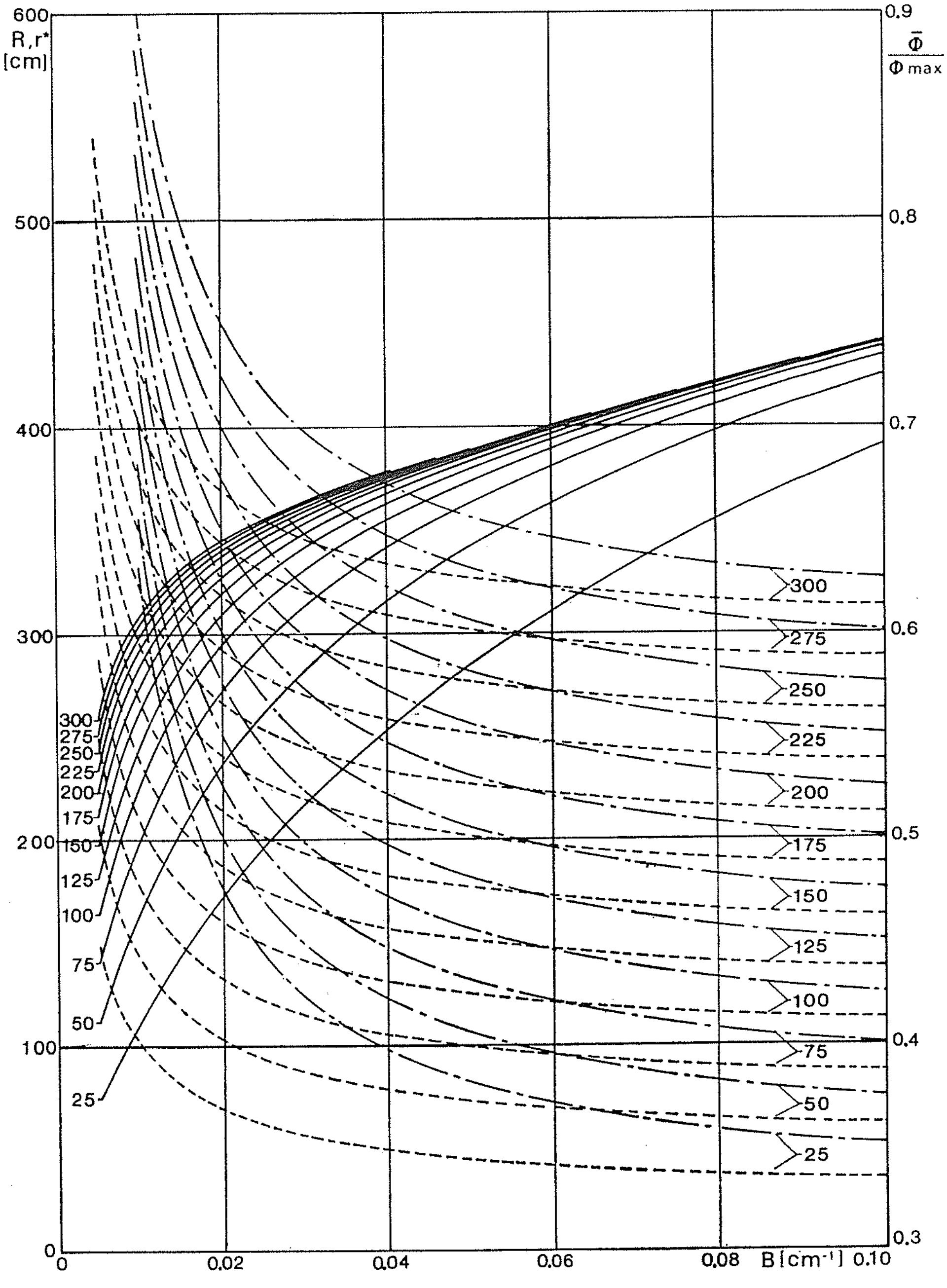

Fig. 1. – Variations of R (—·—·—), r^* (— — —) and γ (——) with B for fixed values of R_0, when H_2O ($L_r = 2.88$ cm) is used as moderator and reflector and $T \gg 3L_r$.

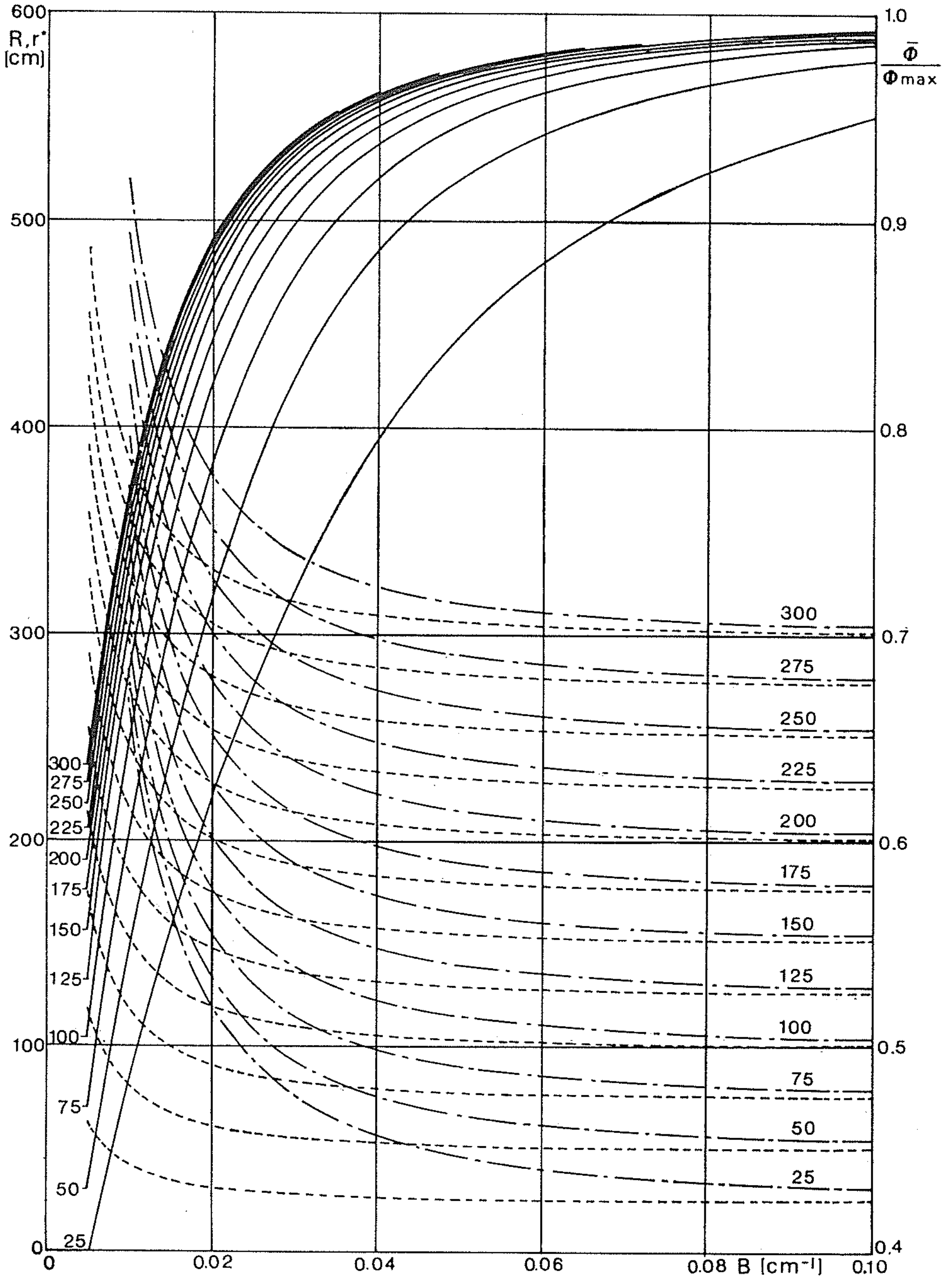

Fig. 2. – Variations of R (—·—·—), r^* (— — —) and γ (——) with B for fixed values of R_0, when graphite (L_r = 52 cm) is used as moderator and reflector and T = 120 cm.

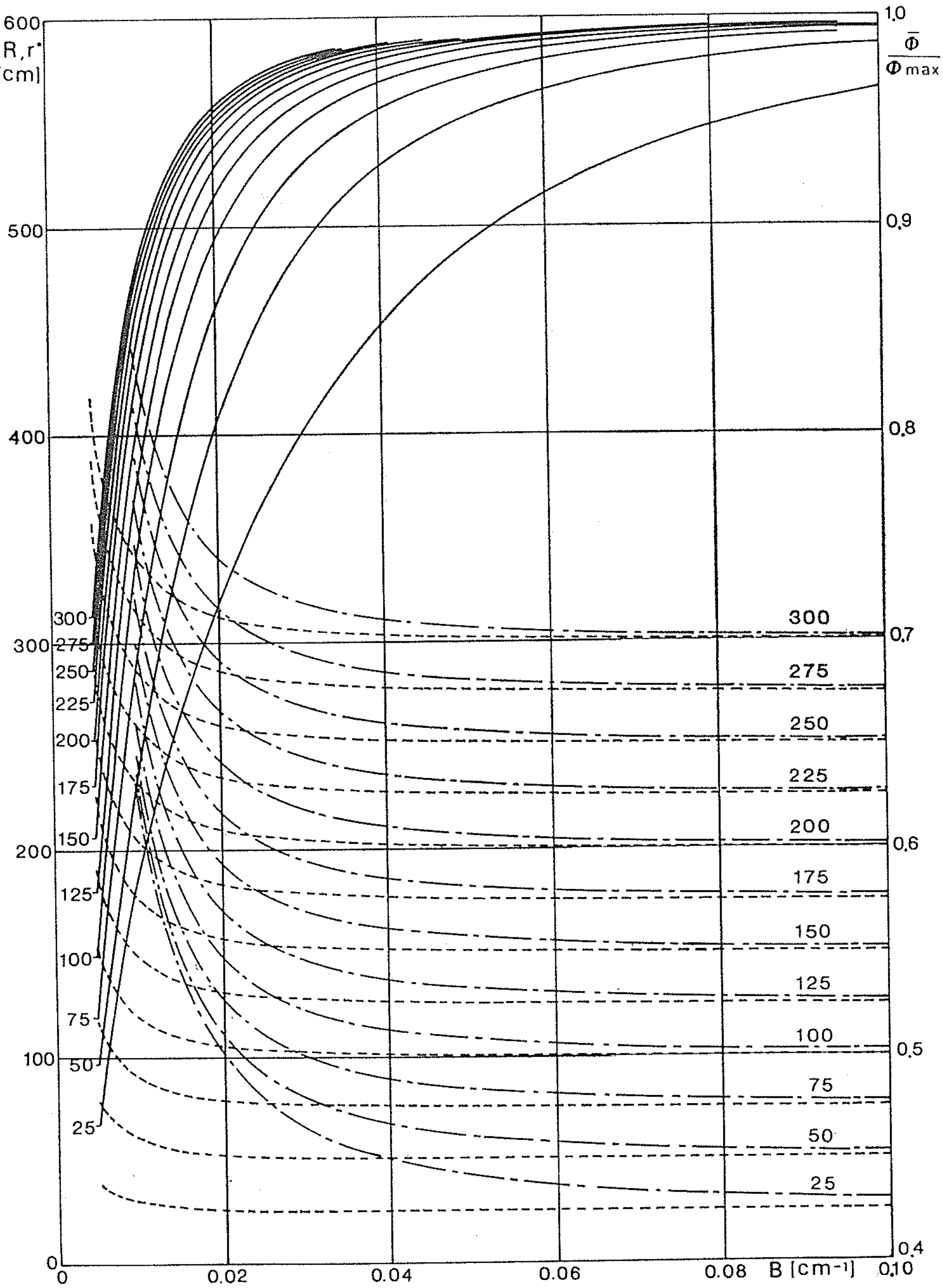

Fig. 3. – Variations of R (—·—·—), r^* (— — —) and γ (——) with B for fixed values of R_0, when a mixture of H_2O and D_2O (0.16% of H_2O; $L_r = 116$ cm) is used as moderator and reflector and $T = 250$ cm.

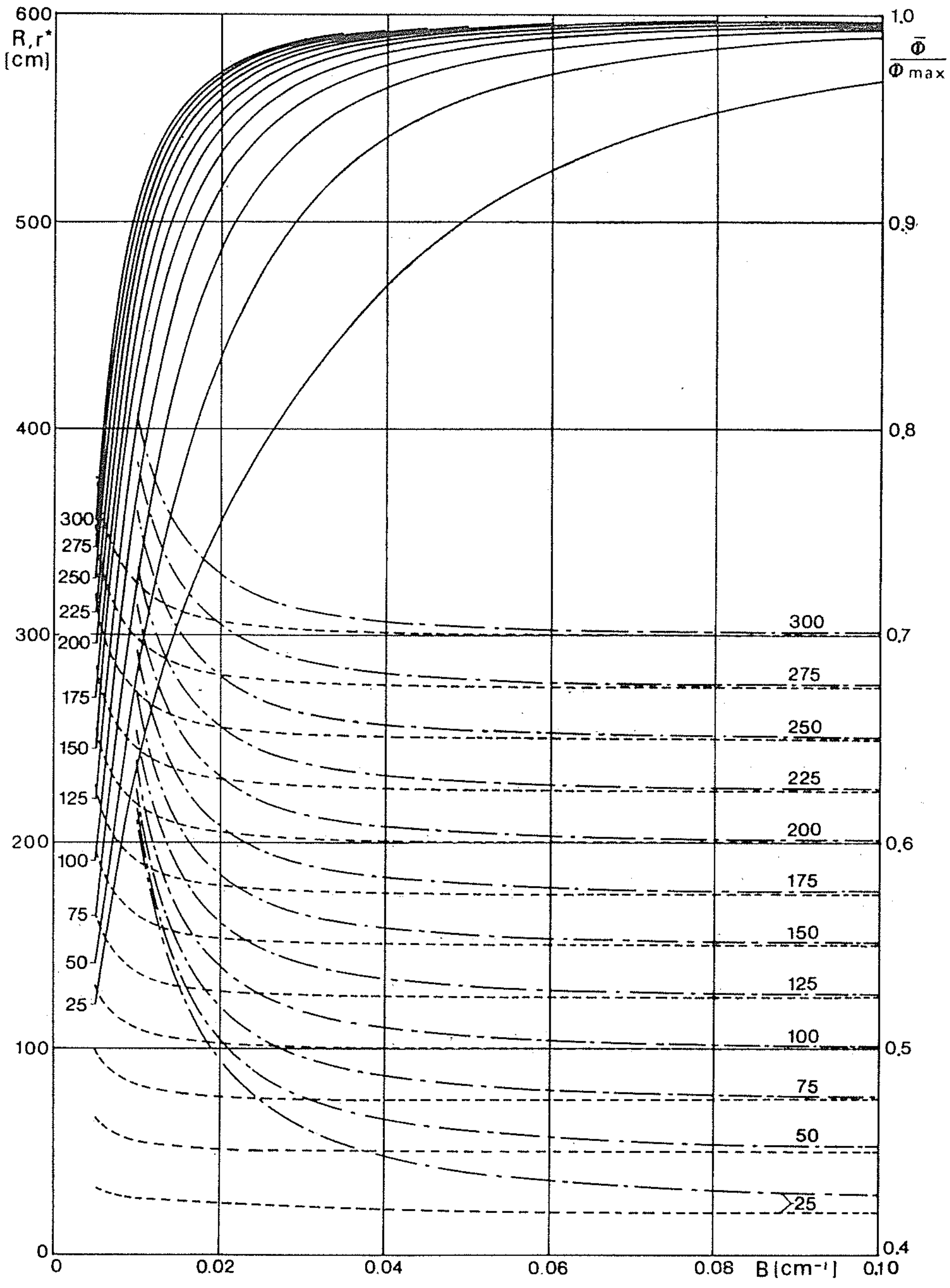

Fig. 4. – Variations of R (—·—·—), r^* (— — —) and γ (——) with B for fixed values of R_0, when D_2O (L_r = 171 cm) is used as moderator and reflector and T = 350 cm.

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Sommario

In questo lavoro si riprende l'esame di un particolare tipo di reattore nucleare sferico con una cavità sferica centrale, già studiato dall'autore in una precedente nota [**1**], *allo scopo di esaminare gli effetti della presenza di materiale riflettente nella cavità centrale. Per tale studio il reattore è considerato omogeneo e a neutroni termici. Con l'equazione della diffusione, relativa allo stato stazionario, si determina la distribuzione del flusso neutronico nella parte attiva, nel riflettore esterno e quello interno e si mette in risalto il maggiore appiattimento del flusso rispetto sia alle altre geometrie convenzionali sia al reattore sferico cavo di* [**1**]. *La presenza del riflettore interno porta ovviamente a dimensioni critiche maggiori di quelle ottenute in* [**1**]. *Si indica una possibile realizzazione pratica di un tale reattore meno complessa di quella considerata in* [**1**].

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