KFKI-1986-40/G

O. AGUILAR

MEASUREMENT OF REACTIVITY TEMPERATURE COEFFICIENT BY NOISE METHOD IN A POWER REACTOR

Hungarian Academy of Sciences

CENTRAL RESEARCH INSTITUTE FOR PHYSICS

BUDAPEST

KFKI-1986-40/G
PREPRINT

MEASUREMENT OF REACTIVITY TEMPERATURE COEFFICIENT BY NOISE METHOD IN A POWER REACTOR

O. AGUILAR*

Central Research Institute for Physics
H-1525 Budapest 114, P.O.B.49, Hungary

HU ISSN 0368 5330

*On leave from: Nuclear Research Center, Havana, Cuba

ABSTRACT

The temperature reactivity coefficient has been estimated on the basis of noise measurements performed in a PWR. The magnitude of the coefficient has been evaluated by relating the values of the APSD and CPSD between ex-core neutron detector signals and fuel assembly outlet thermocouple in the low frequency range. Comparation with $\partial\rho/\partial T$ measurements performed in PWR by standard method supports the validity of the results.

АННОТАЦИЯ

Температурный коэффициент реактивности был измерен в реакторе ВВЭР-440 новым шумовым методом. Для определения данного параметра использовались функции спектральной мощности взаимной корреляции и автоспектральной мощности ионизационной камеры и термопар в области низких частот. Сравнение измеренных значений $\delta\rho/\delta T$ со значениями, полученными по стандартной методике, показывает хорошее согласие.

KIVONAT

VVER tipusu atomerőműben végzett zajmérések alapján meghatároztuk a reaktivitás hőmérséklet együtthatóját. Erre a célra a zónán kivüli ionizációs kamrák és a zóna kilépésénél elhelyezett termoelemek CPSD és APSD függvényeinek alacsony frekvenciás részét használtuk fel. A standard módszerekkel nyert eredményekkel történt összevetés alátámasztja az uj módszer használhatóságát.

1. INTRODUCTION

The feasibility of using neutron flux and core-exit temperature signals in power reactors to estimate the reactivity temperature coefficient has been demonstrated in previous works [1,2,3].

Theoretical studies performed in the references mentioned suggested that, on the basis of noise measurement, the reactivity temperature coefficient in PWR can be estimated using the following expression:

$$\partial\rho/\partial T = G(\omega) \cdot \frac{CPSD(\omega)}{APSD(\omega)} \qquad (1)$$

where: $CPSD_{N,T}(\omega)$: Cross Power Spectral Density between neutronic and temperature signals.

$APSD_T(\omega)$: Power Spectral Density for temperature sensor.

$G(\omega)$: Reactor Transfer function; for PWE-WWER $G(\omega)^{-1} \sim \beta_{EFF} = 0.0075$

This paper is concerned with the evaluation of $\partial\rho/\partial T$ coefficient using expression (1) applied to noise measurements permed in Paks NPP Unit 2.

2. RESULT OF MEASUREMENTS AND DISCUSSION

To support the validity of expression (1) noise signals recorded in Paks NPP Unit 2 during the second fuel cycle, under normal operation, were analyzed and evaluated. Unit 2 is equipped with a sophisticated noise measuring system consisting of in-core neutron detectors, ex-core ionization chambers and fuel assembly outlet thermocouples [4]. The positions of the ex-core, in-core neutron detectors and in-core fuel assembly outlet thermocouples are shown in *Fig. 1*.

A set of four ex-core detectors was used to estimate the $\partial\rho/\partial T$ coefficient for the Paks NPP Unit 2. *Fig. 2* shows the global character of the signals used in the evaluation.

The signals are connected to noise preamplifiers positioned near to the reactor vessel. The preamplified noise signals are cabled to a noise diagnostic laboratory near to the control room of the unit, where the fluctuating signals are further amplified and recorded by a 14-channel FM tape recorder.

All the signals were normalized considering the different amplification factors (internal amplification factor of Paks amplifiers, external amplification factor, etc.). For the thermocouples a factor of 4×10^{-5} volt/^{o}C was used, and an amplification factor of 10^{5} was considered.

The neutron noise signals from each detector were low pass filtered at 4 Hz to prevent aliasing, high pass filtered at 0.01 Hz, digitized with a sampling interval of 0.125 sec, partitioned into blocks of 256 points, Hanning windowed and Fourier transformed. APSDs and CPSDs between pairs of signals were analyzed.

Table 1 shows the magnitude of the coefficient $\partial\rho/\partial T$ estimated for different detector-thermocouple set. The coherence was found in all the cases over 10% and the effect of the temperature fluctuation on the neutron spectrum was local between 0.3-0.4 Hz.

In table 1 it can be noticed the values calculated from the CPSD and APSD pictures at the set of points where the effect was localized.

The last row of table 1, shows the mean value estimated from the set of measurements and the calculated statistical error. These results indicate that the inferred error does not reach 10%.

In *Figs. 3,4* a typical phase behaviour between an ex-core detector and a thermocouple can be observed (see *Fig. 1* for details of detector positions). In the low frequency range, one can observe that a peak appears at 0.63 Hz. We suppose that this peak belongs to the pressure fluctuation in the coolant that affects the neutron spectrum. These results were obtained for this reactor reported in previous works [5,6].

To support the validity of expression (1), the results showed in Table 1, were compared with results obtained by standard forced dynamics methods used in PWRs of WWER type.

In Table 2 the results reported in different papers for measurements performed in PWR-WWER type were summarized.

Since in the references mentioned the measurements were performed in somewhat different conditions, some interpolation of the results should be made. Nevertheless, the results obtained with our method, agree well qualitativly and quantitativly with those reported by other authors, and this support the validity of the method.

2. CONCLUSION

Considering the APSD and the CPSD between a neutronic detector and a thermocouple signal, the value of the temperature coefficient has been estimated for a set of different combinations of ex-core detectors and outlet assembly thermocouples in an NPP of PWR.

The comparation of these results obtained for the temperature coefficient with measurements performed by standard forced dynamics methods in PWR core, supports the validity of the model emphasized and the results obtained.

ACKNOWLEDGEMENTS

The autor thanks Dr. G. Pór for his continuous contribution to this paper and Dr. L. Meskó for correcting the manuscript.

REFERENCES

[1] Pór G., Izsák É., Valkó J. (1985): Some results of noise measurements in a PWR NPP. Prog. in Nucl. En. Vol. 15.

[2] Pór G. (1982): On the evaluation of the reactivity coefficients by noise measurements. KFKI-84-1982.

[3] Aguilar O. (1986): Temperature reactivity coefficient measurement by noise method in power reactors theory. (to be published in KFKI series)

[4] O. Glöckler, Pór G., Valkó J. (1986) Results and interpretation of noise measurements using in-core self powered neutron detectors string at Unit 2 of Paks Nuclear Power Plant. University of Tenesse, USA.

[5] G. Pór and co-workers (1984): The effect of pressurized water level on the low frequency component of the pressure spectrum in a PWR. KFKI-1984-101.

[6] O. Aguilar, G. Pór (1986): Routine evaluation of pressure reactivity coefficient in power reactor by noise method. (To be published in KFKI series).

[7] Obchinikov and co-workers. Exploitation regimes in WWER reactors. Atomizdat, 1981 (in russian).

[8] Adorjan F. and co-workers (1983): Report on measurements made during the commissioning Paks NPP Unit 1. OKKFT A/11.1.1.1

Table 1

Measurement	detectors	peak freq. (Hz)	coherence (%)	$NCPSD_{N,T}$ ($^oC/Hz$)	$NAPSD_T$ ($^oC^2/Hz$)	$\partial\rho/\partial T$ ($^oC^{-1}$)
P2B2K.2A	JK-1/TH-5	0.375	12.25	$1.433\ 10^{-6}$	$8.56\ 10^{-5}$	$-1.26\ 10^{-4}$
P2B2K.2A	JK-18/TH-5	0.375	10.69	$1.259\ 10^{-6}$	$8.56\ 10^{-5}$	$-1.10\ 10^{-4}$
P2B2K.2A	JK-9/TH-5	0.344	13.90	$1.523\ 10^{-6}$	$1.14\ 10^{-4}$	$-1.00\ 10^{-4}$
P2B2K.2A	JK-10/TH-5	0.344	12.65	$1.456\ 10^{-6}$	$1.14\ 10^{-4}$	$-0.96\ 10^{-4}$
P2B2K.2B	JK-9/TH-5	0.375	13.17	$1.165\ 10^{-6}$	$7.39\ 10^{-5}$	$-1.18\ 10^{-4}$
P2B2K.2B	JK-9/TH-5	0.375	12.75	$1.400\ 10^{-6}$	$8.91\ 10^{-5}$	$-1.18\ 10^{-4}$
P2B2K.2B	JK-18/TH-5	0.320	18.00	$2.020\ 10^{-7}$	$1.51\ 10^{-5}$	$-1.01\ 10^{-4}$

Mean Value: $(-1.10 \pm 0.10) \cdot 10^{-4}\ ^oC^{-1}$

Table 2

Reference/ Method.	Reactor Type	Reactivity coeff. (10^{-4} $^oC^{-1}$)	Temperature (^oC)	Boron Conc. (g/Kg)
Obchinikov and co-workers Dynamics stand. methods (16)	WWER-440 Unit 4, Nowoworonezh NPPP	-2.1 -0.5	285 285	5.72 8.58
This Work/ Noise Method.	WWER-440 Unit 2, Paks NPP	-1.10	282.1	6.9
Adorjan F. and co-workers (17)*	WWER-440 Unit 1, Paks NPP	-0.1	260	8.0

(*) At zero power.

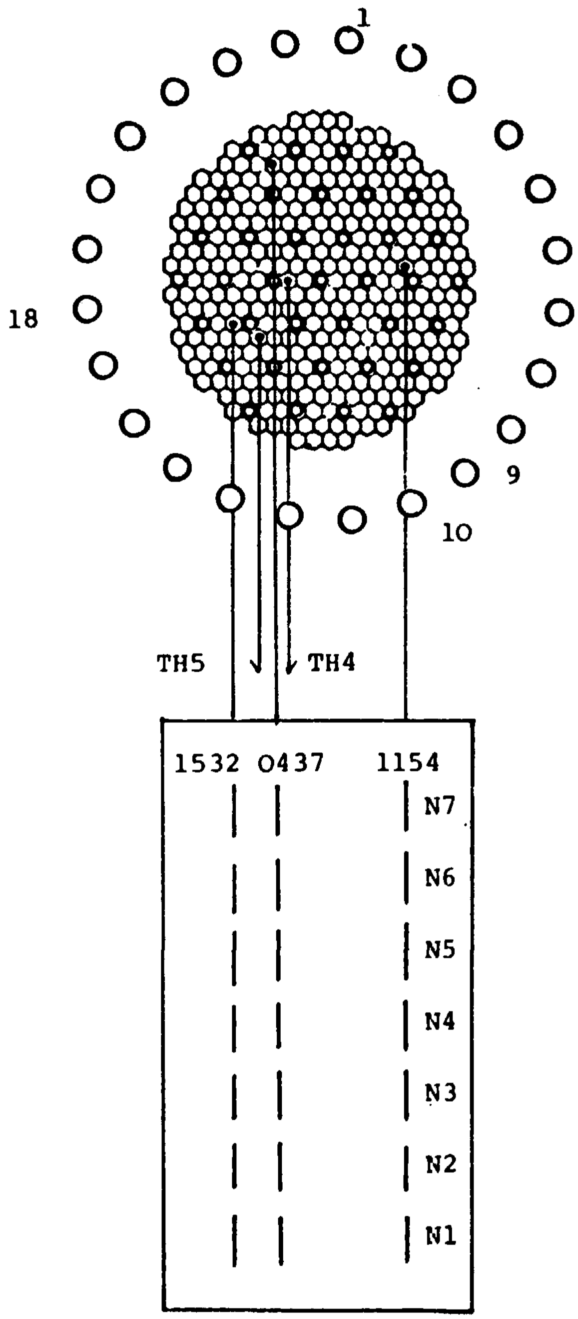

Fig. 1.

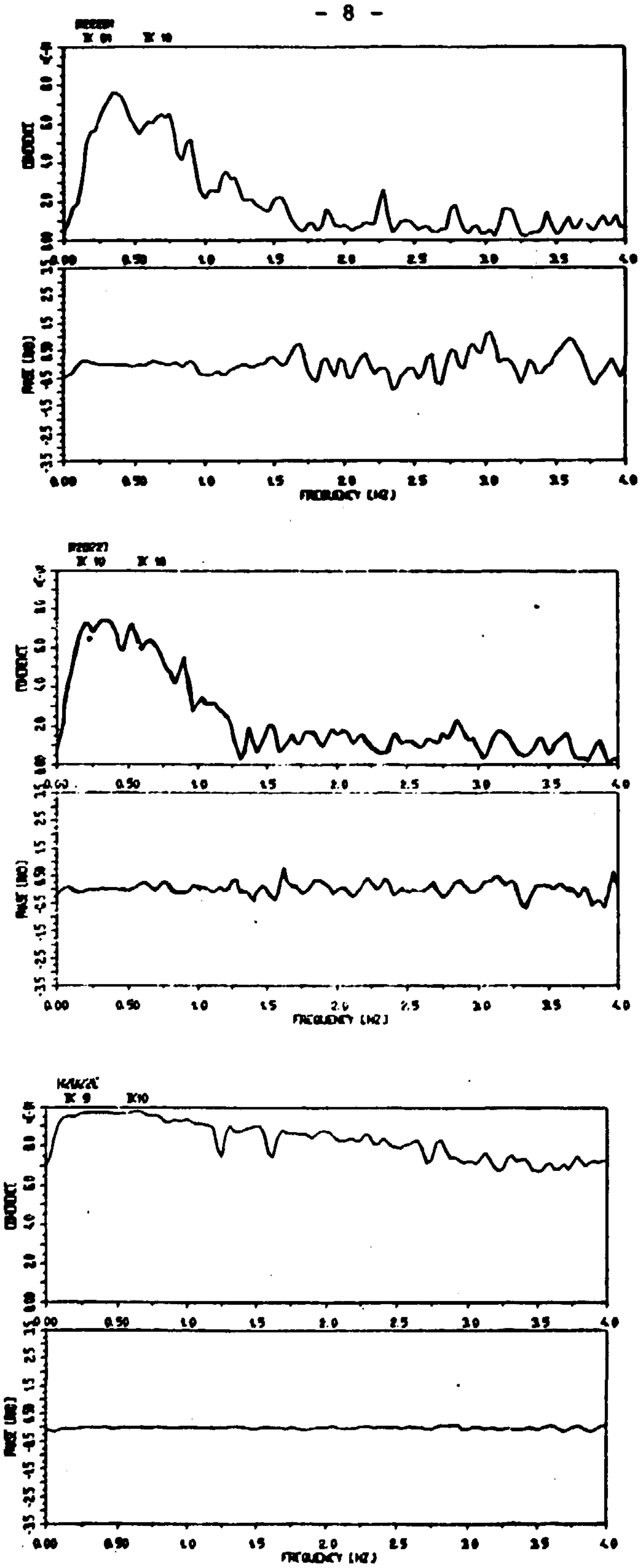

Fig. 2.

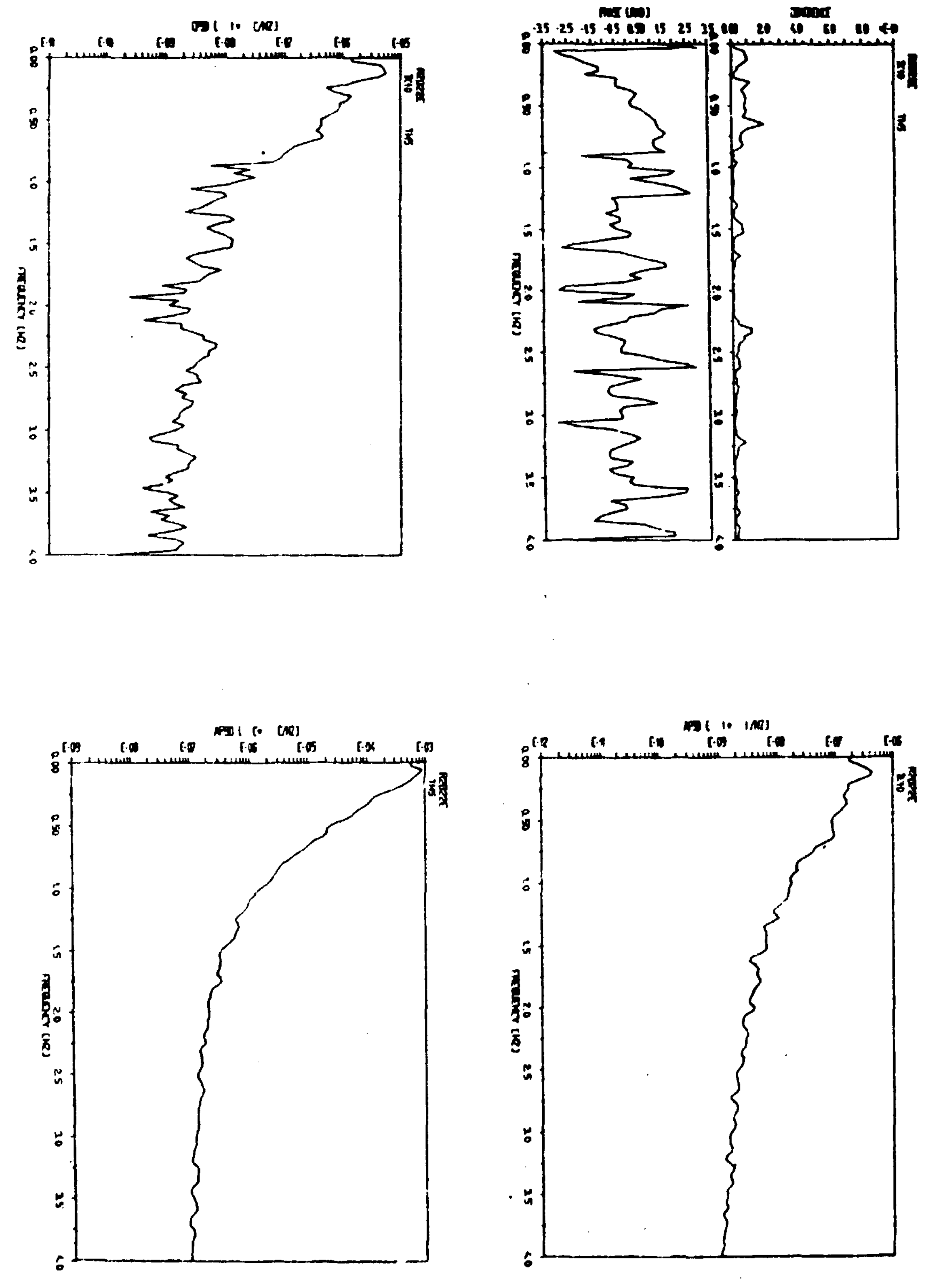

Fig. 3.

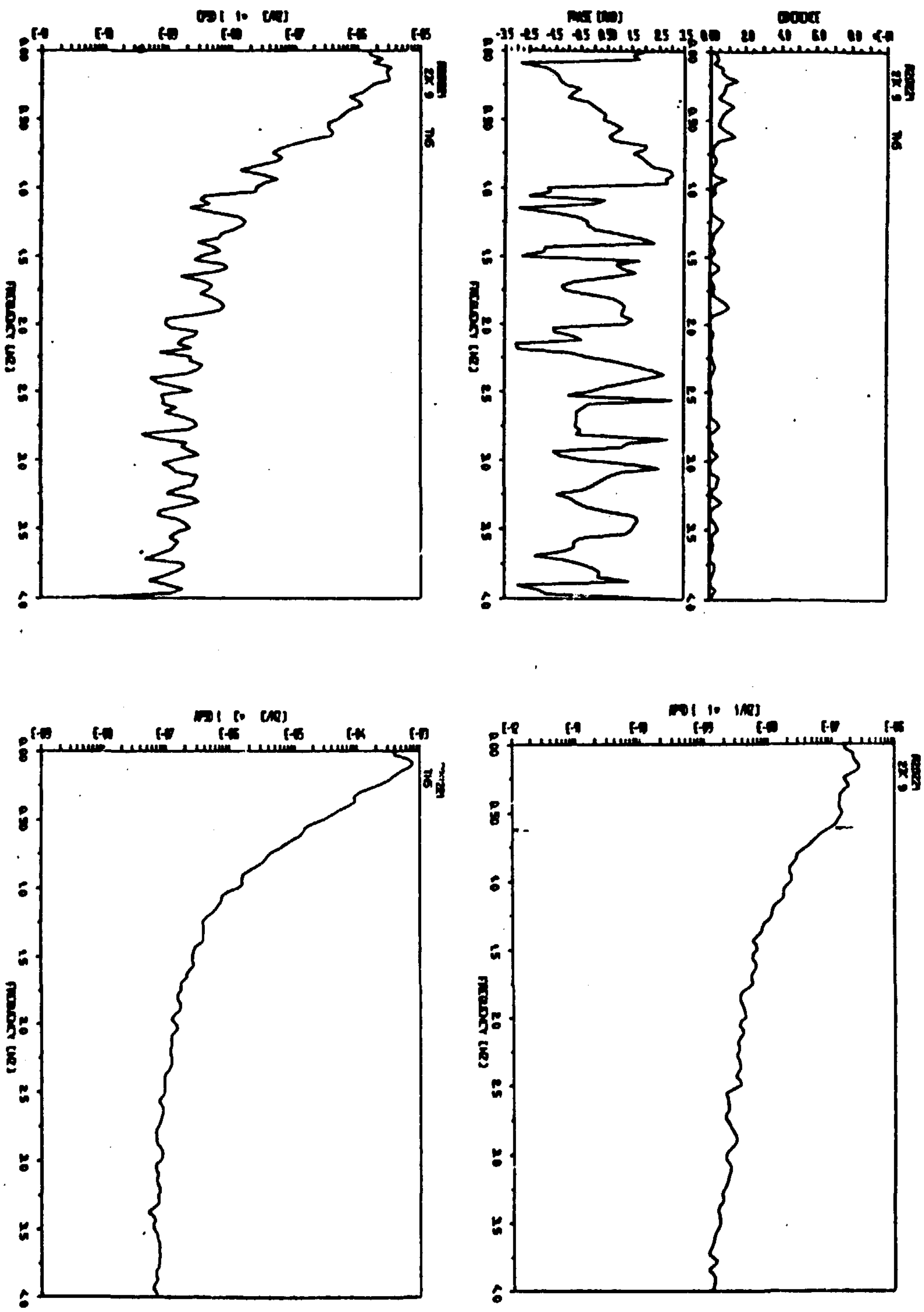

Fig. 4.

FIGURE CAPTIONS

Fig. 1. Positionsof in-core fuel assembly outlet thermocouples and in-core, ex-core detectors.

Fig. 2. Coherence and phase between ex-core detectors.

Fig. 3. } CPSD, APSD, coherence and phase between
Fig. 4. } ex-core detectors and thermocouples.

The issues of the KFKI preprint/report series are classified as follows:

A. Particle and Nuclear Physics

B. General Relativity and Gravitation

C. Cosmic Rays and Space Research

D. Fusion and Plasma Physics

E. Solid State Physics

F. Semiconductor and Bubble Memory Physics and Technology

G. Nuclear Reactor Physics and Technology

H. Laboratory, Biomedical and Nuclear Reactor Electronics

I. Mechanical, Precision Mechanical and Nuclear Engineering

J. Analytical and Physical Chemistry

K. Health Physics

L. Vibration Analysis, CAD, CAM

M. Hardware and Software Development, Computer Applications, Programming

N. Computer Design, CAMAC, Computer Controlled Measurements

The complete series or issues discussing one or more of the subjects can be ordered; institutions are kindly requested to contact the KFKI Library, individuals the authors.

Title and classification of the issues published this year:

KFKI-1986-01/E J. Kollár et al.	The Kronig-Penney model on a Fibonacci lattice
KFKI-1986-02/C A.J. Somogyi et al.	First results of high energy particle measurements with the TÜNDE-M telescopes on board the S/C VEGA-1 and -2
KFKI-1986-03/C K. Gringauz et al.	The VEGA PLASMAG-1 experiment: description and first experimental results
KFKI-1986-04/A J. Révai	Half-classical three-body problem
KFKI-1986-05/A I. Lovas	Quark degrees of freedom in nuclei
KFKI-1986-06/E Gy. Szabó et al.	Lattice gas model on tetrahedral sites of bcc lattice: anisotropic diffusion in the intermediate phase
KFKI-1986-07/K Pálfalvi J. et al.	Tapasztalatok egy (neutron-alfa) magreakción alapuló szilárdtest nyomdetektorokból felépitett személyi albedo neutron doziméter munkaszintű dozimetriai felhasználásáról
KFKI-1986-08/K Nagy Gy. et al.	Összefoglaló értékelés a paksi környezetellenőrző rendszer GM-csöves és jódtávmérő detektorainak jellemzőiről az 1982-1985-ös mérési adatok feldolgozása alapján. OKKFT-A/11-7.5.9.
KFKI-1986-09/K Nagy Gy. et al.	A paksi atomerőmű hideg- és melegvizcsatornájában üzemelő folyamatos vizaktivitás monitorok paraméterelnek és mérési adatainak összefoglaló értékelése. OKKFT-A/11-7.4.13.
KFKI-1986-10/D S. Zoletnik et al.	Determination of the centre of gravity of the current distribution in the MT-1 tokamak

KFKI-1986-11/G R. Kozma et al.	Studies to the stochastic theory of the coupled reactorkinetic-thermohydraulic systems. Part VI. Analysis of low-frequency noise phenomena
KFKI-1986-12/A A. Frenkel	Canonical quantization of the relativistic theory of the Dirac monopole
KFKI-1986-13/D Gy. Egely	Energy transfer problems of ball lightning
KFKI-1986-14/K Németh I. et al.	Hordozható félvezető gamma-spektrométer üzembe állítása, kalibrálása, számitógépes adatfeldolgozása és tesztelése in situ dózisteljesitmény meghatározás céljából. OKKFT-A/11-7.4.12.
KFKI-1986-15/G M. Makai	In aid of in-core measurement processing
KFKI-1986-16/C K.I. Gringauz et al.	First in situ plasma and neutral gas measurements at comet Halley: initial VEGA results
KFKI-1986-17/C A.J. Somogyi et al.	First spacecraft observationsof energetic particles near comet Halley
KFKI-1986-18/E Z. Kaufmann et al.	Unusual maps and their use to approach usual ones
KFKI-1986-19/A H-W. Barz et al.	Effect of correlations on entropy and hadro-chemical composition in heavy ion reactions
KFKI-1986-20/B A. Horváth et al.	Evidence for a different miocene solar cycle?
KFKI-1986-21/M D. Nicholson	On the humanisation of interfaced systems
KFKI-1986-22/L Novothny F. et al.	Kisérlet mérőváltók meghibásodásának zajdiagnosztikájára 2.
KFKI-1986-23/C T.I. Gombosi et al.	An icy-glue model of cometary nuclei
KFKI-1986-24/A P. Lévai et al.	Should the coupling constants be mass dependent in the relativistic mean field models?
KFKI-1986-25/E G.P. Djotyan et al.	Theory of the nonstationary phase conjugation by four-wave mixing
KFKI-1986-26/E P. Szépfalusy et al.	A new approach to the problem of chaotic repellers
KFKI-1986-27/J A. Vértes et al.	Peak shape determination in laser microprobe mass analysis
KFKI-1986-28/E P. Fazekas	Variational ground state for the periodic Anderson model
KFKI-1986-29/A V.N. Gribov	A new hypothesis on the nature of quark and gluon confinement
KFKI-1986-30/A L. Diósi	A universal master equation for the gravitational violation of quantum mechanics

KFKI-1986-31/D J.S. Bakos	Optically pumped FIR lasers and their application in plasma diagnostics
KFKI-1986-32/B Zs. Bagoly et al.	Monopole abundance from first order gut phase transition of the early universe
KFKI-1986-33/B Z. Perjés	Ernst coordinates
KFKI-1986-34/C R.Z. Sagdeev et al.	Comet Halley: Nucleus and jets (Results of the VEGA mission)
KFKI-1986-35/A K. Szlachányi	Non-local fields in the Z(2) Higgs model: the global gauge symmetry breaking and the confinement problem
KFKI-1986-36/B B. Kämpfer et al.	Entropy production in tepid inflation
KFKI-1986-37/A P. Vecsernyés	Comment to the "Reanalysis of the Eötvös experiment"
KFKI-1986-38/F Gy. Szabó et al.	Influence of temperature oscillation on measured crystal weight during Czochralski growth
KFKI-1986-39/C R.Z. Sagdeev et al.	The spatial distribution of dust jets seen by V-2
KFKI-1986-40/G O. Aguilar	Measurement of reactivity temperature coefficient by noise method in a power reactor

Kiadja a Központi Fizikai Kutató Intézet
Felelős kiadó: Gyimesi Zoltán
Szakmai lektor: Pór Gábor
Nyelvi laktor: Meskó László
Gépelte: Berron Péterné
Példányszám: 210 Törzsszám: 86-413
Készült a KFKI sokszorosító üzemében
Felelős vezető: Töreki Béláné
Budzpest, 1986. julius hó