YEARBOOK

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OF THE HUNGARIAN ACADEMY OF SCIENCES

'78

YEARBOOK 1978

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HUNGARIAN ACADEMY OF SCIENCES
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CONTENTS

In January 1978, Prof. Lénárd Pál, academician, was nominated by the Cabinet to be president of the State Office for Technical Development. Dr. Ferenc Szabó, the scientific director of the Atomic Energy Research Institute of KFKI, was appointed by the Hungarian Academy of Sciences to take over the responsibilities of Prof. Pál who had been the Director General of the whole research centre. Dr. Szabó is a state prize holder, a doctor of technical sciences, one of the founders of reactor physics research in Hungary and a leader of these research activities since their beginning. An internationally recognized team of researchers has come into being in the institute under his leadership.

Prof. Pál joined KFKI in 1953 and after holding several leading positions, he became the director in January 1971. His guidance resulted in the present scientific profile of our research centre; a research centre which concentrates on four major fields of science. During Prof. Pál's directorship, ever more efforts were devoted to meeting the requirements of the national economy while still continuing research into basic problems. His own research led to outstanding scientific results concerning the theory of stochastic processes, magnetism and other fields of solid state physics — in which discipline he

created a scientific school. We know that his continued interest will be a source of benefit to KFKI's activities.

On 2nd March 1978, Prof. Lajos Jánossy passed away. Academician Jánossy spent almost three decades in KFKI during which time he played a determining role in the life of the institute; his influence in creating a scientific atmosphere and in shaping and implementing the scientific policy of the institute cannot be over-estimated. Throughout his life he was deeply interested in fundamental problems of physics. He achieved well-known experimental and theoretical results in the fields of cosmic radiation and the nature of light. He was also engaged in basic aspects of relativity theory and quantum theory. In memoriam, one of his last papers on quantum theory, left in manuscript form, is published in this Yearbook.

EDITORIAL BOARD

SOME CONNECTIONS BETWEEN CLASSICAL PHYSICS AND WAVE MECHANICS

by
L. Jánossy

INTRODUCTION

It is a remarkable fact that some of the phenomena connected with the interaction of light of very high intensities can be accounted for in a very simple way using the classical model. At the same time the analysis of these effects in terms of quantum electrodynamics requires the formalism of many photon interactions and the latter — although they lead to the same results as one obtains from the classical considerations — lead to these results in a much more circumstantial way.

We are of the opinion that the fact that the classical picture leads often to satisfactory results is not accidental but is due to deep connections between classical physics and quantum mechanics which connections were not always realized to sufficient extent.

THE HYDRODYNAMICAL MODEL

Extending the well-known work based on ideas put forward by E. Madelung, Ehrenfest and carried on by Takabayasi and many others — we have elaborated in detail a procedure which may be called the hydrodynamical model of quantum mechanics. Our results are to be found in a number of publications.

If we take the one body wave equation in the simple form

$$\left[\frac{1}{2m}\left(i\hbar\nabla + \frac{e}{c}\underline{A}\right)^2 + e\Phi + V\right]\psi = i\hbar\dot{\psi} \qquad (1)$$

new variables can be introduced

$$\rho = \psi\psi^* \qquad \rho\underline{v} = \frac{i\hbar}{2m}\left(\psi^* \operatorname{grad}\psi - \psi \operatorname{grad}\psi^*\right) - \frac{e\rho}{c}\underline{A} \qquad (2)$$

and the relation (1) can be rewritten in the form of the equations of motion of an electrically charged medium moving under the influence of an outer electromagnetic field derived from potentials $\underline{A}$, Φ and also some non electromagnetic forces which can be derived from a potential V. The equations of motion are

$$\rho \frac{d\underline{v}}{dt} = \rho \, \mathrm{grad}\,(Q+V) + e\rho\left(\underline{E} + \frac{1}{c}(\underline{v} \times \underline{B})\right) \qquad (3)$$

where

$$Q = -\frac{\hbar}{2m}\frac{\nabla^2 \rho^{1/2}}{\rho^{1/2}} \qquad (4)$$

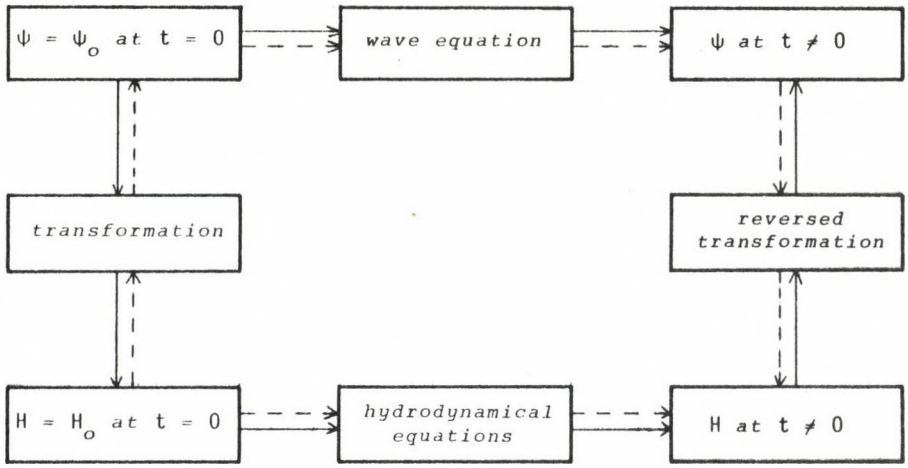
and

$$\frac{d\underline{v}}{dt} = \frac{\partial \underline{v}}{\partial t} + (\underline{v}\ \mathrm{grad})\ \underline{v}.$$

(2), (3) and (4) are mathematically equivalent to the wave equation (1). Thus the motion of a system can be described equally well in terms of the wave function ψ as in terms of the hydrodynamical variables

$$H = \rho,\ \underline{v}. \qquad (5)$$

The variables H have to satisfy a so called Cauchy-condition – i.e. an initial condition which is, however, compatible with the equations of motion. If these conditions are satisfied the transformations (2) are reversible uniquely. The detailed analysis of this procedure has been given in previous publications. So as to avoid misunderstanding we present a scheme which shows how very close the connection is between the hydrodynamical equations and the wave equations.



From the scheme it follows that we can describe the initial condition of a physical system in terms of the wave function which is given by $\psi = \psi_o$ *at* $t = 0$. *The state of the system at any other time* $t \neq 0$ *can be determined by the wave equation (1).*

The same result is obtained if we transform ψ_o *and find thus* $H = H_o$ *at* $t = 0$; *calculating* H *at* $t \neq 0$ *from the initial condition with the help*

of the hydrodynamical equations and using the reversed transformations we obtain eventually ψ from H. This procedure is indicated by full arrows in the scheme.

We can, however, also start from an initial condition $H = H_o$ at $t = 0$ and may obtain H at $t \neq 0$ either directly via hydrodynamical equations or indirectly transforming H_o into ψ_o calculate the change with help of the wave equations and finally transform ψ at $t \neq 0$ back to H at $t \neq 0$.

We see thus that ψ and H describe the motion of the system in equivalent manners; ψ and H are changing in such a way that provided at $t = 0$ $\psi_o \rightleftarrows H_o$ the initial conditions are equivalent. We have at any time $t \neq 0$

$$\psi \rightleftarrows H$$

provided ψ and H are taken to change according to the wave equation (1) respectively the hydrodynamical equations (3) and (4).

The analysis has been carried out not only for the wave equations of the form (1) but also for the Pauli equations and also the Pauli equations including spin orbit interactions.

It is a remarkable fact that the hydrodynamical equations obtained in the various cases contain only directly observable quantities. They contain the electric and magnetic field strengths $\underline{E}$ and $\underline{B}$ but do not contain the potentials $\underline{A}$ and Φ. Furthermore they do not contain the Pauli matrices explicitly but only a vector field $\underline{T}(\underline{r},t)$ which represents the direction of magnetic polarization of the medium. In this way the hydrodynamical variables are invariant with respect to the Weyl-Pauli group.

The wave function is not invariant with respect to this group; therefore the change of ψ in time is not determined fully by an initial condition but it requires also a particular choice of the gauge of the potentials and the representation of the Pauli operators.

It is evident that the physically significant quantities are given by expressions containing ψ which are invariant with respect to the Weyl-Pauli group. Such expressions are the hydrodynamical variables. However, this invariance property does not determine the hydrodynamical variables fully — one parameter remains undetermined. The latter can be determined by the further requirement that the variables should express directly physically significant quantitites — i.e. $m\rho\underline{v} = \underline{p}$ should correspond to density of momentum and another condition concerned with the magnetic polarization of the medium.

SOME APPLICATIONS

For most of the applications of the hydrodynamical model it is essential to determine the outer electromagnetic field the physical system produces which is described by ψ or alternatively H. This can be done by calculating the retarded potentials

$$\underline{A}^{(out)}(\underline{r},t) = \int \frac{\underline{i}(\underline{r}',t')}{|\underline{r}-\underline{r}'|}\, d^3\underline{r}', \qquad \Phi^{(out)}(\underline{r},t) = \int \frac{\rho_e(\underline{r}',t')}{|\underline{r}-\underline{r}'|}\, d^3r' \qquad (6)$$

$$t' = t - |\underline{r}-\underline{r}'|/c.$$

If we start from the wave equation (1) then we have

$$\rho_e = e\rho, \qquad \underline{i} = e\rho\underline{v}/c. \qquad (7)$$

(In the treatment of the spinning electron further terms appear.)

Equations (6) are made use of in all applications of wave mechanics; in our considerations we prefer $\underline{i}$ and ρ_e to treat as real current and charge distribution which in accord with the Maxwell equations gives rise to an outer field.

It is a terminological difference (of not much consequence) if we maintain that the electron is concentrated in a point and ρ_e and $\underline{i}$ give probability densities. Using the latter terminology we have to take $\underline{A}^{(out)}$ and $\Phi^{(out)}$ as given in (6) as the <u>expectation</u> values of the potentials and we have to suppose that for the action of the system outside itself the <u>expectation</u> values (rather than the instantaneous values) are significant. The latter assumption is equivalent to the one that ρ_e and $\underline{i}$ describe real source densitites and their distribution inside the atom.

Using the above formalism we obtain e.g. that an atom which is in a mixed state

$$\psi(\underline{r},t) = \varphi_1(\underline{r})e^{-i\omega_1 t} + \varphi_2(\underline{r})e^{-i\omega_2 t}$$

carries out oscillations and emits electromagnetic radiation with frequency $\omega_{12} = \omega_2 - \omega_1$. The polarization of the radiation corresponds to that of an oscillating dipole, the amplitude vector of the dipole being

$$\underline{\Pi}_o = e\left(\int \underline{r}\varphi_1^*\varphi_2 d^3\underline{r} + \text{complex conjugate}\right).$$

In the case where

$$\underline{\Pi}_o = 0$$

no dipole radiation with frequency ω_{12} is emitted — in the latter case the mode of oscillation is such that multipole radiation is being emitted.

If the atom is in a constant outer field then this field gives rise to polarization and the outer field of the atom gives a dipole field which is observed in a polarized dielectricum. In the case of an atom subject to an outer radiation field — we obtain by the formalism the induced radiation which together with the primary radiation is observed as refraction and diffraction phenomena.

INTERACTION WITH LIGHT OF HIGH INTENSITY

If an atom is subjected to electromagnetic radiation then one finds by solving the wave equation (1) that the perturbation caused by the radiation gives rise to a steady outflow of the electron; the latter effect is the ordinary photo effect. The rate of flow is proportional to the intensity of the perturbing radiation — and the momentum of flow is in accord with the conservation laws. This consideration leads to the theory of the photo effect valid for low intensities of light.

Considering higher intensities of incident light it becomes insufficient to consider the process in terms of a first order perturbation. Developing in powers of the incident energy one is led to further perturbation terms which correspond in the usual terminology to two or more photon photo effects.

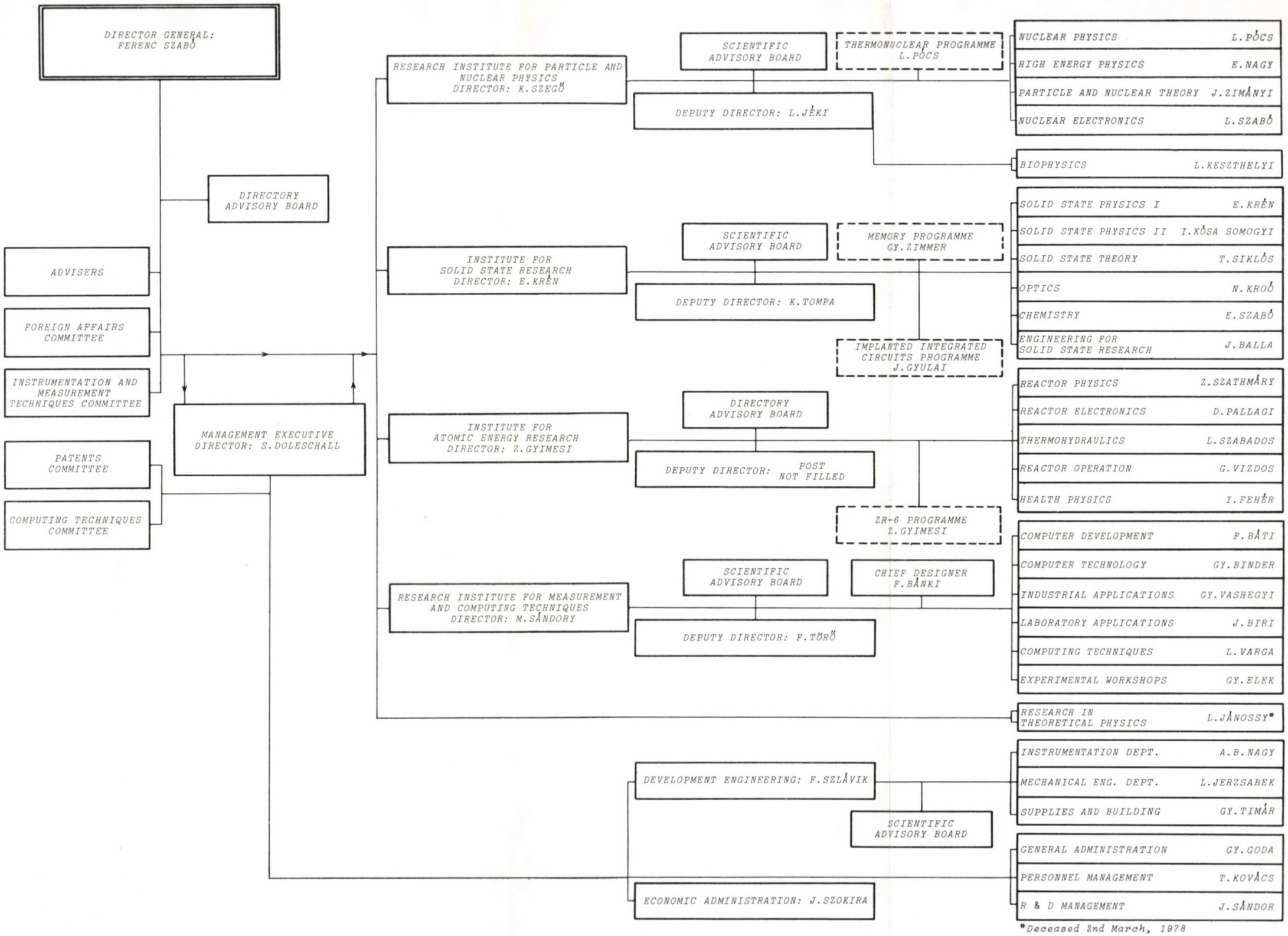
Treating the problem in terms of the hydrodynamical equations one is necessarily led to the same results as using the wave mechanical treatment since the methods are equivalent. This is, however, only true for the exact solutions of the wave equations or of the hydrodynamical equations. In the case of approximate solutions there is always the danger that because of the approximations the one or the other method breaks down and leads to unreliable results.

The hydrodynamical model leads to a particularly simple picture in the case of extreme high intensities of light. To show this consider for the moment a metal and consider as model an electron enclosed into a potential barrier. If we apply a strong electromagnetic field to this cloud then — if the field strength is sufficiently large — field emission sets in. In the case where an electromagnetic wave falls on a cloud then we expect field emission for at least part of the period — if the amplitude is strong enough. This field emission is independent of the frequency of the incident light. In the case of lower amplitude the electromagnetic wave cannot pull out parts of the cloud during one period, in

this case a kind of resonance effect helps in the process of emission. This latter process becomes predominant in the case of low intensities when the original Einstein relation appears to be valid exactly.

Without going into details we note that in the case of the photo emission caused by light of high intensity a strong dependence of the photo emission on the state of polarization of the incident light was observed. The photo emission is relatively strong if the light is so polarized that the electric field strength of the incident light possesses a considerable component perpendicular to the surface of the photocathode. The latter circumstance shows clearly that a sufficiently strong field largely independent of frequency can pull out electrons of the surface.

The quantitative treatment of the effect has not been completed so far — we give this effect merely as an interesting example for consideration.



*Deceased 2nd March, 1978

FUNDAMENTAL PROBLEMS OF PHYSICS

*L. Jánossy**, *A. Ádám*, *P. Király*, *A. Werner*, *Mária Ziegler-Náray*

Due to the untimely death of Professor Jánossy who had been the head of research work on fundamental problems of physics, it became one of the main tasks of his close collaborators to deal with his scientific heritage. A compilation of his recently published scientific works was made and it has been published as the sixth volume of his collected papers. Unpublished manuscripts have been put into systematic order and are, at least in part, being prepared for publication. A compilation of his scientific correspondence is also to be published.

Research on the classical and quantum characteristics of electromagnetic radiation has been continued, mainly by a critical study of recently published experimental results. Our seminars, with participation of research workers from several fields, have been continued on a somewhat broader range of topics than previously.

Work on cosmic ray physics has been continued in collaboration with members of the Cosmic Ray Department of our Institute as well as with research workers of the University of Durham, Durham, England. A review paper on the experimental and theoretical aspects of cosmic ray anisotropy over nine decades of energy has been submitted for publication. The interrelationship between the slow spatial variation of the interstellar wind and the constancy of the phase of maximum of cosmic ray anisotropy over three decades of energy has been clarified. New upper limits have been obtained for the discrete source contribution to the gamma rays observed by the COS-B satellite. Both results have been submitted for publication.

The physics - mathematics education experiment in secondary school teaching, initiated by Professor Jánossy, is being continued with the participation of members of this group. Three new booklets have been

*Deceased 2nd March, 1978

prepared to aid this programme. The second and third volumes of a university textbook on vector analysis, based on the manuscripts of the late Professor Jánossy, are being prepared for publication.

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RESEARCH INSTITUTE
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RESULTS

THEORY OF RELATIVITY AND ASTROPHYSICS

B. Lukács, Z. Perjés, Á. Sebestyén

Solutions of Einstein's equations with nongeodesic shearfree eigenrays for both spacelike and timelike Killing symmetries were obtained using the three dimensional spin coefficient method. The electrovac generalization of these metrics having common eigenrays has been constructed. Thus we have exhausted three cases of the possible four.

In twistor theory a new picture of particle internal properties has been obtained. The space of internal quantum numbers is, therein, elevated to the status of a manifold. A low-mass hadron, which is an extended object in space-time, turns out to be pointlike in the internal manifold.

The algebra of 4-twistor particles has been analysed in detail. A 4-twistor particle is represented by a pair of spinning points in the internal space. It is currently conjectured that 4-twistor particles model newly discovered hadrons.

In studying empty static space-times a tetrad formalism has been developed in which the timelike field of the tetrad is parallel to the Killing field of the manifold. This formalism enables one to construct a concise and elegant mathematical apparatus which we have called protensor analysis. The use of this method makes it possible to write down Einstein's equations in a rotationally covariant form and to easily incorporate additional conditions specifying the solutions of the problem.

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4. B. LUKÁCS: Solutions of the SU(1,1) spin coefficient equations with nongeodesic eigenrays. KFKI Report 78-81 (1978)

5. B. LUKÁCS: Concise relativistic continuum mechanics for heavy ion physics. KFKI Report 78-82 (1978)

THEORETICAL PARTICLE PHYSICS AND FIELD THEORY

A. Frenkel, P. Hasenfratz, P. Hraskó, M. Huszár, J. Kuti, Julia Nyiri, K. Szegő, K. Tóth

The various contraction schemes of the Poincaré group in the infinite momentum limit have been studied with special regard to the connection between these schemes and the physical content of some models in high energy physics, such as the parton model and the multiperipheral model.

The possibility of unifying some subgroup of the conformal group and unitary symmetry groups has been investigated. The emerging inhomogeneous unitary group seems to be of practical use for describing some properties of the elementary particles.

The relativistic invariance of the theory of the Dirac monopole has been further studied. The main line of our work on the magnetic monopole is shifting towards applications in particle physics.

The study of "bag" type field theoretical models has been continued with special emphasis on the application of the most modern methods in quantum field theory. In the framework of the "CERN-bag" model the dynamical description of the baryons has led to some results.

A remarkable amount of work has been devoted to a better understanding of the relationship between the renormalization groups of the Wilson and Bogolubov type in order to apply renormalization group methods in quantum chromodynamics.

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*Eötvös Loránd University, Budapest

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EXPERIMENTAL PARTICLE PHYSICS - COUNTER TYPE MEASUREMENTS

G. Jancsó, D. Kiss, I. Mannó, E. Nagy, L. Urbán, Gy. Veszterombi

Final results have been reached in the search for charmed particles using the BIS on-line magnetic spectrometer at Serpukhov, USSR. In the experiment, carried out in collaboration with teams from Dubna, Berlin, Sofia and Tbilisi, upper limits have been estimated for the cross section of inclusive charmed particle production in 40 GeV nC interactions by looking for $\Lambda\pi$, $K\pi$, $\Lambda\pi\pi$, $K\pi\pi$ final states.

Two members of the group continued their research activities at the CERN Intersecting Storage Rings (ISR). One of them participated in the CERN-Hamburg-Heidelberg-Annecy-Vienna Collaboration, where final results have been obtained in the study of the large angle pp elastic scattering at ISR energies (see *Fig. 1*). The analysis of the differential cross section shows that the elastic scattering becomes predominantly diffractive at ISR energies, even at high momentum transfers such as $-t \gtrsim 4$ GeV^2, and the t-range increases with the energy where the concept of the geometrical scaling holds.

Another member participated in the British-French-Scandinavian Collaboration to study the large p_T phenomena and correlations in multiparticle final states in proton-proton collisions. The analysis shows that the events have a complex structure consistent with a composition in terms of *Fig. 2*.

a) A TRIGGER side jet, consisting mainly of the trigger particle itself. This particle carries, on average, about 95% of the jet transverse momentum. Two body resonances including the trigger particle have been observed (uncorrected for acceptance) at the 5% level.

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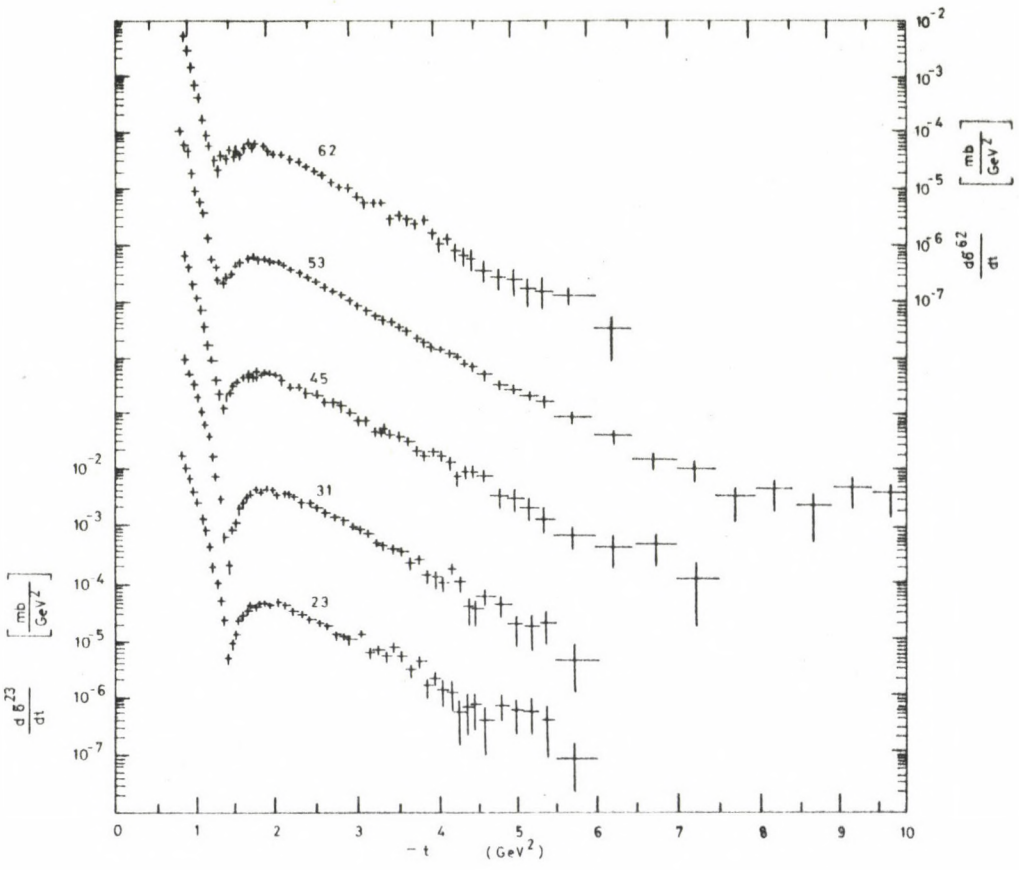

Fig. 1

Differential cross section of the pp elastic scattering measured at the CERN ISR

b) An AWAY side jet with a changing direction from event to event, giving rise to a broad average distribution in rapidity of AWAY side particles. These show approximate scaling in x_E for $p_{TRIG} \gtrsim 3$ GeV/c.

c) An underlying event, with two FORWARD jets, to some extent resembling normal inelastic events, but with a small recoil to the trigger particle.

Two members of the group have been working on the preparation of the μp deep inelastic scattering to be carried out in collaboration between CERN, Dubna, Munich and Saclay. A third member joined an analogous experiment of the European Muon Collaboration.

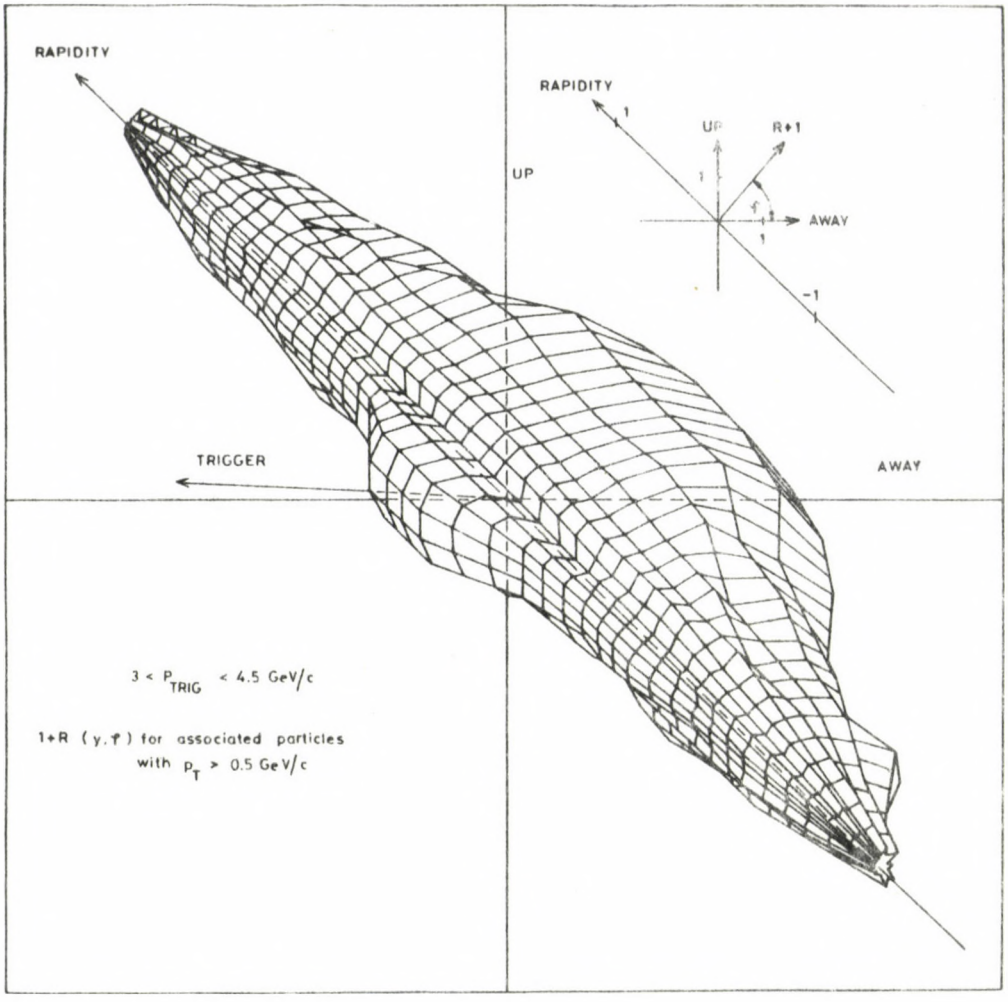

Fig. 2

Average density of the particles in high p_T events relative to the density in normal inelastic events, as a function of rapidity y and azimuth φ

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*Joint Institute for Nuclear Research, Dubna, USSR

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EXPERIMENTAL PARTICLE PHYSICS - MEASUREMENTS WITH HYBRID DETECTORS

E. Dénes, G. Eszes, T. Gémesy, K. Hajdu, Ágnes Holba, E. Nagy, G. Pintér, Cs. Postásy, J. Spitzer, J.D. Tóth, L. Urbán

The group, divided into three teams, is participating in the preparation of two major experiments to be carried out using electronic particle detectors in combination with a streamer chamber.

The first team is concerned with the RISK spectrometer which has been moved to the experimental hall of the proton synchrotron of the Institute for High Energy Physics, Serpukhov, USSR. After installing the equipment, a methodological and a physical test took place. During the physical test, about 5000 anti-deuteron events were recorded on films and on magnetic tapes. The off-line data processing programs on our ES 1040 computer have also been improved.

The second team is participating in setting up the software chain of the vertex detector system of the European Muon Collaboration. This system, consisting of a 2m long streamer chamber and associated particle

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identifiers together with an existing forward spectrometer, will be used to study complete exclusive final states in the deep inelastic scattering of muons and hadrons.

The third team is dealing with the processing of the streamer chamber pictures, in particular, it contributed to the design of a new automatic measuring system known as RIMA.

STUDY OF ELEMENTARY PARTICLES IN A BUBBLE CHAMBER

T. Gémesy, Livia Jenik, S. Krasznovszky, G. Pintér

The investigations into relativistic nuclear physics have been continued. A target consisting of three 1 mm tantalum (A=181) plates was placed in the working volume of the 2m propane bubble chamber. The chamber was exposed to p, d, He and C beams at momenta of (2-5) GeV/c per nucleon.

The inelastic cross sections of the interactions of p, d, He and C with carbon and tantalum nuclei at P_o = 4.2 GeV/c were obtained. The experimental cross sections are in satisfactory agreement with the predictions of one of the geometrical models (see *Fig. 3*).

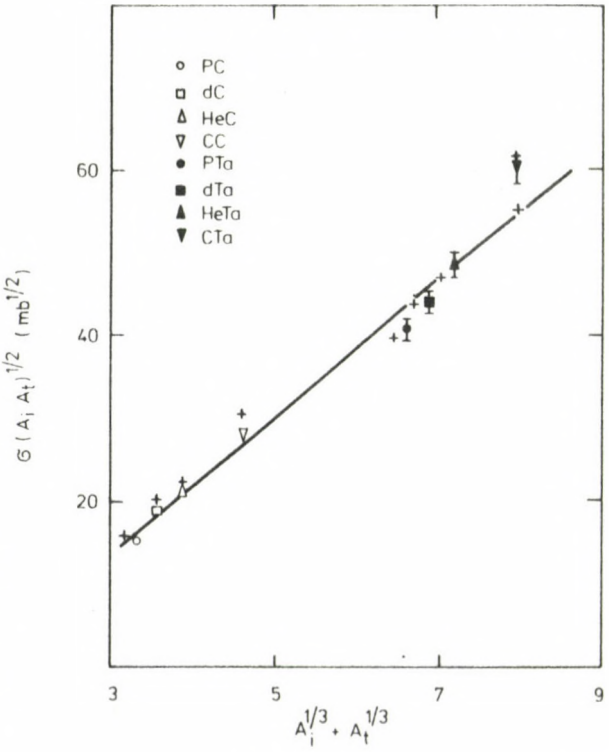

Fig. 3

Inelastic cross section versus the atomic weight of projectile nucleus A_i and target nucleus A_t. The solid line corresponds to the calculation using the geometrical model

The dependence of secondary particle multiplicities on the number of interacting nucleons of the projectile nucleus $\langle \nu_i \rangle$ was investigated. The multiplicities of π-mesons and fast protons ($P_p \geq 700$ MeV/c) grow approximately proportionally to $\langle \nu_i \rangle$, while the change of the g-particle multiplicity becomes slower with increasing $\langle \nu_i \rangle$ (see *Fig. 4*).

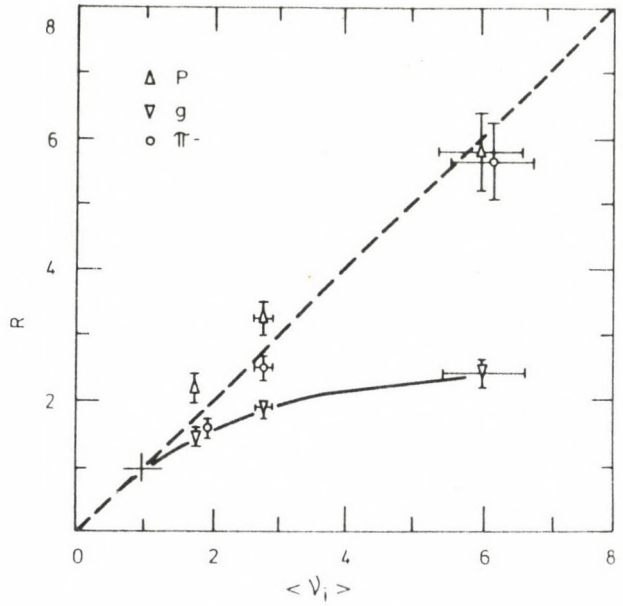

Fig. 4

Normalized multiplicities for fast protons with $P_p \geq 700$ MeV/c, g-particle and π^--mesons versus the average number of interacting nucleons of the projectile nucleus ($\langle \nu_i \rangle$)

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ANISOTROPY OF HIGH ENERGY GALACTIC COSMIC RADIATION

G. Erdős, T. Gombosi, J. Kóta, A.J. Somogyi, A. Varga

After successful demonstration of the existence of first and second harmonics in the 10^{13}-10^{14} eV galactic cosmic radiation region (see Yearbook '76 of the Central Research Institute of Physics, p. 11), the possibility of increasing the accuracy of measurement and extending measurements to the 10^{14}-10^{16} eV region were investigated.

The performance of large sized (500x10x10 cm) proportional counters as tools for long term detection of extensive air showers produced by 10^{13}-10^{16} eV primary particles was investigated in cooperation with the Institute for Cosmic Ray Research of the University of Tokyo and the Cosmic Ray Research Laboratory of the University of Nagoya, Japan. The measurements carried out at the Extensive Air Shower Station at Akeno, Japan, showed that the proportional counters of the type investigated had inefficiencies less than $1.7\times10^{-3} + (2.4\pm0.9)\times10^{-5}$ T with T being the room temperature in degrees centigrade; and various other temperature instabilities were less than 10^{-4} ^{o}C. Proportional counters of the type investigated are thus suitable for measuring cosmic ray intensity variations of the order of 10^{-4} even at moderately stabilized (e.g. to $\pm$ 5 ^{o}C) temperatures.

The theory of correlated detector sets was worked out to achieve sufficiently high measured fluxes of high energy (10^{15}-10^{16} eV) particles and thus to decrease statistical fluctuations below a level allowing the extension of anisotropy measurements to the energy region 10^{15}-10^{16} eV.

THEORETICAL INVESTIGATIONS IN COSMIC RAY PHYSICS

G. Erdős, J. Kóta, A.J. Somogyi

In an attempt to interpret the anisotropy of 10^{13}-10^{14} eV galactic cosmic rays, earlier we suggested that the rise of a second harmonic could be attributed to anisotropic pitch angle scattering in interstellar space. The implications of this model have now been examined in detail and have enabled us to conclude that, to match the observed ratio of second to first harmonics, the local interstellar magnetic field should point toward declinations around 30^{o}, while the spectrum of the field-fluctuation should be steeper than $k^{-1.5}$. The latter finding is supported by the near constant magnitude of the anisotropy over two decades of energy, and is also consistent with the -5/3 exponent of the Kolmogorov spectrum expected on theoretical grounds.

Numerical investigations were carried out to study the anisotropies of solar origin in the 50-1000 GV region where diffusion should be ineffective. We considered regular particle motion - with no diffusion - in the large scale interplanetary magnetic field. Energy losses along various computed trajectories were compared to give the anisotropy predicted. By assuming a co-rotating warped current sheet to separate the two polarities of the interplanetary magnetic field, we were able to explain all the main features of the high-rigidity variations observed. The warped shape of the current sheet is essential in producing anisotropy. In our model were reproduced the co-rotation together with its cut-off between 50 and 100 GV, the polarity dependent sidereal variation, the semidiurnal variation as well as some of the changes which were taking place in 1969 in connection with the reversal of the solar magnetic field.

Theoretical arguments were brought forward to point out that the imperfect co-rotation might be responsible for the semidiurnal variation at neutron monitor energies. The rigid co-rotation is proportional to the heliocentric distance. The slower-than-linear increase of co-rotation may give rise to tensor-type anisotropy which appears in semidiurnal intensity variation.

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INVESTIGATIONS WITH UNDERGROUND MUON TELESCOPES

G. Benkó, G. Erdős, K. Kecskeméty, J. Kóta, G. Neuprandt, A.J. Somogyi, A. Varga

The energy range of 10^{11}-10^{12} eV forms an intermediate region where the influence of the interplanetary magnetic field on galactic cosmic rays tends to disappear. The underground muon telescopes operating in the Institute since 1958 and registering cosmic rays of these energies have made it possible to determine the upper energy limit of the solar modulation. During the past year we extended our study by including sidereal time variations and the power spectrum of fluctuations.

Periodic variations in sidereal time carry important information both on galactic anisotropy and on solar effects. By analysing bi-hourly intensity data in the period 1958-1963 the first two sidereal harmonics

were determined on a year-to-year basis. This analysis was also performed separately for the periods when the Earth was in the sectors of alternating polarities of the interplanetary magnetic field. A marked difference was observed in the phases of the two diurnal waves, while both vectors shifted gradually toward earlier hours during subsequent years. Combining our results with those of the Southern hemisphere Hobart underground station, Tasmania, Australia, we were able to disentangle solar and galactic effects and point out the existence of galactic anisotropy at $\sim 10^{11}$ eV. The anisotropy vector obtained has an amplitude of 0.02% and time of maximum at ~5 h.

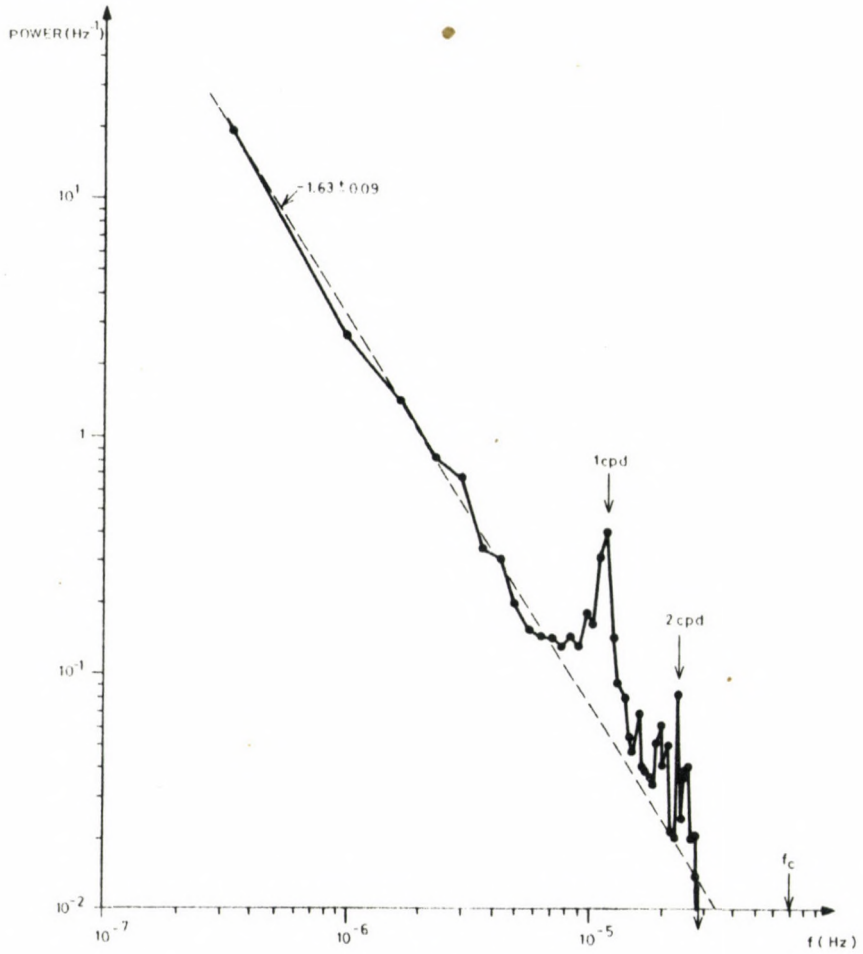

Fig. 5

Power spectrum of the fluctuations of underground muon intensity variations, Budapest, 1958-1963. Arrows indicate first and second harmonics of diurnal variation, 1 and 2 cycles per day (cpd), f_c is the Nyquist frequency

In addition, we have performed the power spectral analysis of the intensity variations corrected for meteorological effects for the above period. In the frequency range of 2.8×10^{-8} to 7×10^{-5} Hz significant peaks have been found at the frequencies corresponding to 1 and 27 days together with their several higher harmonics. Apart from these peaks the frequency dependence in the spectrum derived is well described as $P(f) \sim f^{-1.6}$ in the whole frequency range examined (*Fig. 5*). The performance of a cross spectral analysis of corrected data with the atmospheric pressure and height of 200 mb isobaric level enabled the meteorological origin of the fluctuations to be excluded. A similar analysis showed no correlation between the intensity variations and sector structure of the interplanetary magnetic field.

SPACE RESEARCH

T. Gombosi, G. Huba, K. Kecskeméty, J. Kóta, Erzsébet Merényi, A.J. Somogyi, Annamária Szentgáli-Páldi, Mariella Tátrallyay, A. Varga

In 1978 we continued processing the data of the satellite Prognoz-5 and began the data processing for the satellite Prognoz-6 launched on 22 September 1977. At the same time, further analyses and interpretations of the data obtained by the satellites Prognoz-3, Prognoz-4, Prognoz-5 and Prognoz-6 were carried out in collaboration with scientists of the Nuclear Research Institute of the Moscow State University and the Space Research Institute, Moscow, USSR. We have completed a catalogue of data measured by the satellite Prognoz-3. This cataloque will present the hourly averages of proton fluxes in three energy intervals (1-5 MeV, 14-30 MeV and E>40 MeV) and that for electrons of E>40 keV.

Two solar particle events associated with the flares of 24 September and 22 November 1977 were studied on the basis of observations made on board the satellite Prognoz-6. *Figure 6* shows the spectra of electrons and protons for both events. The electron spectrum may be approximated by a power law with an exponent $\gamma \approx 2$ for the interval 0.01-10 MeV. The proton spectrum has a rather sharp break around 1 MeV with a spectral exponent $\gamma \approx 0.6$-0.7 between 0.07 and 1 MeV; at higher energies $\gamma \approx 2$. Since the flare on 22 November 1977 occurred over a very quiet background, it was possible to compare the observed particle fluxes with calculated values using a diffusion coefficient $\kappa = \kappa_o r^{\beta}$ in the model. The values of κ_o and β were determined by the least squares method. For protons the following relation can be established in the interval 0.085-50 MeV

$$\beta = 1.3 - 0.15 \lg E \ [\mathrm{MeV}].$$

κ_o is nearly constant between 0.1 and 10 MeV and there is a remarkable increase towards higher energies. Time of particle escape from the corona into the interplanetary space as well as the grammage traversed by the particles were estimated.

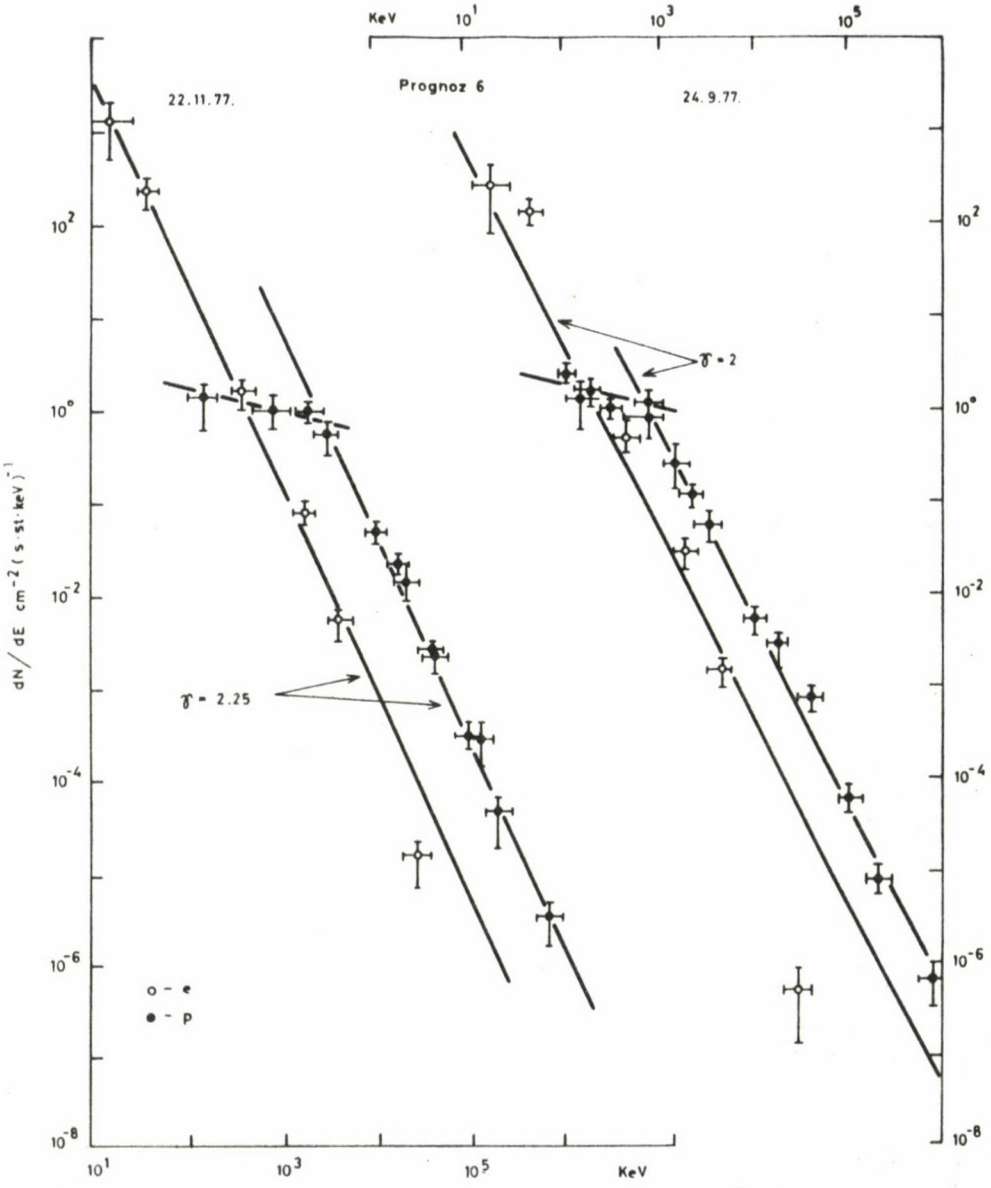

Fig. 6

Proton and electron energy spectra measured by Prognoz-6 for the flares of 24 September and 22 November 1977

The acceleration of charged particles by flare-generated interplanetary shock waves was investigated on the basis of observations of energetic storm particle (ESP) events. These events can be seen in the intensity variation of energetic solar particles superimposed on flare particle events at the time of the passage of the shock wave. In three energy channels between 1 and 80 MeV, the particle fluxes were analysed for 20 events of the period 1967-1972 in connection with the time behaviour of several plasma parameters at the shock front. We established a relationship between the total energy carried by particles appearing in the ESP event and the magnitude of the pressure jump at the discontinuity. It is pointed out that the amount of shock energy converted to the acceleration of ESPs in not negligible and contributes to the deceleration of the shock wave.

Together with Soviet scientists we continued the interpretation of plasma data measured by the satellites Venera-9 and Venera-10. As a result of a detailed study of a great quantity of measurements, it was proved that the interaction between the solar wind and Venus is basically not of magnetic character. By analysing further measurements, it was confirmed that electrons play an important role in the formation of the Venusian night-time ionosphere, as already published in 1977. These electrons of an average energy of about 40 keV get into the umbra of Venus as a result of the interaction of the planet's atmosphere and the solar wind.

In course of the International Magnetospheric Study, the geophysical observatories of the world and the space probes in the magnetosphere performed coordinated observations between 1 December and 12 December 1977. In collaboration with Soviet scientists we processed the magnetic field and plasma data measured by the satellite Prognoz-6 within 3 months and were thus able to present them at the IMS Symposium organized in the framework of the COSPAR conference in June, 1978.

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2. V.G. KURT**, YU.I. LOGACHEV**, V.G. STOLPOVSKII**, N.F. PISSARENKO*, M. GROSS***, A. RAVIART***, L. TRIEGER***, T. GOMBOSI: Analysis of energetic particle events following solar flares of September 24 and November 22, 1977. KFKI Report 78-37 (1978)

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FOREIGN RELATIONS

LECTURES BY VISITING SCIENTISTS

E.T. Newman	(University of Pittsburg, Pittsburg, Pennsylvania, USA) The theory of H space
J.H. Weis	(CERN, Geneva, Switzerland) Parton model and quark confinement in two dimensional QCD
D. Pottinger	(University of Dublin, Dublin, The Republic of Ireland) Semiclassical description of extended objects in quantum field theory
G. Preparata	(CERN, Geneva, Switzerland) Geometrodynamics
J.J. Aubert	(Laboratory d'Annecy de Physique des Particles, Annecy, France) The future accelerator of Europe: the large electron positron storage ring
H. Vogel	(Deutsches Elektronen Synchrotron, Hamburg, FRG) Observation of the $\underline{\gamma}$ in e^+e^- collisions
V.E. Barnes	(Fermi National Accelerator Laboratory, Chicago, Illinois, USA) Antineutrino experiments at Fermilab
K.I. Gringauz	(Space Research Institute, Moscow, USSR) The plasma of the magnetosphere and the interplanetary medium
S. Pintér	(Geophysical Institute of the Slovak Academy of Sciences, Hurbanovo, Czechoslovakia) Prediction of the incidents of solar-terrestrial relationships

STAFF MEMBERS ON STUDY TOURS

E. Dénes	Joint Institute for Nuclear Research, Dubna, USSR	3 years
Livia Jenik	Joint Institute for Nuclear Research, Dubna, USSR	2 years
P. Hasenfratz	University of Guelph, Canada	3 months

J. Kuti	Laboratory of Theoretical and Particle Physics, Orsay, France	1 ½ months
I. Mannó	Joint Institute for Nuclear Research, Dubna, USSR	6 years
Julia Nyiri	Joint Institute for Nuclear Research, Dubna, USSR	2 years
L. Urbán	Annecy Laboratory of Particle Physics, Annecy, France	2 years
Gy. Vesztergombi	Joint Institute for Nuclear Research, Dubna, USSR	8 years
I. Wagner	Joint Institute for Nuclear Research, Dubna, USSR	4 years
A.J. Somogyi	Institute of Cosmic Ray Research, University of Tokyo, Tokyo, Japan	9 months
A. Varga	Lebedev Physical Institute, Moscow, USSR and High Altitude Observatory, Tien-Shan, USSR	2 months

GUEST SCIENTISTS AND FELLOWS

J. Szwed	Jagellonian University, Cracow, Poland	1 month
K.I. Gringauz	Space Research Institute, Moscow, USSR	1 month
S. Pintér	Geophysical Institute of the Slovak Academy of Sciences, Hurbanovo, Czechoslovakia	1 month
M.I. Verigin	Space Research Institute, Moscow, USSR	1 month

THESES

M. Tátrallyay	On the determination of alternating electromagnetic fields in two-dimensional structures using the finite difference method. (For the academic degree of Candidate of Geosciences)
T. Gombosi	The interaction between flare particles and the interplanetary medium. (For the academic degree of Candidate of Physical Sciences)

Á. Sebestyén	An extension of the principle of covariance to closed systems. (For the academic degree of Candidate of Physical Sciences)
J. Spitzer	Inclusive and semi-inclusive analysis of neutron interactions at 40 GeV/c. (For Ph.D. degree)

RESULTS

THEORETICAL NUCLEAR PHYSICS

Gy. Bencze, I. Borbély, L. Csernai, P. Doleschall, T. Dolinszky, J. Lovas, J. Polónyi, J. Révai, J. Zimányi

The investigations now in progress cover a wide spectrum of nuclear theory, ranging from problems of the hadron structure through the N-body scattering up to such complex processes as the heavy ion reactions.

With regard to the nucleon-nucleon interaction, it has been pointed out that the One-Boson Exchange Model (OBEM) supplies rather small values of the coupling constants for interactions involving the vector meson ϕ and the scalar resonances δ and S^*. In view of the fact that ϕ, δ and S^* contain strange quark - antiquark pairs, these particles can be formed only via the violation of the Okubo - Zweig - Iizuka (OZI) rule. Weakness of the couplings discussed seems to reinforce the validity of the OZI rule as far as the N-N interaction is concerned. By virtue of the OZI rule, the number of simultaneously exchanged mesons is limited by the number of quark constituents of the nucleon. Therefore, the OZI rule may provide an explanation for the success the OBEM has had.

Previous studies of the short wavelength limit in scattering on singular potentials have been extended to include an analysis of the residual term within the continuous cut-off (CCO) phase approach for the whole class of singular interactions. The exact asymptotic formulae obtained work the better the more singular is the potential. The same is true of the 'turning point approximation' of the asymptotic phase shift for the singular case.

The technique of the CCO-approach has also been generalized to yield a correct mathematical treatment of the high energy Dirac scattering in the higher partial waves, too. By means of a new type of phase equations, explicit formulae have been derived for the phase shifts and the wave functions, which become exact in the high energy limit. In contrast to the standard Parzen formula, the CCO phase shift supplies new information on the interactions at each energy.

The numerical study of three-nucleon systems has been continued by working with separable interactions that reproduce the results of the phase shift analysis for n-n scattering up to 400 MeV. The main point was to see to what extent vector and tensor polarizations depend on the properties of the N-N interaction as well as how theory and experiment agree in this field.

The theoretical basis as well as the practical methods for the empirical continuation of the differential cross section into the non-physical region of the variable cos ϑ have been reexamined. Equivalence of the available methods has been proven. Conditions for the applicability have been given and the published applications reviewed. The correct procedure has been found in many cases to provide insignificant or even incorrect structure information. Therefore, experimental data should be analysed in a statistically complete manner, based on a physical understanding of the process.

The theory of scattering involving N identical particles gives rise to nontrivial mathematical problems concerning symmetrization (antisymmetrization) of the observables. A general algebraic theory of 'identical particle scattering' has been developed, which can be applied to a wide class of N-particle scattering integral equations. The theory makes use only of the permutation symmetry of the N-particle system specified by its permutation group. In view of this, the method can equally be applied to bosons and fermions as well as to an arbitrary number of kinds of identical particles.

In the field of nuclear models, non-statistical effects influencing the El gamma strength have been studied. Detailed realistic shell model calculations have been performed for ^{116}Sn, including an analysis of the strength distribution. Simple schematic model calculations have confirmed the existence of low lying states of strength coming up to within some few per cent of the total strength. In view of the non-statistical nature of the fine structure background states, different possibilities for the strength distribution have been scrutinized.

As regards heavy ion reactions, the disintegration stage of a hot zone in a high energy process has been examined in terms of hydrodynamics. The initial non-homogeneously compressed matter is assumed to have an oblate shape. An approximate solution to the hydrodynamic equations is obtained by solving a pair of coupled nonlinear differential equations for the semiaxes of the boundary. The boundary passes through a spherical shape and finally ends in a prolate configuration as rarefaction proceeds. Good agreement between model calculations and experiment has been established for the angular distribution of the central collision in the processes C+Ag and O+Ag, at energies of about 200 MeV/nucleon. Comparison

with experiment allows one to estimate the ratio between the major and the minor axes of the initial oblate shape. Both nonhomogeneity and shape asymmetry have been found to lead to enhanced forward and backward ejection of matter in the c.m. frame.

The relaxation times necessary to establish chemical equilibrium between different hadrons in a hot, dense hadronic matter are investigated in a statistical model. The consequences for heavy ion collisions are exploited in the framework of a simple reaction model. The possibility of Bose-Einstein pion condensation about the break up time of the nuclear fireball is pointed out.

The transfer processes in heavy ion reactions have been studied in terms of the molecular model. The recoil effect was taken into account by a matrix transformation applied to the adiabatic S-matrix.

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ISOBARIC ANALOGUE RESONANCES

Ilona Lovas-Fodor, J. Sziklai

Resonances consistent with fragmented $g_{9/2}$ analogue resonance have been found in ^{53}Mn corresponding to the E_x = 3.715 MeV level in the ^{53}Cr parent nucleus. The resonances were located through the $^{52}Cr(p,\gamma)^{53}Mn$ reaction. Total γ spectra were measured with a Ge(Li) detector in 2 keV steps in the expected proton energy range. Excitation functions for the different primary transitions were constructed (see *Fig. 1*).

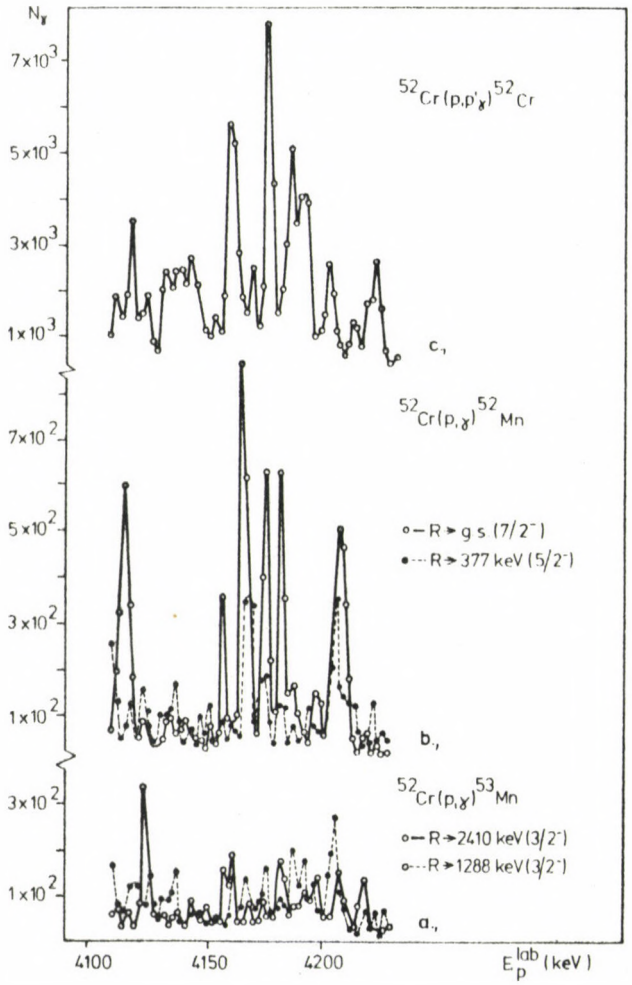

Fig. 1

Excitation functions of the different primary γ transitions in the $^{52}Cr(p,\gamma)^{53}Mn$ reaction (a, b) and the $^{52}Cr(p,p'\gamma)^{52}Cr^*$ process (c)

The $g_{9/2}$ IAR was found in nine components at E_p = 4115, 4134, 4140, 4157, 4165, 4167, 4182, 4188 and 4197 keV. The angular distribution of γ rays was measured on the five strongest resonances which were suggested as having spin J = 9/2 based on the γ excitation functions and branching ratios. The absolute gamma transition strength distribution was fitted with a strength function (see *Fig. 2*).

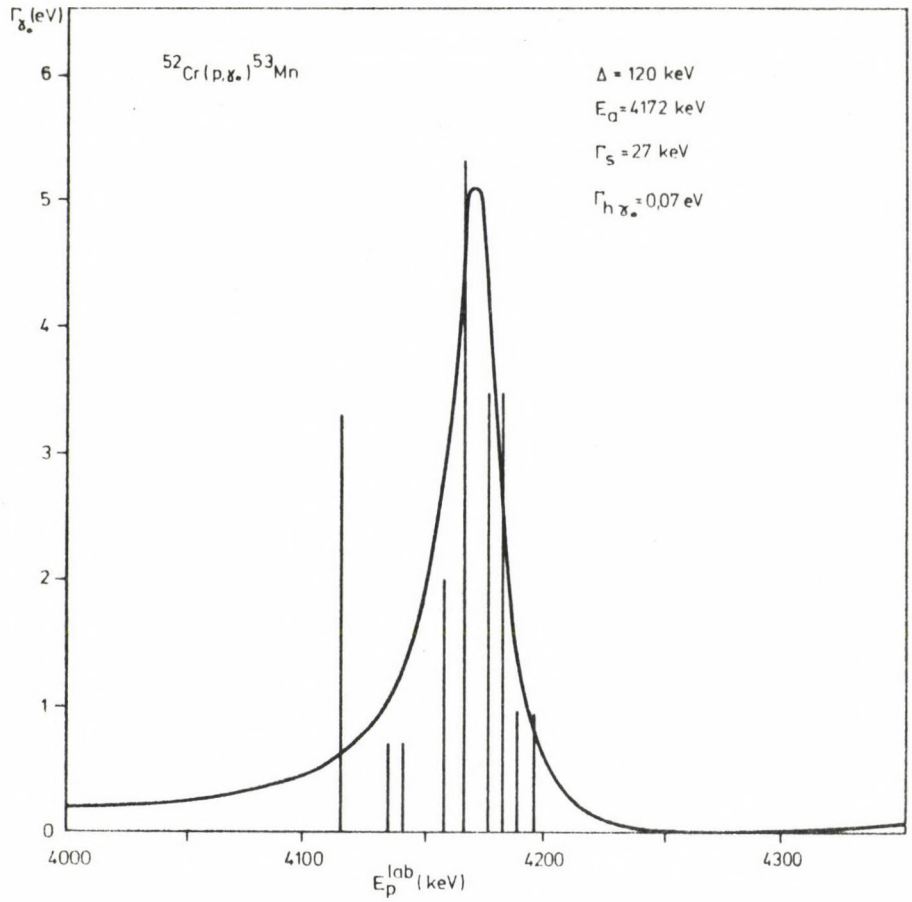

Fig. 2

Distribution of the Γ_{γ_0} widths as a function of proton energy. Bars represent experimental results and the curve is the theoretical fit

The region of the IAR E_a, the spreading width Γ_s, and the analogue--hallway coupling matrix element were determined from the fit. The Γ_{γ_0} transition strength for the IAR was determined as $\overline{\Gamma}_{\gamma_0}$ = 21 keV.

The work was performed in cooperation with researchers of the Zentralinstitut für Kernforschung, Rossendorf, GDR.

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COUPLED-CHANNEL EFFECTS IN DIRECT REACTIONS

Gabriella Pálla

The (p,t) reaction on the even-even Sm isotopes has been investigated at a proton energy of 25.5 MeV. The simple assumption of a direct one-step two-nucleon transfer fails to explain the observed transitions to the collective low lying states, which have anomalously shaped angular distributions. The (p,t) reaction has been calculated with the inclusion of higher order transitions that go through intermediate collective states. The indirect transitions including inelastic excitations in both of the target and final nucleus are found to be almost as large as the direct ones for the 2^+ quadrupole and 3^- octopole states. A satisfactory agreement in magnitude and shape has been found for the angular distributions in the whole nuclear range where a transition in character from vibrational to permanently deformed can be observed.

The cross sections of helion scattering leading to the ground state and the first four to six excited states of the even-even stable samarium isotopes were analysed at an incident energy of 40.9 MeV in terms of the strong coupling approximation assuming the $^{144, 148}Sm$, ^{150}Sm and $^{152, 154}Sm$ nuclei to be harmonic vibrators, asymmetric rotator and symmetric rotators respectively. A systematic study was carried out to deduce $2^{\lambda}(\lambda=2,3,4,6)$-pole deformation parameters and a single common optical model potential for this nuclear range. A description of the elastic and inelastic scattering cross section is given in the framework of the coupled channels theory and the collective model; the importance of multistep processes in inelastic scattering is emphasized.

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The existence of a single common optical model potential that is able to represent the measured scattering data demonstrates (*Fig. 3*) that in a nuclear region which is collective in nature the coupling of elastic and collective-inelastic channels is the most important effect on the optical-model potential, i.e. in the dissimilarity of the individual one-channel potentials the effect of collective characteristics of nuclear states is manifested indirectly.

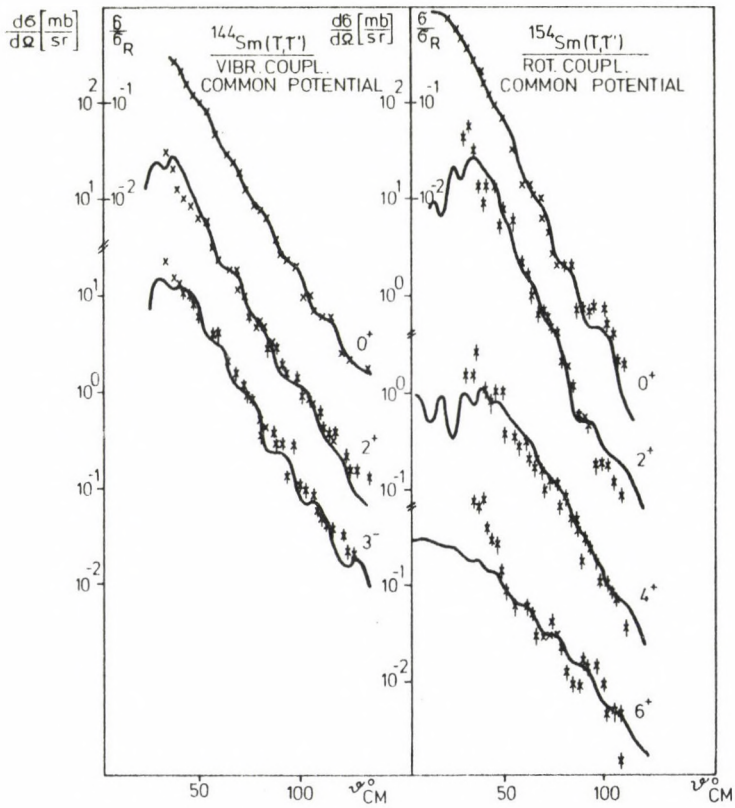

Fig. 3

Differential cross sections of elastic and inelastic scattering leading to the excitation of the low lying states in ^{144}Sm and ^{154}Sm. The curves are the theoretical predictions using the "common potential" and vibrational and rotational coupling

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NUCLEAR FISSION STUDIES

J. Kecskeméti, A. Lajtai

The measurement of the energy spectrum of neutrons from the reaction $^{235}U(n_{th},f)$ was completed in the 0.01-2 MeV energy region. Further measurements have been carried out on the neutron spectrum of the $^{239}Pu(n_{th},f)$ reaction using the TOF method with a gas scintillation chamber and a glass scintillation detector of ^{6}Li content as fragment and neutron detectors, respectively.

The spectra of neutrons are measured relative to that of the spontaneously fissioning ^{252}Cf. To obtain more complete information the experiments have been extended to the direct determination of the background from scattered neutrons. The background from delayed γ-rays was determined with a glass scintillation detector of ^{7}Li content.

In order to overcome the problems arising from the very high α-intensity of the ^{239}Pu a special fission chamber was constructed for the fragment detection. Experiments were performed for a precise determination of the neutron detector efficiency relative to the $^{6}Li(n,\alpha)$ cross section.

This work is being carried out in cooperation with the Institute for Physical Energetics, Obninsk, USSR.

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QUASI-FREE INTERACTION OF INTERMEDIATE ENERGY PROTONS

J. Erő, Z. Fodor, P. Koncz, Z. Seres

The quasi-free interaction of 670 MeV protons with correlated nucleon pairs within the nuclei was investigated at the proton synchrocyclotron of the Joint Institute for Nuclear Research, Dubna, USSR, in cooperation with the Laboratory of Nuclear Problems. The analysis was completed of experimental data of (p,nd) and (p,pd) reactions on ^{6}Li and ^{7}Li target nuclei.

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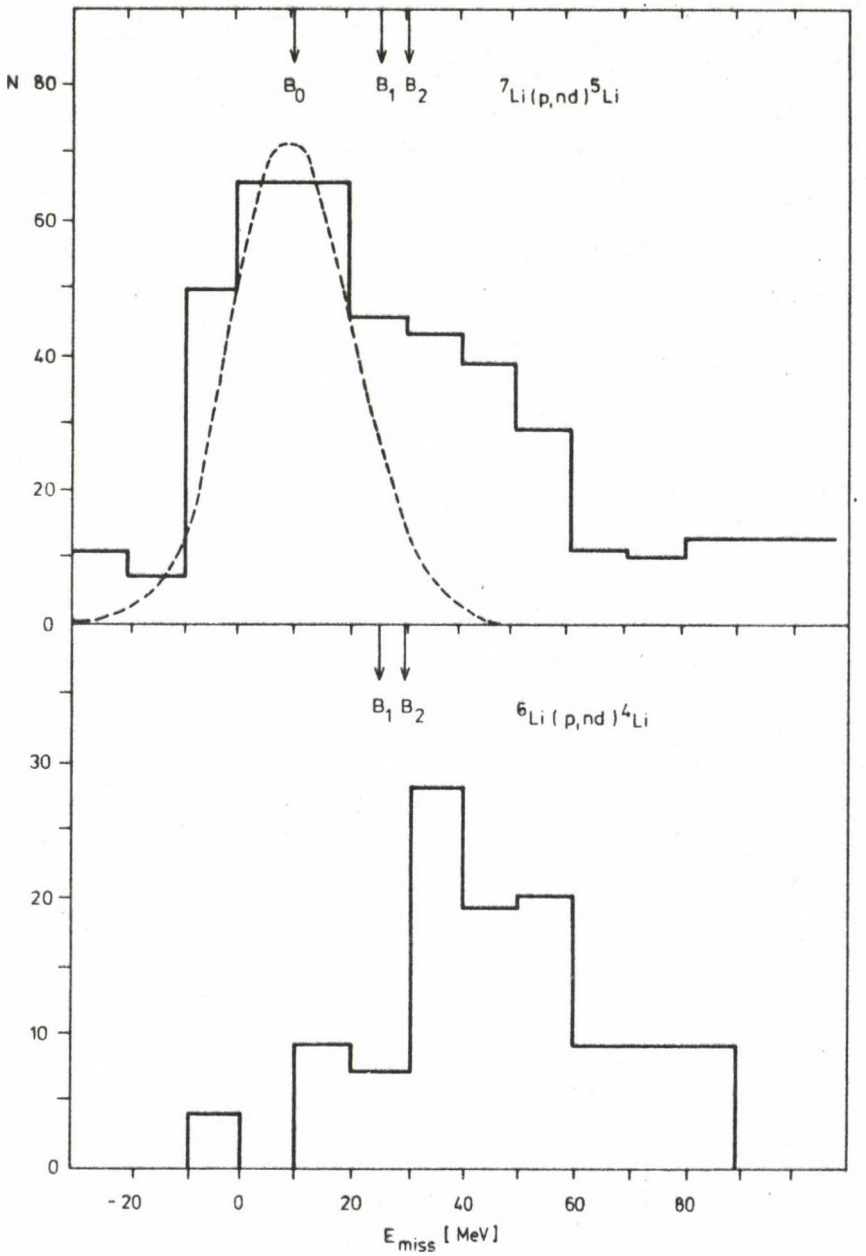

Fig. 4

Missing energy spectra for reactions $^7Li(p,nd)^5Li$ and $^6Li(p,nd)^4Li$. The arrows mark the missing energies corresponding to the residual nucleus in ground state (B_o) and in the states with one and two holes in the s-shell (B_1 and B_2). The dashed line represents the experimental resolution. N is the number of events related to given particle detector angles (θ_n=14.7° and θ_d=6.5°)

Evidence has been found in the ^{7}Li(p,nd)^{5}Li (ground state and first excited state) reaction for the quasi-elastic exchange scattering of protons on two correlated neutrons (*Fig. 4*). Transitions to highly excited or completely disintegrated states of the residual nucleus have also been observed. Their cross sections and energy distributions are similar to those observed in the reaction ^{6}Li(p,nd)^{4}Li which have quasi-free character and are associated with large missing energies corresponding to the break-up of the alpha core (*Table I*).

Table I

DIFFERENTIAL CROSS SECTIONS

$\frac{d^2\sigma}{d\Omega d\Omega_n}$ ($\mu b\ sr^{-2}$)			
Reaction	*total* (E_{miss}>-20 MeV)	*"low" events* (-10<E_{miss}<25 MeV)	*"high" events* (25<E_{miss}<60 MeV)
$^{7}Li(p,nd)^{5}Li$	215 ± 27	96 ± 14	62 ± 10
$^{6}Li(p,nd)^{4}Li$	120 ± 21	12 ± 6	77 ± 14
$^{7}Li(p,pd)^{5}He$	2410 ± 270	1560 ± 170	682 ± 75
$^{6}Li(p,pd)^{4}He$	4800 ± 530	3680 ± 400*	950 ± 105*

*The ranges are: -20 to 15 MeV ("low" events) and 15 to 60 MeV ("high" events)

It has been shown that in the ^{6}Li(p,pd)^{4}He reaction at intermediate energies the dominating mechanism is the quasi-free scattering of protons on quasi-deuterons. In the case when two p-shell nucleons are involved in the interaction, the momentum distribution of the recoil alpha particle measured at large angle scattering geometry is wider than predicted by the theory using realistic intercluster wave functions with correct exponential asymptotics (*Fig. 5*). Three-body calculations, however, give momentum distribution in excellent agreement with experiment indicating that (p,pd) reactions may provide detailed information on the two-nucleon wave functions in nuclei. Interactions followed by disintegration of the residual nucleus also have a quasi-free scattering character and can be interpreted as scattering on the deuteron component of the alpha core.

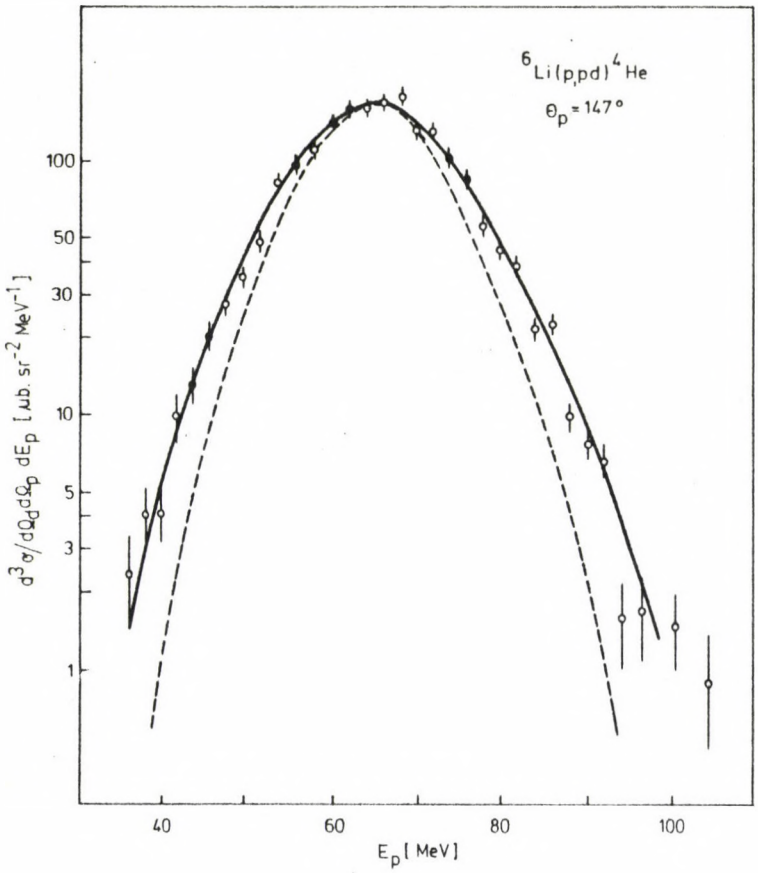

Fig. 5

Measured differential cross section of $^6Li(p,pd)^4He$ reaction leading to ground state. Dashed line calculated using cluster wave function with correct asymptotics, solid line by three-body calculation. θ_p is the angle of the proton telescope

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MÖSSBAUER STUDIES ON CONDENSED SYSTEMS

Judit Balogh, I. Dézsi, B. Molnár, D.L. Nagy
*Visiting research worker: Matild Eszterle**

Previous studies on impregnated and reduced silica supported PtFe catalysts have been continued and extended to the $RuFe/SiO_2$ system including the study of the calcined state.

It has been established that during the preparation of the catalysts the pH of the impregnating solution plays an important role. High dispersity can only be obtained if the pH value during the impregnation is kept at low (~1) values. Although the dispersity decreases during calcination the higher dispersity in the impregnated stage results in a higher dispersity in the calcined stage, too.

On studying the metal-metal interaction in PtFe catalysts it has been found that below 40 at. % Fe concentration high dispersity superparamagnetic PtFe alloy is formed on the surface of the support the cubic structure of which is highly distorted. At Fe concentrations higher than 40 at. % the excess iron cannot be reduced. In contrast to Pt, Ru hinders the reduction of iron in the concentration range 40-70 Fe at. %. The explanation of this phenomenon needs further investigation.

This work was done in cooperation with L. Guczi of the Institute of Isotopes of the Hungarian Academy of Sciences, Budapest.

For the investigation of the kinetics of the first step in the crystallization process of the Fe-B system, $Fe_{83}B_{17}$ samples were heat treated in a calorimeter at different temperatures. The amount of α-Fe precipitates in the partly crystalline alloys was determined. The kinetics of α-Fe precipitation at 670 K is shown in *Fig. 6*.

We have begun to study the effect of the transition metal and metalloid substitution on the short range order in the Fe-B system. Systematic study of Fe-Ni-B alloys has shown that below

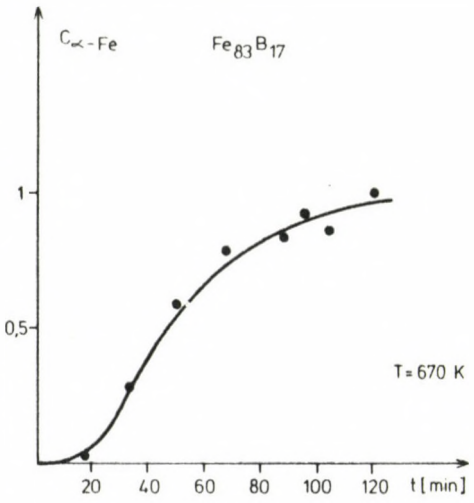

Fig. 6
Fraction of precipitated α-Fe ($C_{\alpha-Fe}$) as a function of annealing time (t)

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a critical Ni content the hyperfine field distributions are practically identical, but a significant narrowing occurs at high Ni content. This type of behaviour contradicts the predictions of all kinds of dense randomly packed structure models and gives a further justification of the prominent role of short range order in the structure of amorphous alloys. Identification of the crystalline products at different concentrations is in progress. Investigations on the Fe-B-C system were begun. The first results show that there is no significant change in the hyperfine field distribution of the $Fe_{84}B_6C_{10}$ alloy compared with the $Fe_{84}B_{16}$ sample. This work was performed in cooperation with members of the Institute for Solid State Research.

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LATTICE LOCATION OF Co IMPLANTED IN SILICON

I. Dézsi, E. Kótai, T. Lohner, A. Manuaba, G. Mezey

The Mössbauer spectra of implanted Co in Si and Ge showed two resonance absorption lines. The interpretations of this result are contradictory because it could earlier have been explained by the existence of Co atoms at one or at two different lattice sites; however, recent Mössbauer measurements carried out in a high magnetic field have revealed that Co atoms can be found only at one lattice site of low symmetry.

Channelling and backscattering experiments were performed on Co implanted in Si at 70 keV with a dose of $1x10^{14}$ atom/cm^2 in order to obtain further information on the lattice location of Co.

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The simple triangulation led directly to the conclusion that implanted cobalt had no substitutional component because attenuation was not experienced in the Co peak within the experimental error of ±15% taking a spectrum along the <110> direction. The remaining cobalt atoms were randomly placed.

More detailed information was obtained on the location of foreign atoms from the backscattering yield measured as a function of the angle between the analysing beam and the low index direction. It was found that the cobalt curve was considerably narrower than the silicon one. The ratio of the half widths is about 0.5.

Our result indicates that the localized part of cobalt is in positions shifted from the centre of the tetrahedral sites. At such positions an electric field gradient may exist and it may explain the origin of the quadrupole split lines observed by Mössbauer spectroscopy. This work has been performed in cooperation with R. Coussement and G. Langouche of the University of Leuven, Heverlee, Belgium.

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POSITRON ANNIHILATION STUDIES

Á. Balogh, I. Dézsi
*Visiting research worker: Khalid Al Ani***

Measurements have been made on In-Pb alloys. The aim is to study the defect structure and to determine the vacancy formation energy in the different samples. The utilization of room temperature angular correlation curves enabled the determination of the vacancy fountain energy on $In_{80}Pb_{20}$ alloy to be completed. The value is 0.55 ± 0.05 eV, which is very near to the values of In and Pb, known from the literature.

The crystallinity of different quartz samples was studied by using positron annihilation lifetime and Doppler broadening measurements. The natural Brazilian quartz single crystal (crystallinity 1) and the amorphous silica glass produced from silicon tetrachloride (crystallinity 0) were used as reference points for the determination of the crystallinity

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of the various quartz samples which were fused from natural Brazilian quartz by a detonating gas fire. Both methods have given the same result thereby demonstrating that positron annihilation measurements can be successfully used as a non-destructive method to detect the crystallinity of silica glasses.

Positron annihilation lifetime measurements have been performed on V_3Si single crystals; this substance has the highest superconducting--transition temperature ever observed. From the measured lifetimes using the Ferrell model it has been estimated that about 17.2% of the positrons annihilate on core electrons.

The studies on quartz and V_3Si samples were performed in cooperation with G. Brauer of the Zentralinstitut für Kernforschung, Rossendorf, GDR.

A program package has been created (named POSITRON) for evaluating positron annihilation measurements on ES 1040 computers. The evaluating system endeavours to use the services of the operating system to the utmost extent. The main feature of its structure is its modulating ability and the advantage of this is obvious when a fitting program needs to be changed or new measuring equipment is to be interfaced.

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3. Á. BALOGH, I. FARAGÓ: Positron evaluating system for positron annihilation measurements on R-40 (ES 1040) computers. KFKI Report 78-79 (1978)

*Zentralinstitut für Kernforschung, Rossendorf, GDR
**Technische Universität, Dresden, GDR

THEORETICAL PLASMA PHYSICS

Á. Ág, Gy. Páris, K. Lelkes

A collisionless magnetoactive plasma with anisotropic temperature distribution and with non-vanishing drift velocities has been investigated. The dispersion relation is established for the resonant and non--resonant cases.

For the previous plasma the coefficients of the three-wave interaction are determined. The corrections may be large in the resonant cases.

The Fokker-Planck equation is considered in a weakly turbulent plasma with the aim of calculating corrections of the transport coefficients.

A two-wave interaction system is discussed with sources. By suitable transformations the system is investigated by the methods developed by Poincaré and Bautin. The principal properties of the solutions are given and integrals are calculated by numerical methods.

The investigation of the radial diffusion of a cylindrical plasma filament is continued for the case when the diffusion coefficient has a power dependence upon the density and the equation has sources or sinks having a power dependence too. The properties of self-similar solutions are investigated.

On extending our works to the three wave interactions we encountered the "strange attractor" problem, i.e. a non-linear causal system which in some region of its parameters exhibits special randomness, namely, the integral curves do not tend to any limit but remain finite. Our analytical investigation of this system was unsuccessful but the strange attractor, originally found by M. I. Rabinovich in calculations performed on an analog machine, has been reproduced using a digital computer.

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SOFT X-RAY EMISSION OF THE PLASMA OF THE T-10 TOKAMAK

G. Hordósy, G. Hrehuss, B. Kardon, I. Szentpétery

In tokamak research aimed at realizing controlled nuclear fusion by magnetic confinement of hot plasma, the measurement of electron temperature as well as the tracing of heavy impurities in successive phases of the discharge are among the most important tasks. The heavier ions play a definitive role in forming the energy balance of the plasma since a considerable fraction (up to 80%) of the input ohmic power can be radiated away by bremsstrahlung, recombination and excitation of bound-bound transitions on these impurities. In addition, more recent studies suggest that the occurrence of disruptive instabilities which terminate the plasma current at an early phase of the discharge are connected in some way with the impurity content of the plasma.

To investigate such problems soft X-ray spectrometers of high efficiency and medium energy resolving power have already been developed. The scintillation-ionization chamber can be applied in the quantum energy region 150 eV - 3000 eV. Another system, based on the semiconductor X-ray detector of Kevex and PGT respectively, is best applicable for energies above 1500 eV.

The measurements performed previously at the T-10 tokamak of the I.V. Kurchatov Atomic Energy Institute, Moscow, USSR, have been extended to the study of radial dependence of the spectral intensity distribution in the case of medium current (300 kA) deuterium regimes (*Fig. 7*).

By a set of measurements along the central chord of the plasma column the time dependence of the characteristic impurities of Fe or Mo as well as that of the effective plasma charge Z_{eff} have been determined. It has been found that in the case of T-10 the dominant contribution to the heavier impurities comes from the components of the first wall (Fe, Cr, Ni).

In the lower quantum energy region (below 3000 eV) peculiar differences have been found in the time development of the spectral structure for normal and for disruptive discharges (*Fig. 8*). These differences seem to suggest that the conditions for a disruption are preformed at an early stage of the discharge.

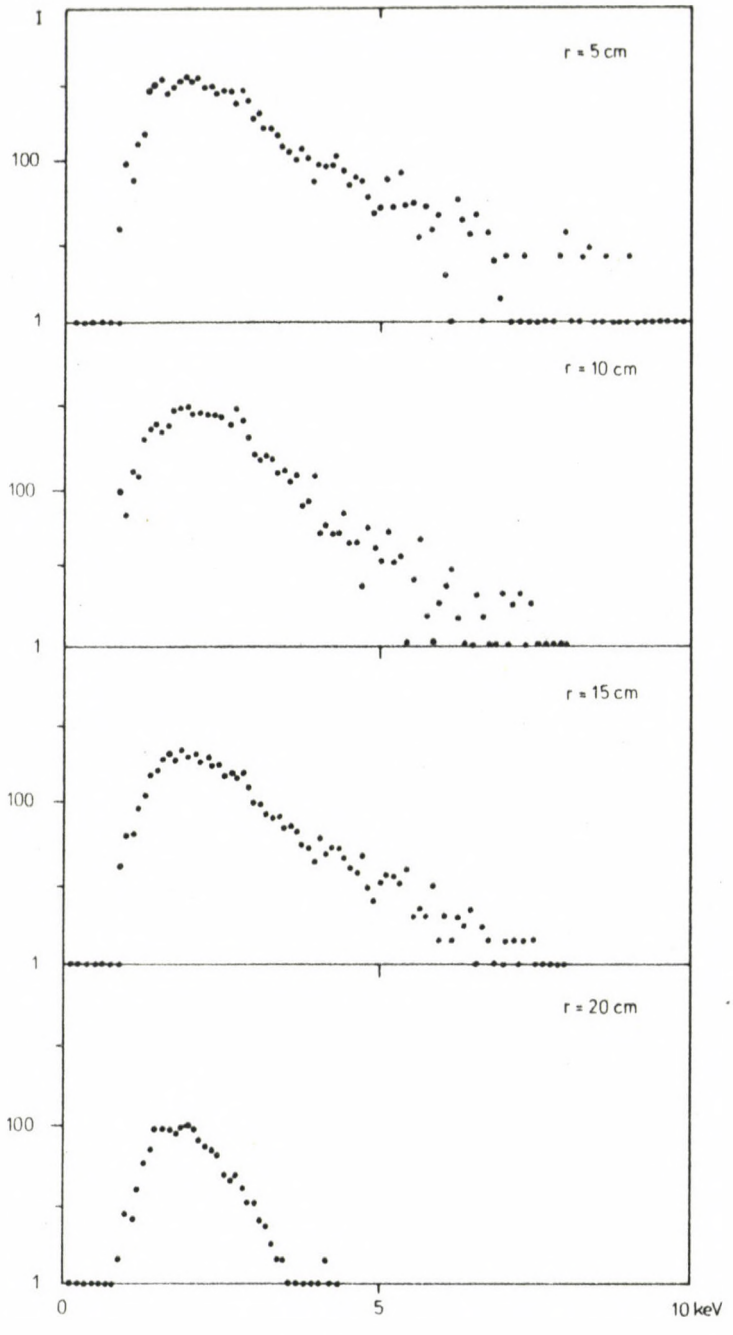

Fig. 7

Spectral intensity distribution at different minor radii of the tokamak T-10 measured by means of a PGT semiconductor detector

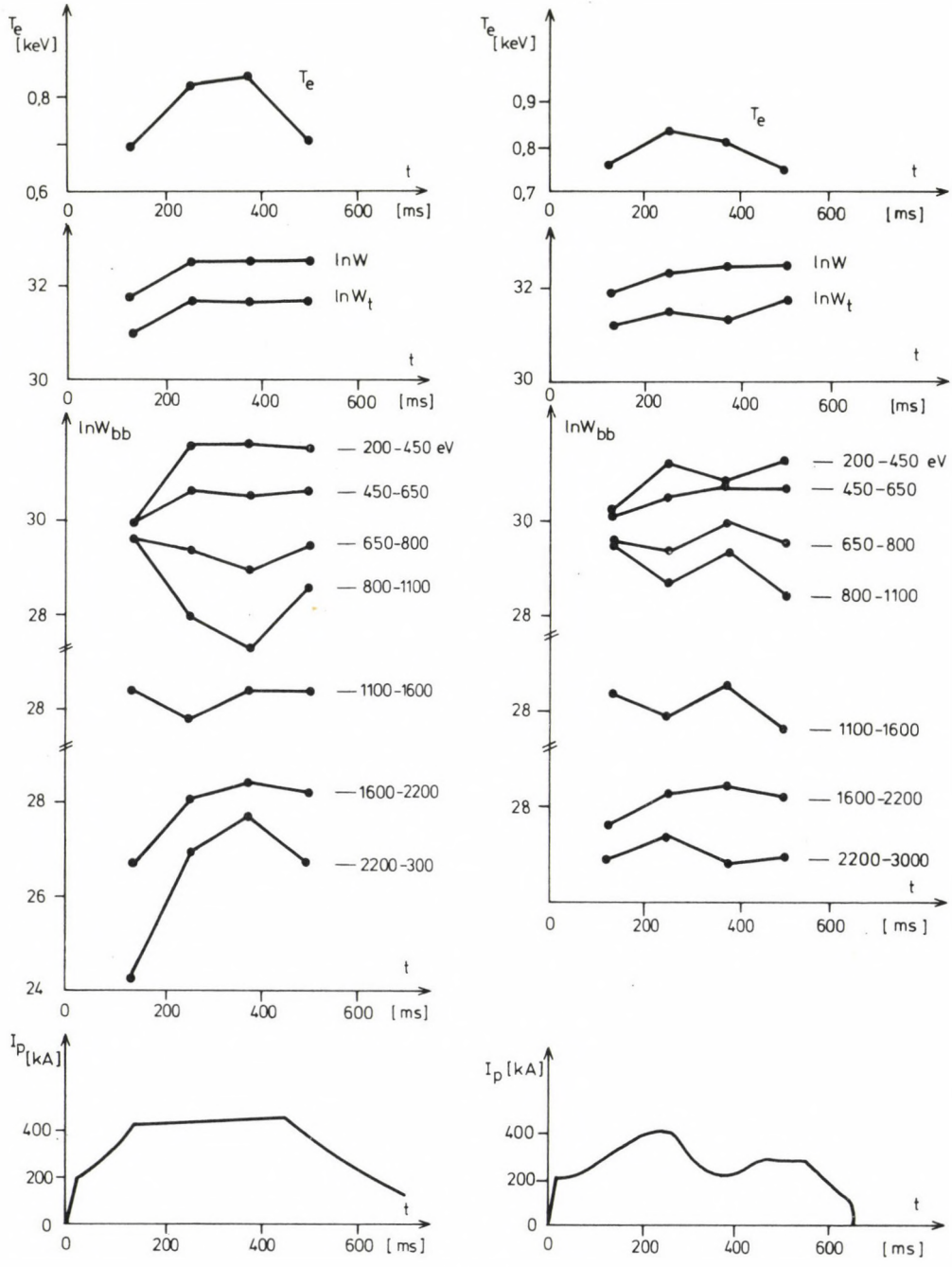

Fig. 8

Time development of the radiated power at different quantum energies below 3 keV for normal and disruptive discharges

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SELF FOCUSING PHENOMENA IN PLASMAS

J.S. Bakos, I.B. Földes, Zsuzsa Sörlei

In laser beam and plasma interaction the laser radiation - in general - influences the physical properties of the plasma by heating the electrons or by exerting a ponderomotive force on the electrons. A slight change in plasma parameters can cause a reaction on the beam itself thereby distorting the wavefront of the radiation. The wavefront distortion appears as focusing or defocusing of the originally parallel beam. This phenomenon, known as self-focusing, plays an important role in the measurements of plasma parameters when using laser radiation or on heating the plasma by electromagnetic waves.

We have investigated the self-focusing effect in laser produced plasma where the focusing of the driver radiation itself takes place. The experimental set up can be seen in *Fig. 9*. The radiation of the single mode and single frequency radiation of the Q-switched ruby laser was focused in air by lens L_1.

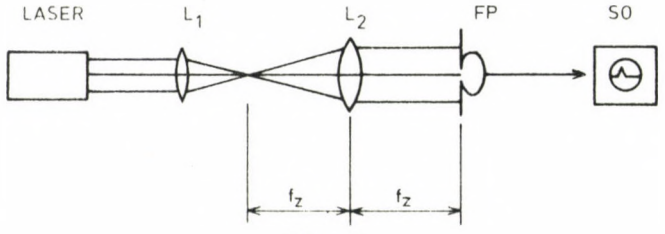

Fig. 9

Experimental set up
FP = Fast Photodiode; SO = Storage Oscilloscope

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The radiation transmitted through the spark in the focal point was collimated by lens L_2 and the space distribution was measured in the second focal plane by the fast photodiode and storage oscilloscope. The self focusing of the radiation causes the distortion of the shape of the laser pulse (*Fig. 10*).

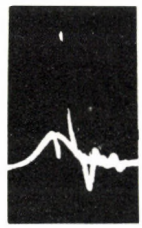

Fig. 10

Shape of the laser pulse passing the plasma in comparison with the originally Gaussian shape of the light pulse

The originally bell shaped laser pulse (the picture of which was taken for comparison) was strongly distorted. At the beginning of the spark strong absorption sets in. As a result of the self-focusing, a sharp pulse appears a short while after the spark ignition, this collects the driver radiation thereby forming a small cone along the optical axis. The amplitude of the light pulse is many times higher than that of the original light pulse.

The focusing results from the hollow type distribution of electrons in the laser spark which distribution is the result of the motion of the spark under the influence of the driver electromagnetic wave.

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INVESTIGATION OF IMPULSE DISCHARGE IN HELIUM BY THOMSON SCATTERING

J.S. Bakos, P.N. Ignácz, J. Szigeti

In every tokamak research work it is necessary to know the distribution and the absolute values of the plasma density and temperature. For local measurement of these quantities the Thomson scattering is one of the most accepted methods.

The light of the pulsed laser is focused to a small volume inside the plasma and the light scattered by the free electrons undergoes broadening. Thus the distortion of the spectral distribution can be characterized by the local plasma parameters: the spectral density of the scattered light is a function of the electron density and temperature in the focal point.

Our intention is to measure the electron temperature by laser scattering in the tokamak of our Institute which is now under construction. Pending completion of the installation, we have constructed a small plasma source for preliminary experiments.

The plasma source was a simple impulse discharge in helium with the following parameters:

filling pressure of the helium:	3 Torr
current maximum:	5 kA
current impulse duration:	10 μs

The laser used in this scattering experiment was a giant pulse ruby laser synchronized to the discharge. The experimental arrangement is shown in *Fig. 11.*

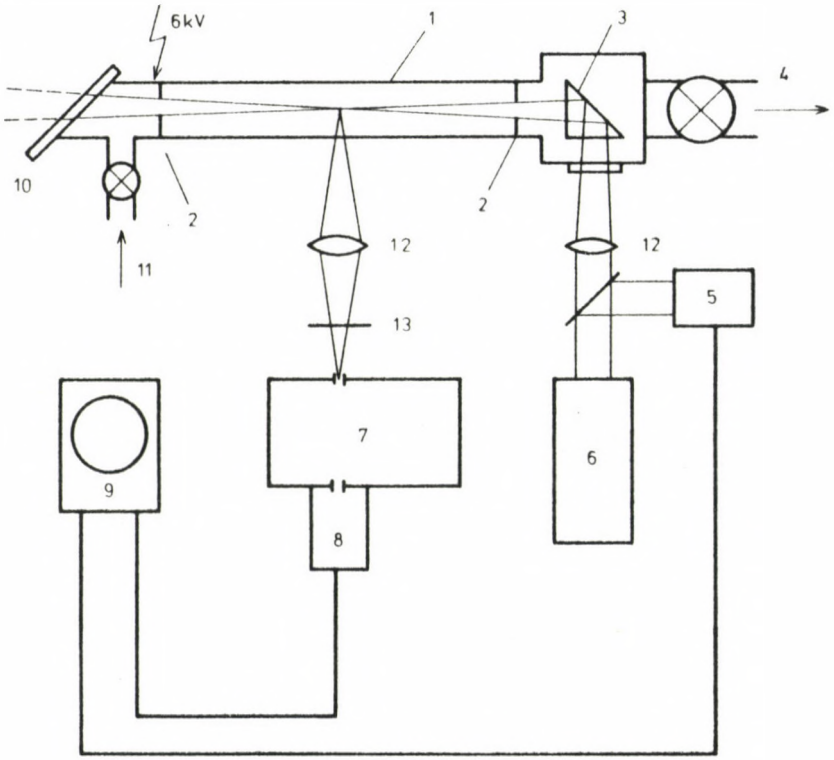

Fig. 11

Experimental scheme of Thomson scattering

1. Discharge vessel (glass tube), 2. stainless steel electrodes, 3. prism, 4. vacuum pump, 5. monitoring photomultiplier, 6. ruby laser, 7. monochromator, 8. photomultiplier for the scattered light, 9. oscilloscope, 10. absorber glass, 11. He inlet, 12. focusing lenses, 13. polarizer

By scanning the monochromator around the wavelength of the laser, we measured the spectrum of the scattered light, perpendicular to the incident wave. The spectrum, which is shown in *Fig. 12*, was taken 7 μs after the starting of the discharge, the laser was focused along the discharge axes. From this spectrum an electron temperature of 3.4 ± 0.1 eV and an electron density of (3.8 ± 0.2) x 10^{16} cm^{-3} could be calculated by a three parameter fitting procedure.

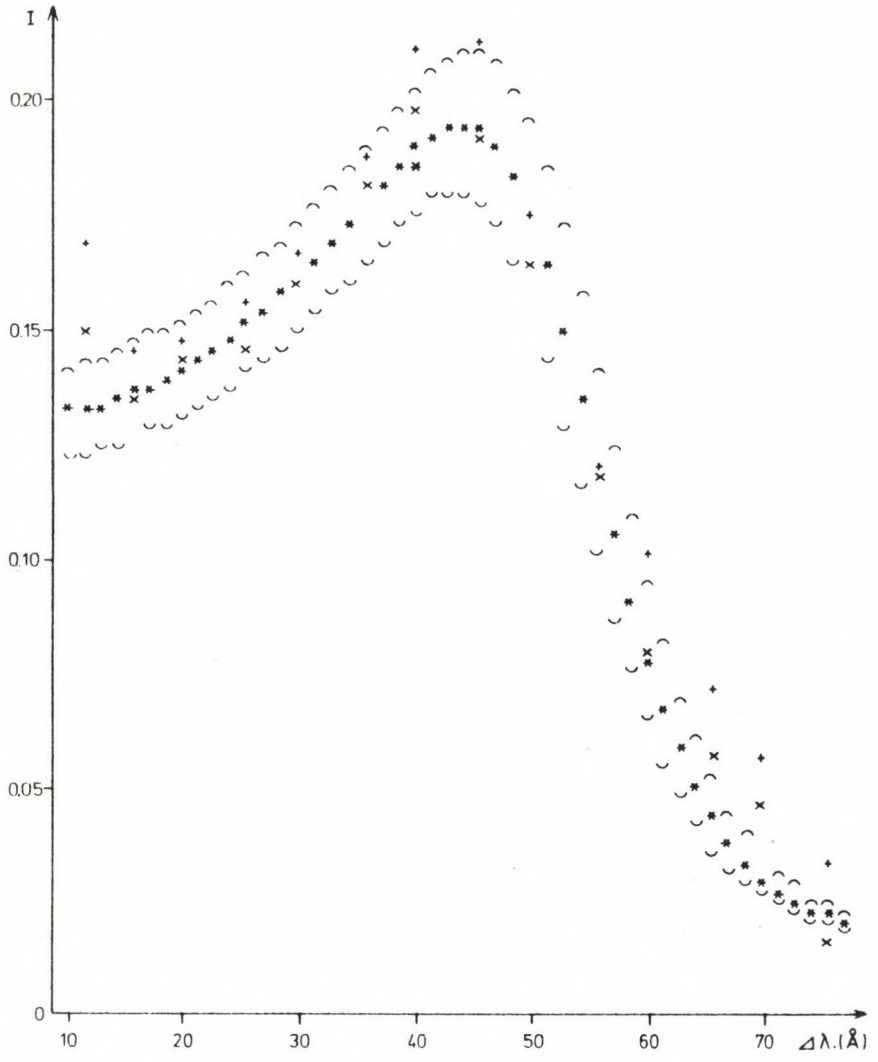

Fig. 12

The scattered spectrum 7 μs after plasma ignition.
Δλ is the wavelength difference between incident and scattered light;
I is the intensity in arbitrary units

BIOPHYSICAL RESEARCH

I. Demeter, P. Hargittai, Vera Jánossy, L. Keszthelyi, A. Orosz, Z. Szőkefalvi-Nagy, L. Varga
Visiting research workers: Katalin Hollós-Nagy and A. Grinberg***

Last year the PIXE (particle induced X-ray emission) method for trace element analysis and our own nuclear method (based on the $^{14}N(d,p)^{15}N$ nuclear reaction) for the determination of the protein content of certain biochemical preparations were further improved and applied in solving problems where the quantity of the trace elements related to the protein content of the sample plays an important role.

Investigations on the optical properties of membranes of the nerve have been also started.

Details of the work performed are given below:

1. The utilization of the $^{14}N(d,p)^{15}N$ nuclear reaction enabled us to measure the distribution of the protein content on the cut surface of a barley seed. The result was an inhomogeneous protein distribution similar to the case of maize.

2. As applications of the method for the determination of the trace elements related to the protein content of the sample, further measurements were performed:

a) The question of binding of the dye ZnI_2, OsO_4(ZIO) used for the staining of the synaptic area of nerve cells to the amino acids was investigated. According to earlier suppositions, the binding takes place between the sulphur atoms and the dye molecules. In contrast to this we found much more Zn,I, and Os atoms bound to glutation molecules which are three times heavier than the cystein molecules (*Table II*) despite the fact that both of them contain one sulphur atom per molecule.

Table II

RATIOS OF THE NUMBER OF ATOMS RELATED TO THE NUMBER OF SULPHUR ATOMS FOUND IN THE GLUTATION PREPARATION TO THAT FOUND IN CYSTEIN

$$[(X/S)_{Glutation}/(X/S)_{Cystein}]$$

N	*Zn*	*I*	*Os*
3.3	*6.8*	*3.2*	*1.3*

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This suggests the conclusion that the whole mass of the molecules takes part in the binding of the dye. The number of nitrogen atoms in glutation turned out to be three times more than that in cystein which is in good agreement with the chemical compositions involved.

b) The Fe and Mo content of the nitrate reductase enzyme of the bacterium *Risobium Melilotti* was determined.

c) It was established that the Ti is not bound to the chlorophyll in the leaves of the plants sprayed with a solution of titanium salt.

d) We have proved that the ratio of the sulphur to the protein content of the hair along its length is constant. The result is presented in *Fig. 13.*

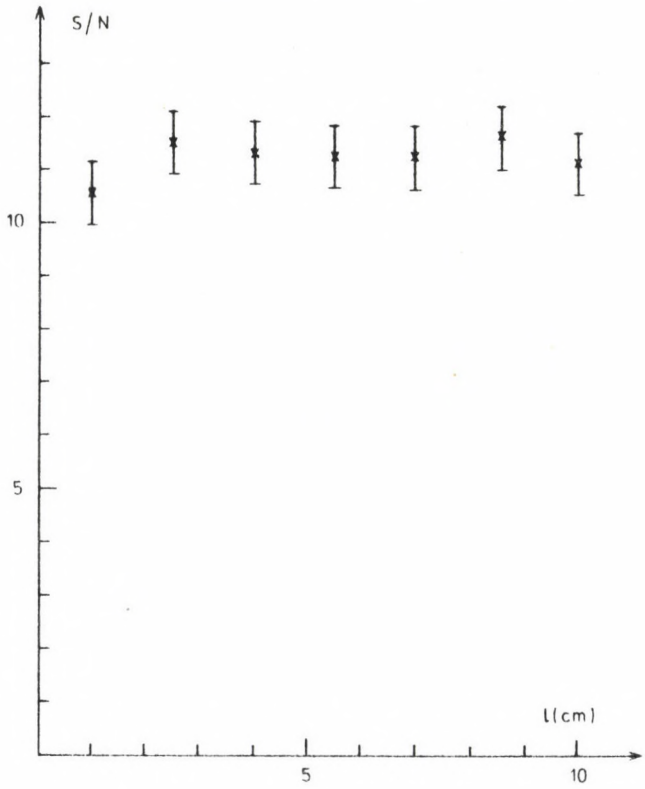

Fig. 13

Dependence of the ratios of sulphur and nitrogen content of hair in arbitrary units on the distance from the follicle (ℓ)

3. The ionoptics of a microbeam system together with the beam deflecting elements and the chamber for the determination of the protein content simultaneously with PIXE measurements have been planned and partially completed.

4. As a result of the reduction of the background it became possible to determine a quantity of nitrogen of 50 ppm within a few minutes.

5. The trans-membrane potential of the synaptosomes has been studied by utilizing electrical pulses as a depolarizing agent. Potential-sensitive dyes have been used to follow membrane potential changes when investigating the light emission and excitation spectra. ANS (1-anilino-8--naphthalino-sulphonic acid), Acridin orange, Pyronin G, and Neutral Red stained synaptosomes were investigated. The kinetics of the uptake-release processes of ANS in synaptosomal suspension was experienced.

The osmotic features and the preservation of the synaptosomes were studied by light scattering.

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4. L. KESZTHELYI: Origin of asymmetry of biomolecules and the weak interaction: a Critical Review.Origins of Life 10, 327 (1978)

PARTICLE ACCELERATORS AND TOKAMAK: DEVELOPMENT, OPERATION AND INSTALLATION

G. Bürger, L. Gyimesi, E. Klopfer, P. Kostka, Z. Mészáros, J. Roósz, Cs. Seres, M. Szulman

Last year the operation of the EG-2R, 5 MeV pressurized Van de Graaff type ion accelerator was continued for nuclear, solid state physics and biophysical research. During 1978 the accelerator was running in the energy range of 0.8-4.8 MeV for 4271 working hours. In the current range of 1-5 μA, analysed and stabilized beams of protons, deuterons and $^4He^+$ ions were given at any target place. The short-time relative energy stability is about 1.5×10^{-4}.

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**Institute of Biophysics, Biological Research Center, Szeged, Hungary

During 1978 several turbomolecular pumps were installed at the beam extension system; a 9 degrees beam line and target place and a stabilizing system for beam position were built up. Installation of an oil-free gas compressor and another alteration of the gas handling system were started. At the end of year, the periodic testing of the pressure vessel of the accelerator was done up to 2.2 MPa.

Because of the building of laboratories of the Tokamak-type thermonuclear device, the operation of the NG-200, 200 keV open-air Cockroft--Walton ion accelerator was interrupted in 1978.

In connection with the development of the instrumental base for plasmaphysical research, the installation of a tokamak-type experimental unit has been continuing. The engineering works related to the building have been finished and the physics laboratories connected with the tokamak were completed. The mounting of the tokamak device itself and the installation of a data measuring computer are now in progress.

FOREIGN RELATIONS

LECTURES BY VISITING SCIENTISTS

F.S. Levin	(Brown University, Providence, USA) Arrangement channels quantum mechanics - Application of few body methods to atomic and nuclear structure
S. Moszkowski	(University of California, Los Angeles, Calif.,USA) Potential between heavy ions
H.W. Barz	(Zentralinstitut für Kernforschung, Rossendorf, GDR) Description of nuclear resonance states within the continuum shell model
B. Jakobsson	(Nordita, Copenhagen, Denmark) Relativistic heavy ion collisions
A. Scott	(University of Georgia, Athens, Georgia, USA) Inelastic proton scattering
H. Vogel	(Universität Erlangen-Nürnberg, Erlangen, FRG) High-pressure Mössbauer experiments at low temperatures in large magnetic fields
B. Sawicka	(Institute of Nuclear Physics, Cracow, Poland) Conversion electron Mössbauer spectroscopy of implanted systems

L. Rohrer	(Beschleunigerlaboratorium der Ludwig-Maximilian Universität und Technische Universität München, Garching, FRG) Developments in the Munich Tandem-Accelerator Laboratory. Electronics and accelerator techniques
Yu. Merekov	(Joint Institute for Nuclear Research, Dubna, USSR) Production of composed fragments by high energy protons
M.S. Rabinovich	(Lebedev Physical Institute, Moscow, USSR) World's Energetics; World's Fusion Program; On Impurities, About Fusion Projects in the Soviet Union, Results of studies on Stellarator L2

STAFF MEMBERS ON STUDY TOURS

P. Doleschall	University of Maryland, College Park, ML., USA	7 weeks
P. Doleschall	Institut für theoretische Physik, Universität Tübingen, Tübingen, FRG	1 month
Gy. Bencze	University of Maryland, College Park, ML., USA	7 weeks
T. Dolinszky	Istituto di Fisica G. Marconi, Universitá di Roma, Rome, Italy	3 months
J. Révai	Joint Institute for Nuclear Research, Dubna, USSR	5 years
L. Csernai	Tandem Accelerator Laboratory Uppsala, Sweden, University of Lund, Lund, Sweden	1 month
G. Pálla	Universität Hamburg, I. Institut für Experimentalphysik, Hamburg, FRG	2 months
G. Kluge	Joint Institute for Nuclear Research, Dubna, USSR	3 years
T. Nagy	Joint Institute for Nuclear Research, Dubna, USSR	3 years
J. Erő	Joint Institute for Nuclear Research, Dubna, USSR	3 years
Z. Fodor	Joint Institute for Nuclear Research, Dubna, USSR	4 years

Z. Seres	Joint Institute for Nuclear Research, Dubna, USSR	4 years
Z. Szőkefalvy-Nagy	Facultés Universitaires de Namur, Namur, Belgium	1 year
P. Hargittai	C.N.R.S. Laboratoire Neurobiologie Cellulaire, Gif sur Yvette, France	4 months
P. Hargittai	Centre de Neurochimie, Strasbourg, France	4 months
D. Horváth	Joint Institute for Nuclear Research, Dubna, USSR	6 years
Zs. Kajcsos	Institut für Festkörperforschung der Kernforschungsanlage-Jülich, Jülich, FRG	18 months
G. Mezey	California Institute of Technology, Pasadena, Calif., USA	1 year

GUEST SCIENTISTS AND FELLOWS

C. Chandler	University of New Mexico, Albuquerque, New Mexico, USA	1 month
S. Moszkowski	University of California, Los Angeles, Calif., USA	1 month
J. Dusek	Charles University, Prague, Czechoslovakia	1 month
B. Jakobsson	Nordita, Copenhagen, Denmark	6 weeks
M. Znojil	Institute of Nuclear Physics Řež, Czechoslovakia	1 month
Khalid Al Ani	Nuclear Research Institute, Baghdad, Iraq	5 years
J. Frackowiak	Silesian University, Katowice, Poland	6 months
Jihad Mulhem	Tichren University, Latahia, Syria	4 years
H. Vogel	Universität Erlangen-Nürnberg, Erlangen, FRG	1 month

THESES

G. Hordósy	The measurement of X-ray radiation of tokamak plasmas (For Ph. D. degree)

RESULTS

INSTRUMENTS AND SYSTEMS

O. Baka, Á. Csepregi, Gy. Erdélyi, J. Erő, G. Farkas, F. Ferenczy, I. Hernyes, J. Jani, Zsuzsa Juhász-Kovács, J. Koch, T. Kovács, Gy. Kozma, L. Lohonyai, A. Montvai, J. Nagy, I. Nádai, J. Pazonyi, M. Sándor, L. Szabó, S.Szalai, I.T.Szücs, P.Takács, Gy.Thaler, Márta Tóth-Bodonhelyi, J. Urbán, I. Veress, J. Windberg, A. Zarándy

Several instruments have been developed for the experiments on the tokamak due to be installed in the Institute. A laser energy meter was made for laser diagnostics measurements. The instrument is capable of very accurate measurements of both the power of continuous lasers and the energy of pulsed lasers of short pulse duration. For the purpose of the same measurements, an 8-channel fast amplifier and an 8-channel sample and hold module were designed. The latter instrument takes samples from the fast analogue signals applied to its inputs, then it stores the samples in an analogue way for a longer period for processing in a CAMAC data processing system. For the purposes of fusion research a 2x10 kV and a 16 kV high voltage power supply were also developed.

For high energy physics research the development of a track-chamber picture evaluation system (RIMA) has begun. Based on the latest results of semiconductor technology the system will make possible the mass-processing of streamer chamber photographs. The apparatus is controlled by computer; the measurement, the recognition of picture and trace elements as well as their arrangement into traces are all performed on-line.

The prototype of the proportional tube-detectors replacing the GM tubes used in cosmic ray measurements was manufactured. The high accuracy cosmic ray measurements of a duration of several years require a measuring system of high stability. The requirements are especially high with respect to the constancy of the parameters of the gas mixture. In the gas mixing apparatus developed for this purpose the mixing ratio of argon and carbon dioxide can be varied as needed; the constancy of the mixing ratio is better than 0.5%, the capacity of the instrument has a maximum of 2.5 litres/min.

The data handling system of the proportional tube-detector telescope was designed. The detector signals are amplified by circuits built with fast ECL integrated circuits. The measurement results are collected by a CAMAC system.

For measurements performed in the Joint Institute for Nuclear Research, Dubna, USSR, 15 multiwire proportional chambers with 120x120 mm active area were developed and manufactured. The prototype of a detector with an active area of 600x1000 mm was also completed. In this chamber the wires of the signal wire planes are at an angle of 45°.

The instruments and data transmitting units designed for the Environmental Radiation Protection Control System of the Paks Nuclear Power Plant were completed. The development of the operating programme of the system is in progress.

The extension of the range of CAMAC instruments has been continued. A universal PROM programmer, an IEC bus controller and a 4K capacity memory module with 24 bit word length were designed. With the help of the latter unit analysers of short dead time can be realized in CAMAC system.

For the extension of the CAMAC analogue (CAMALOG) instrument family the development of a stretcher and biased amplifier, a constant fraction discriminator and a nanosecond delay module was begun.

For biophysical measurements a deflection amplifier module producing high voltage ramp signals, a biological measurement amplifier, and a high current light stabilizer were manufactured.

To complete the Kronotron system, operating at Tien-Shan, USSR, a counter control interfacc was designed.

In the space research programme the model of the KSD-1/B data collecting and control unit was designed and built. The instrument will fly in one of the satellites of the Intercosmos programme.

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3. G.G. AKOPYAN*, V.A. VALOV*, K. SEIDEL*, A. MEISTER*, D. PABST*, L.B. PIKEL'NER*, S. SZALAI: The isomer shift of neutron resonances. Preprint JINR R3-11740 (1978) (in Russian)

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*Joint Institute for Nuclear Research, Dubna, USSR

FOREIGN RELATIONS

STAFF MEMBERS ON STUDY TOURS

G. Farkas	Institut für Hochenergiephysik, Zeuthen, GDR	22 months
F. Ferenczy	Joint Institute for Nuclear Research, Dubna, USSR	4 years
I. Hernyes	Joint Institute for Nuclear Research, Dubna, USSR	3 years
L. Lohonyai	Joint Institute for Nuclear Research, Dubna, USSR	2 1/2 years

INSTITUTE FOR SOLID STATE RESEARCH

RESULTS

THEORETICAL SOLID STATE PHYSICS

J. Bergou, P. Fazekas, G. Forgács, F. Iglói, J. Kollár, Nóra Menyhárd, E. Paveczki, T. Siklós, Gy. Solt, J. Sólyom, P. Szépfalusy, I. Tüttő, F. Woynarovich, A. Zawadowski

The study of quasi one-dimensional organic systems has been continued. A review of the present state of the art of the Fermi gas model of these systems has been compiled. The relationship of this model to other statistical physical and field theoretical models and the approximations involved in finding the equivalence of the various models have been studied.

In the framework of a generalized Ginzburg-Landau scheme based on the microscopic model of weakly interacting chains of 1D Fermi gases the observed critical behaviour near the 53 K phase transition of TTF-TCNQ has been accounted for.

In cooperation with the Theoretical Physics Laboratory of the Joint Institute for Nuclear Research, Dubna, USSR, and the Theoretical Department of the Institute Boris Kidrič, Vinča-Beograd, Yugoslavia, we have continued the study of the ferroelectric phase transitions in order to develop a general theory which also takes into account the tunnelling between the different states. We have continued the study of dynamic critical phenomena below the critical point by the renormalization group; for the spherical model, an exact solution has been given.

Using high temperature expansions we determined the values of the critical exponents and the phase exponent thereby completing our study of the critical states of the three-dimensional Heisenberg model.

Significant advances have been made in understanding the electrical, structural and magnetic properties of pure and doped 1T-TaS_2. A marginal Mott-localization takes place leading to a situation where the $\ln\rho \sim T^{-1/3}$ behaviour of the electrical resistivity can be ascribed to three-dimensional variable range hopping. The magnetic moment of the localized electrons is quenched by spin-orbit interaction.

As a first step towards a proper treatment of quantum effects in non-conducting donor $(TCNQ)_2$ salts, a physically transparent remarkably accurate, two-parameter variational treatment has been given for the Ising chain in a transverse field.

In cooperation with the University of Virginia, Charlottesville, Virginia, USA, the superconducting properties of the A-15 compounds (Nb_3Ge, Nb_3Sn, V_3Si, etc.) were investigated. The electronic properties of these materials suggest that in addition to the usual phonon exchange between the electrons the assumption of an additional mechanism (acoustic plasmons) is necessary to describe the high superconducting temperature of these materials.

A detailed review has been prepared for the description of the low temperature properties of Kondo alloys. We generalized the Anderson model for degenerate orbitals. The role of the two-roton bound state has been studied in neutron scattering on superfluid He^4.

Multiphoton transitions of a free electron in an intense external radiation field as well as the physical meaning of the Green's function of a free electron + external field system constructed by using Volkov states have been investigated in some detail. Work concerning the development of high power hollow cathode lasers has also been continued.

The study of lattice dynamical effects connected with impurities in metallic lattices has been continued. One of the most important results of the calculation based on the pseudopotential method is that we are able to state, that pair forces and three-body interactions together set up the deformation field even in the lowest order calculation that does not neglect the periodicity of the lattice. Using the LMTO method we calculated the band-structure of tungsten and determined the Fermi velocity in different directions. The results of the calculation enable us to interpret electron-spin resonance experiments of new types; a comparison of the calculated values of the Fermi velocity with other available experimental data gave remarkably good results. The effect of spin-orbit coupling on the electronic structure of transition metal dichalcogenides was also investigated. We have studied different theoretical models for the structure of disordered systems (liquid metals).

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5. S. STAMENKOVICH***, N.M. PLAKIDA**, V.L. AKSIENOV**, T. SIKLÓS: Effects of tunnelling and phonons in the dynamical model of structural phase transitions. Report JINR P17-11856, Dubna, (1978) (in Russian)

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12. L. MIHÁLY, A. ZAWADOWSKI: Fermi liquid theory of the degenerate Anderson model. KFKI Report 78-84 (1978)

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14. I. TÜTTŐ, A. ZAWADOWSKI: Role of the two-roton bound state in neutron scattering on superfluid He^4. J. Phys. C 11, L385 (1978)

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16. I. TÜTTŐ, J.RUVALDS++: Relaxation time and electron-phonon interaction in the A-15 Compounds. Preprint, University of Virginia (1978)

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***Institute Boris Kidrič, Vinča-Beograd, Yugoslavia
+Eötvös Loránd University, Budapest
++University of Virginia, Charlottesville, Virginia, USA

17. P. FAZEKAS, E. TOSATTI*: The electrical, structural and magnetic properties of pure and doped 1T-TaS_2. Preprint IC(78)34, Trieste, (1978)

18. P. FAZEKAS, A. KÖVÉR: Simple variational treatment for the Ising chain in a transverse field I. Static properties at zero temperature. KFKI Report 78-48 (1978)

19. J. BERGOU, M. JÁNOSSY, K. RÓZSA, L. CSILLAG: High voltage hollow cathode lasers for spectroscopy. Proc. 3. Fachtagung für Laserspektroskopie, Graz, Austria, 1978. (in press)

20. G. SOLT: Atomic displacement around an impurity and the three-body interactions in metals. Phys. Rev. B 18, 720 (1978)

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24. J. KOLLÁR, U.K. POULSEN**, O.K. ANDERSEN***: Cohesion and band magnetism from canonical bands ibid. p. 29

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RESEARCH ON MAGNETISM

L. Gál, Gy. Kádár, Márta Pardavi-Horváth, G. Pető, I. Szabó, Gy. Zimmer

Using the optical sampling technique developed it is possible to study the saturation velocity of the moving domain walls. In the new high mobility YSmCaFeGeO type garnet samples the magnetic drive field corresponding to the saturation velocity is in general quite large (larger than 50 Oe), which was not the case in the earlier samples. This cannot be explained by the present theories. In large drive fields and under the application of in-plane field a new type of wall configuration can be observed, viz. the so called diffuse wall. The width of this wall may be several μm and it moves very rapidly.

Another field of application of the sampling technique is the study of the motion of bubbles on propagating structures. Bubble motion is not at all uniform and at high frequency propagation larger velocities are

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present than the saturation velocity. It is the in-plane field of the permalloy which enhances the velocities.

A program to assist the computer simulation of bubble domains and walls was developed; this program provides a fast procedure for calculating the cylindrical demagnetization matrix.

The development of a new method has been started for measuring the mechanical properties of thin films independently of the substrates and the condensation methods. The deformation of the substrate relative to a reference surface is obtained by vacuum fixing the substrate to a given surface.

The condensation speed and the density of a reactively RF sputtered SiO_2 layer were examined as a function of the partial pressure of oxygen. The condensation speed decreases and the density increases with the partial pressure of oxygen.

The magnetoresistance anisotropy was investigated in continuous and patterned permalloy layers. Hysteresis of the magnetoresistance as a function of the magnetic field direction was detected in the μ-range dimensions of the pattern geometry. This hysteresis was a function of the magnitude of the magnetic field as well. The shape anisotropy accounted for this effect. Because it is a source of the low signal-to--noise ratio, this hysteresis may well have a very important role in the operation of bubble detectors.

Work has begun in an attempt to relate the role of impurities and deposition parameters to the microstructure of aluminium. The average grain dimensions were examined for different copper concentrations and the decrease by one order of magnitude relative to the pure aluminium was detected at a concentration of 0.1 w %.

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2. M. PARDAVI-HORVÁTH, L.J. VINOKUROVA**, A.V. VLASOV**: Magnetic phase transitions in Fe-Rh alloys. Inst. Phys. Conf. Ser. London 39, 603 (1978)

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MAGNETIC BUBBLE MEMORY RESEARCH

M. Bak, Éva Baka-Vázsonyi, M. Blaskó, L. Farkas, E. Fellegi, Irén Fellegvári, L. Gál, L. Gosztonyi, Gy. Juhász, Gy. Káddr, Judit Kántor, Róza Kertes, B. Keszei, L. Királyhidi, G. Konczos, E. Krén, M. Marton, Z. Nyitrai, J. Paitz, Márta Pardavi-Horváth, E. Pásztor, G. Pető, I. Pintér, L. Pogány, A. Ribényi, A. Sallai, Judit Sasvári, G. Serfőző, I. Szabó, Éva Szabon-Haraszthy, B. Szigeti, J. Vandlik, G. Vértesy, Zófia Vértesy, Katalin Zámbó-Balla, Gy. Zimmer, Éva Zsoldos-Ravasz

In the past year magnetic bubble memory devices have appeared on the commercial market in the USA and Japan as a result of the 8-10 years research and development efforts. The results of research on bubble memory technology obtained in 1978 in the Institute can be summarized as follows:

Fig. 1
50 mm diameter GGG single crystal grown by the Chochralsky method

(a) (111) oriented gadolinium--garnet (GGG) single crystal platelets are the substrates for the epitaxially grown magnetic garnet bubble material. GGG crystals of 22-25 mm diameter were grown by the Chochralsky method with low dislocation density. The bulk crystals were sliced and polished carefully yielding about 1500 pieces of high quality substrates.

Experiments have been carried out to study the dynamical changes caused by the decrease in melt quantity during the growth process, namely the changes in melt flow distribution, in melt composition and temperature distribution in order to improve the quality and yield of bulk crystal production. By making use of the results of these experiments not only was the useful length of the bulk crystals increased, but a preliminary experiment for growing GGG crystals of 50 mm diameter was also successful (*Fig. 1*).

A new Chochralsky type equipment, CEB-2 (*Fig. 2*) has been put

into operation for growing 52-55 mm diameter GGG crystals regularly in the future, and another (CEB-3) is being constructed.

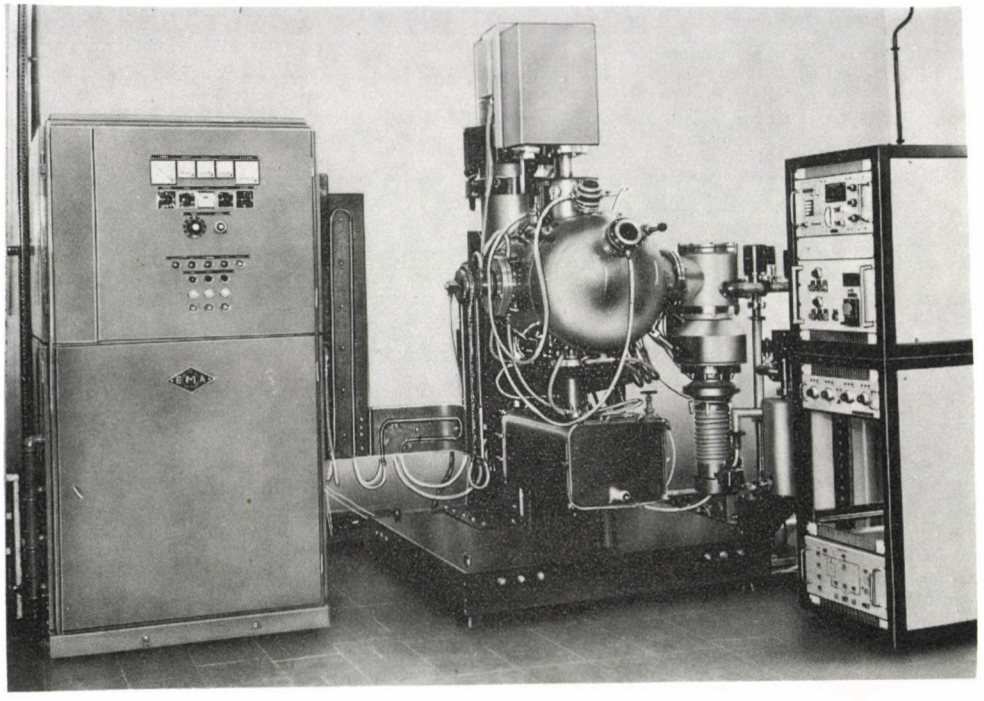

Fig. 2
Chochralsky-type equipment for growing 52-55 mm diameter GGG single crystals

(b) Magnetic garnet films with 5 μm bubble diameter were grown by liquid phase epitaxy (LPE) on the substrates by using the growth technology developed earlier. Experiments have been carried out to study the effect of growth conditions on the coercive force and the effect of chemical etching on the bubble collapse field of the LPE garnet films. As a result, techniques have been developed by which the coercive force can be decreased to less than 0.5 Oe in the case of serial growth and the collapse field can be adjusted to a prescribed value with an accuracy of 0.5 Oe.

A considerable decrease in the time needed for the growth of an expitaxial magnetic garnet film can be achieved by the multi-wafer growth technique, when more than one substrate is dipped simultaneously into the flux. The effects of wafer-holder construction and growth parameters on the crystallographic and magnetic quality of the crystals were studied

and a multi-wafer growth technology has been developed and utilized giving an acceptable yield.

Magneto-optical methods for the measurement of Néel-temperature, stripe domain periodicity and effective anisotropy field have been applied in order to characterize the LPE films besides the standard characterization methods. The dependence of the effective uniaxial anisotropy field on the orientation of the crystallographic axes inside the (111) plane is displayed in *Fig. 3*.

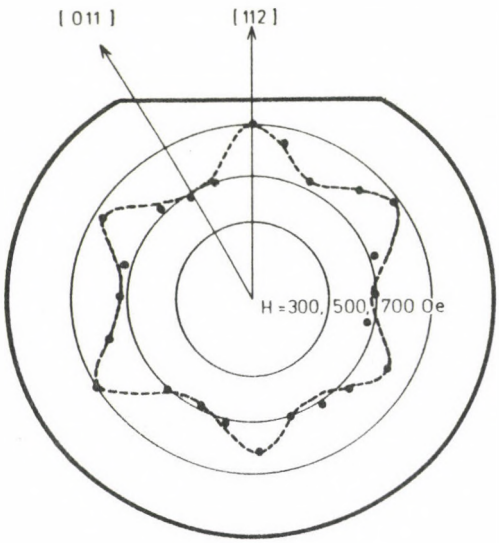

Fig. 3

Orientation dependence of the effective anisotropy field in the (111) plane of LPE garnet films

In order to establish the appropriate technical conditions and the cleanliness necessary for the production of LPE bubble garnet materials, the wafer surface cleaning technique and the environmental circumstances have been improved and an automatic LPE equipment is being constructed.

The bubble garnet films were regularly ion-implanted by $^{20}Ne^{+}$ ions of 80 keV energy and $2x10^{14}$ ions/cm^2 dose for the suppression of hard bubbles. The designs of a new ion-implanter were prepared with a radiofrequency ion-source to produce a 120 keV $^{20}Ne^{+}$ ion-beam continuously scanned for being homogeneous on the surface of a 75 mm diameter target.

(c) The bubble manipulating elements are produced on the surface of the LPE garnet material by photolithography from vacuum-deposited metal films. Current loops are made of electron-beam evaporated Al(Cu) layers, magnetic field access manipulating elements are photolithographed of RF sputtered permalloy films. The methods of metal film deposition and characterization have been further improved.

The chemical and physical processes of photoresist exposure and development have been studied in detail in order to approach the resolution limits of photolithography.

A plasma-etch apparatus was put into operation that can effectively be used instead of wet chemical etching for the removal of SiO_2 spacer films during chip-fabrication and the residual photoresist from the top of the photolithographed metal elements (*Fig. 4*).

Test circuits and bubble memory chips have been produced by the consecutive technological steps described above and the yield of the production process has been investigated. Bubble memory chips containing several thousand bubble manipulating permalloy elements could be produced with a yield of 10-15%.

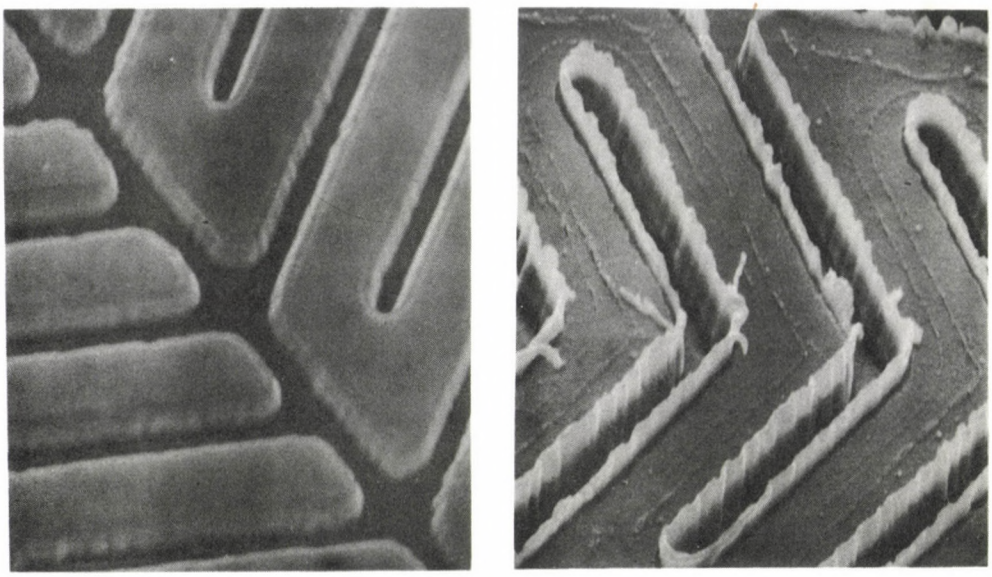

Fig. 4

Plasma-etch removal of photoresist from the top of ion-etched permalloy figures before (left) and after (right) the plasma-etch

(d) Bubble manipulating elements were functionally tested and the superiority of gap-tolerant half-disk type propagating elements with respect to former TI type elements was proved in agreement with the literature. A semi-automatic wafer-tester was designed and constructed for the selection of active chips in the wafer and defective loops in the case of major-minor loop chip-organization, for the measurement of the margin, i.e. the operating ranges in bias and rotating magnetic fields, and for the measurement of the electrical parameters of current loops. Preliminary studies have been carried out in order to become acquainted with the problems of the design of magnetic and thermal parameters of chip packages.

As a preceding step to the computer-aided design of the lay-out of a bubble memory chip of about 30 Kbit capacity, the masks of a 0.8 Kbit memory chip were prepared by using a software system developed in the Institute and preliminary tests seem to justify the hope that the efforts of recent years will give rise to useful devices in the near future.

OPTICAL MEMORY RESEARCH

Gy.L. Bencze, Gy. Eisler, A. Hámori, G. Kiss, L. Kriveczky, Gy. Nagy, P. Varga, Vu duy Phu, Cs. Zakar

(a) Ageing of holograms

Phase holograms are light sensitive because in the bleaching process the Ag atoms are reconverted into silver halogenides. We investigated the influence of the illumination with light of different spectral composition on the phase holograms: Agfa Gevaert 10E75 plates were subjected to the influence of light for 60 days and the variation in the efficiency of holograms taken with various exposures was measured. In *Fig. 5* the relative change in the efficiency of the holograms is shown as a function of time. The illumination power densities were:

for white light	900 $\mu W/cm^2$
for violet light	75 $\mu W/cm^2$
for green light	120 $\mu W/cm^2$
for red light	230 $\mu W/cm^2$

(For comparison, in a very sunny room the density is 1000 $\mu W/cm^2$ whereas in an optical lab under good visibility conditions it is only 30 $\mu W/cm^2$.)

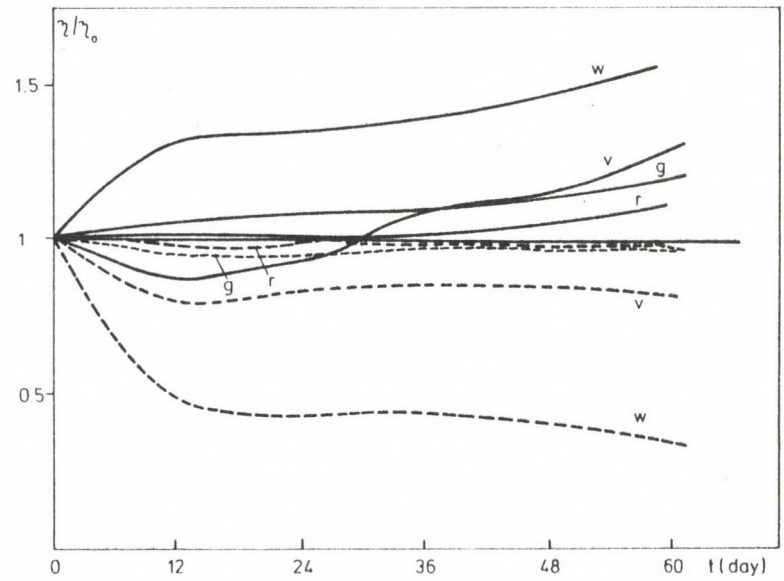

Fig. 5

Change in the efficiency of holograms (η/η_0) *as a function of the time of illumination* (t).
w:white, v:violet, g:green and r:red light.
(For the explanation of solid and dashed lines see text)

The change in the efficiency of holograms taken with an exposure energy corresponding to the maximum of the yield is plotted with a full line; the same for holograms exposed with energies on the linear part of the efficiency-exposition curve is represented with a dashed line. For red light illumination minimal illumination-dependence was observed. The reason for the violet light causing an increase in efficiency has not yet been clarified.

(b) Picture processing system

In our optical memory research the qualification of the elements of the memory model (such as the page composer or optical elements) as well as the model itself is necessary for processing two-dimensional pictures. For this purpose a closed-circuit television system was developed by which a high resolution was obtained in the number of picture elements as well as in the range of intensity. The block diagram of the system can be seen in *Fig. 6*.

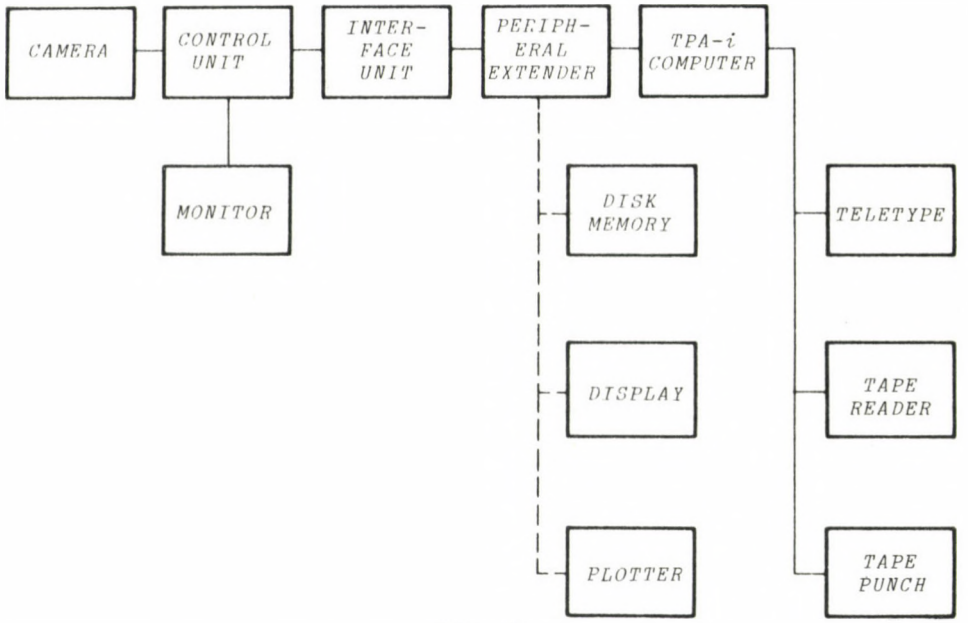

Fig. 6

Block diagram of the picture processing system

ORGANIZATION

The Chalnicon-type camera measures the intensity of the picture elements using the common serial scanning method. The number of picture elements is 1000x1000, the size of the active area is 10x10 mm^2, and the range of intensity is more than two orders of magnitude.

The control unit controls the scanning electron beam in the camera, digitizes the analogue video signal into 8 binary coded bits and assigns the picture elements to be measured. The conversion of the video signal is performed in one picture element in each line, while the assignment of the elements can be made along a vertical scanning line in the present system operation.

The monitor displays the picture to be measured as well as the scanning line.

The three units mentioned above are of type C1000 produced by Hamamatsu, Japan.

The interface connects the control unit to the computer via the programmed and direct memory access channels.

The computer is a TPA-i, and is equipped with an operative memory of 16 Kbit, a peripheral extension unit and standard peripheral units (teletype, tape punch and reader).

OPERATION

The digitized intensity values originating from a program-defined area of the camera are stored in the operative memory. After collection the data can be printed out on the teletype unit either directly or by making the necessary calculations.

The programs, developed until now for the camera supervision, make possible the storage and the printing out of the intensity data collected along a vertical or horizontal scanning line, the position of which can be determined anywhere within the scanning area. We plan to enlarge the computer configuration and the computer programs. The former involves a magnetic disk (for the storage of system programs and the whole picture) and analogue peripheral units (display and plotter), the latter is due to contain special calculations (mean and standard deviation, contrast enhancement, etc.).

MAIN TECHNICAL DATA

Picture size:	10x10 mm^2
Range of intensity:	0.1-1 lx
Number of gray levels:	256
Resolution (electronic):	1024x1024 points
Resolution (optical):	700x700 points
Linearity:	better than 1%
Shading:	10%
Collection time:	20 s/picture

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ION IMPLANTED INTEGRATED CIRCUITS PROGRAMME

P. Barna, F. Bányai, J. Gyimesi, J. Gyulai, A. Hegedüs, Cs. Iványi, P. Keresztes, L. Királyhidi, R. Kósza, E. Kótai**, Le hoang To, T. Lohner, Á. Majoros, A. Manuaba, G. Mezey, T. Mohácsy, T. Nagy, D. Pacher, E. Pásztor, P. Révész, P. Riedl, B. Sallay*, Vera Schiller, G. Vályi*

A 256-bit static RAM built from inverters containing pairs of E-D transistors was used to demonstrate the power of ion implantation. The use of E-D pairs presents a number of electronic and architectural advantages: smaller access time and area, wider range for the power supply, etc. An interesting feature of this circuit is that the decoder consists of a special tree circuit. In such a way one can decrease the dissipation of the circuit.

The main constructional parameters of the circuit are as follows: 10-12 ohmcm, n-type, <111> orientation silicon; the p-n junction depth is 1.6 μm; the threshold voltage of the driver is $V_{TD} = -1.8$ V; the threshold voltage of the field oxide is $V_{TF} \leq -30$ V; the threshold voltage of the load transistor is $V_{TL} = +5$ V.

A special measuring circuit was used to adjust these technological parameters. The functioning of the basic circuit has been completed with the use of a special 4-bit RAM. There are two critical points of the technological procedure: the accuracy of the channel length of drivers (0.4 μm) and the adjustment of the threshold voltage of the depletion transistors by boron implantation. For the solution of these problems measurement techniques have been developed. The determination of the change of channel geometry is based on the measurement of the effective channel length. The effective channel length was determined by measuring the conductance of two transistors with different geometry.

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The amount of electrically active boron in the channel region of the load transistors has also been determined by means of electrical measurements. It can be determined from the dependence of the threshold voltage on the body potential.

The effect of high power laser light to anneal radiation damage of ion-implanted semiconductors (mainly silicon) was discovered only a few years ago. Laser annealing enables complete removal of damage and full electrical recovery of ion-implanted layers. When a single laser pulse is applied (energy density 2 J/cm^2, duration 10-50 nsec), recrystallization occurs due to liquid-phase epitaxy.

We have been working on three different projects to study laser annealing. It has been shown that amorphous evaporated layers of silicon regrow epitaxially on silicon substrates using single laser pulses (see *Fig. 7*). When laser annealing is applied, layers can be produced in which the electrical activity of foreign atoms (for example antimony) exceeds by orders of magnitude the limit of solid solubility. The thermal stability of such layers has also been investigated.

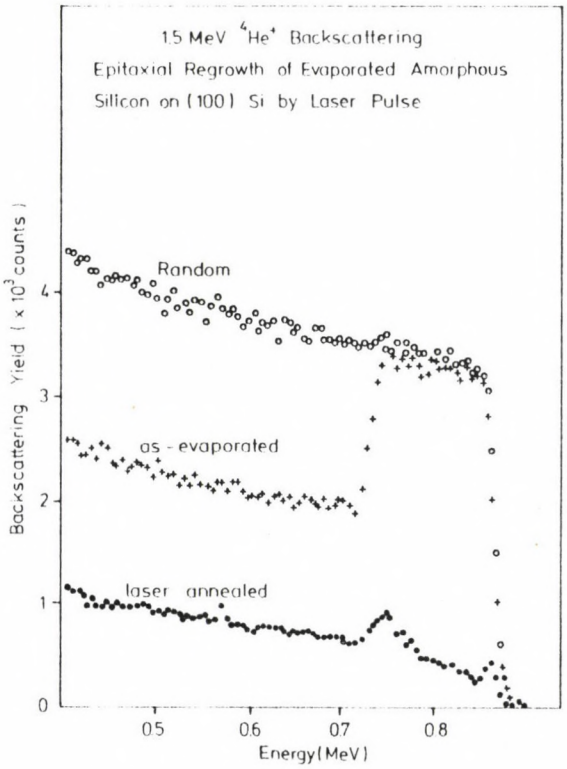

Fig. 7

Epitaxial regrowth of evaporated amorphous silicon on (100) Si by laser pulse

Our earlier studies showed that silicon heavily damaged by argon implantation does not regrow during thermal annealing. Recent experiments, performed together with co-workers of the California Institute of Technology, Pasadena, California, USA, using laser annealing showed regrowth of amorphous implanted layers in silicon containing even 1.5% atomic concentration of argon.

Two other projects have been completed: study of the so-called "snow-plow" effect and the diffusion of antimony in silicon. *Figure 8* shows the correlation between the oxide growth rate and the concentration of Sb. At high oxide growth (110 Å/min) the concentration of Sb atoms in substitutional lattice sites exceeds the limit of solid solubility.

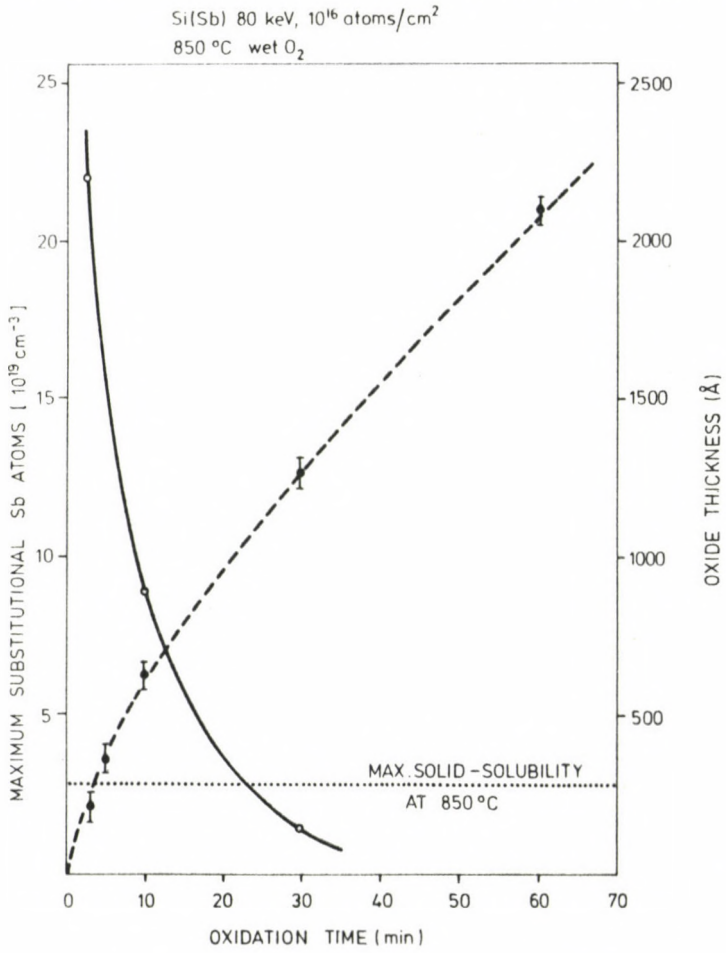

Fig. 8

Change of maximum concentration of the substitutional Sb atoms in the peak (solid line) and of the oxide thickness (dashed line) vs. oxidation time

This is a nonequilibrium state which can be eliminated using drive-in diffusion. In *Fig. 9* the results of studies on lattice location are summarized for antimony concentrations less than the limit of solid solubility. In this case, the number of substitutional atoms is constant, that is, the diffusion of interstitial atoms takes place first.

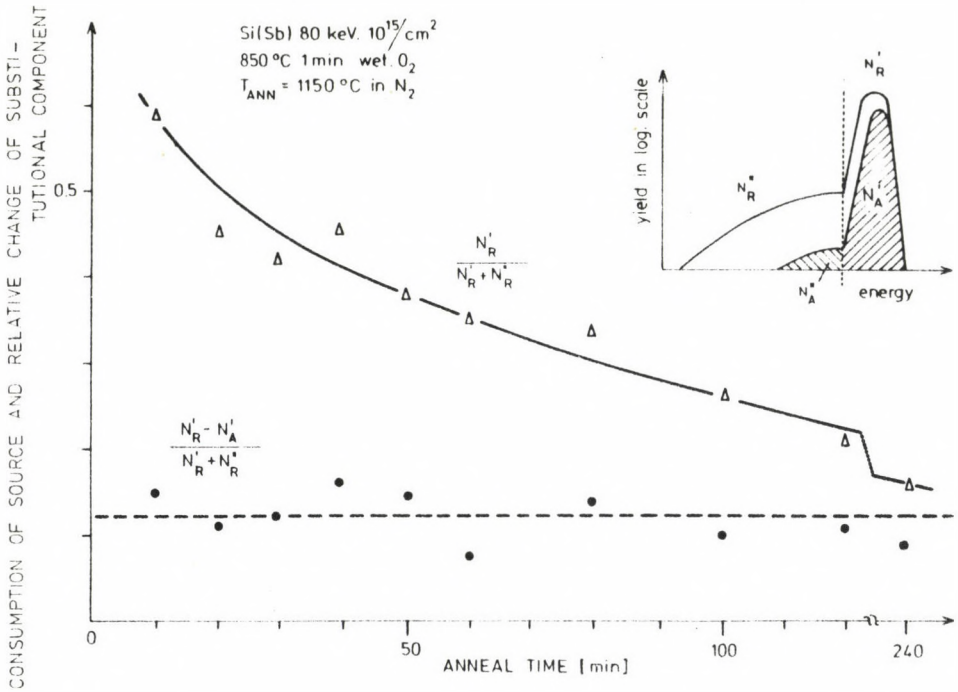

Fig. 9

Consumption of diffusion source (solid line) and relative change of substitutional component vs. anneal time; N' represents the amount of antimony in the peak; N'' is related to the amount of antimony in the diffused tail of the profile for random (R) and aligned (A) spectra

In the framework of our cooperation with the Institute of Physics of Semiconductors, Novosibirsk, USSR, the effect of laser annealing on the profile of implanted Zn in Si was studied as well as the recrystallization of amorphous implanted layers by laser annealing. By means of the nuclear reaction $^{16}O\ (\alpha,\alpha)\ ^{16}O$ the sensitivity of oxygen detection has been improved. Using this method the native oxide after laser annealing was studied.

Another of our partners in laser annealing studies was the Physical Technical Institute, Kazan, USSR. As an example of our collaborative work we proved by electrical measurements that Al implanted silicon laser treatment is more effective than thermal annealing.

Recent results in cooperation with the California Institute of Technology, Pasadena, California, USA, completed our work to perfect epitaxial silicon layers on sapphire (SOS). We demonstrated that implantation in a channelled direction and subsequent medium-temperature heat treatment results in perfect regrowth of the silicon. This effect causes an essential improvement in the leakage current in SOS circuits.

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+++Max-Planck-Institut für Plasmaphysik, Garching, FRG
++++California Institute of Technology, Pasadena, Calif., USA

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AMORPHOUS SEMICONDUCTOR RESEARCH

Mária Füstöss-Wégner, J. Gazsó, J. Hajtó, Margit Koós, I. Kósa Somogyi, L. Tóth, G. Zentai

Our studies were centred on the chalcogenide glasses $GeSe_2$, $GeSe_3$ and As_2S_3, since these were found able to exhibit reversible transitions between optical phase states under the influence of intense laser irradiaton.

In the field of photoluminescence (PL) investigations most attention was paid to the problems of the so-called "fatigue" effects, i.e. when the PL efficiency decays under permanent irradiation. Fatigue types A and B have been observed:

Type A. Under continuous irradiation by an Ar-ion laser (λ=514.5 nm, I=2 W/cm^2) and measured at 77 K, A-type fatigue is very rapid in $GeSe_3$, less pronounced in $GeSe_2$. With an increasing amount of Te additive (up to 10%), the maxima of the emission bands shift toward longer wavelengths, and the PL efficiency decreases. Both effects are stronger in the glasses of the $(GeSe_2)_{1-x}Te_x$ system. On the other hand, fatigue kinetics remain unaffected. The results may be interpreted in terms of exciton recombination also taking into account the structural properties of these glasses.

Type B. This type of fatique has been observed in the Ge-Se system in the temperature range 80-300 K. The duration of this effect is less than 30 s, depending on temperature and wavelength. After fatigue B, the PL intensity recovers to its starting value within a restoration time $\tau_o \geq 20$ s if the sample is in the dark. The results can be explained by comparing the probabilities of the radiative and the non-radiative transitions of quasi-excitons formed during illumination.

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In As_2S_3 glasses natural optical activity was found. The value of the rotation angle depended on the incident polarization direction relative to the sample, i.e. optical anisotropy was established. An explanation for it may be based on the assumption that the layered structure of crystalline As_2S_3 (which in itself is asymmetric) is conserved to some extent in the glass.

Other types of measurements confirmed that Te in low concentration substitutes S in As_2S_3 without altering the band gap, but solely by modifying the band tail distributions. No significant change in the A.C. conductivity was observable, thus supporting the idea of electron transport by hopping between deep-lying localized states.

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ORGANIC CONDUCTORS AND SEMICONDUCTORS

Mária Erő-Gécs, G. Grüner, K. Holczer, A. Jánossy, Katalin Kamarás, G. Mihály, L. Mihály, S. Pekker, Katalin Pintér, Katalin Ritvay-Emandity

The intensive study of quasi one-dimensional organic materials began a few years ago. We have prepared a wide range of materials and carried out different types of experiments in order to find the most important factors determining the physical properties.

Magnetic susceptibility measurements were presented for a series of donor$(TCNQ)_2$ salts. The consequences of random donor stacking in certain materials were discussed, together with the situation where the donors were symmetric and donor-acceptor interactions were of no importance in the magnetic susceptibility. The differences of the magnetic properties of different groups were correlated with the donor properties. The dielectric constant and conductivity of the high conductivity organic charge transfer complex salts $Qn(TCNQ)_2$ and $NMeAd(TCNQ)_2$ were measured at 9.1 GHz in the temperature range 4-320 K. The large increase with temperature of the dielectric constant is at variance with theoretical models describing the systems as metals or semiconductors at high temperatures. A model of localized states requires unreasonably large dipole moments in the excited state to fit with observations. In samples containing 7% of impurities disrupting the TCNQ chains the dc conductivity is strongly decreased, it exhibits no maximum, and the dielectric constant is also depressed. Coherence lengths (ℓ) were estimated from the temperature dependence of the dielectric constant. A decrease from ℓ=110 lattice constants for the pure sample to ℓ = 16 for the most impure sample corresponds well to the impurity content of 7%.

Optical absorption spectra of complex TCNQ salts (Qn, 2-2'BIP, 4-4'BIP, NMePy and MEM) compressed into KBr were measured. It was demonstrated that the low energy transition around 0.3 eV appears in all cases, but this is not simply related to the transport properties.

Differential thermal gravimetry and differential scanning calorimetry studies of the 390 K phase transition of $NMeQn(TCNQ)_2$ on samples

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containing different amounts of acetonitrile solvent were performed. It was shown that evaporation of the solvent is the driving force of a phase transition of this material. Transport properties - dc and ac conductivity and dielectric constant - of the phase containing the solvent are weakly dependent on solvent concentration.

Madelung energy and simple band structure calculations on different models of the TTT_2I_3 complex have indicated that the iodine chains do not play an active role in the conduction process. The relatively small Coulomb coupling of the iodine chains to the crystal obtained by the Madelung calculations rationalizes the structural findings about the ordering of these chains at low temperatures. Optical and conductivity results on the organic charge transfer complex $TTT_2I_xBr_{3-x}$ indicated that the iodine chain is non-conducting and disorder is important in the parent compound TTT_2I_3.

A non-linear electric field dependence was found in the quasi one--dimensional organic conductors $Qn(TCNQ)_2$. Non-ohmic behaviour sets in at electric fields as low as 2 V/cm and it can be observed to temperatures above 100 K. Results obtained on a series of crystals with different lengths show that in defect free crystals the non-linearity is intrinsic. Microscopic breaks enhance whereas chemical impurities depress the non-linearities. The observations are in contradiction with a simple band semiconductor model and also with models where transport properties are assumed to be determined by short localization lengths. The non-ohmic conductivity was studied in a model based on soliton excitations of charge density waves. The effect of bound solitons was taken into account and the possibility of non-linear conductivity at low electric fields was shown. The temperature dependence of the phenomenon was estimated.

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LIQUID CRYSTAL RESEARCH

L. Bata, Ágnes Buka, N. Éber, I. Jánossy, Katalin Pintér, I. Pócsik, J. Szabon

In 1978 the research of cholesteric and smectic systems that started in the previous year was continued.

On cholesteric-nematic mixtures electro-optic effects have been investigated. We measured the threshold of the electric field induced instability in a planar texture as a function of the sample thickness (*Fig. 10*). The observed oscillatory behaviour was explained in terms of the "coarse-grained" continuum theory of cholesterics.

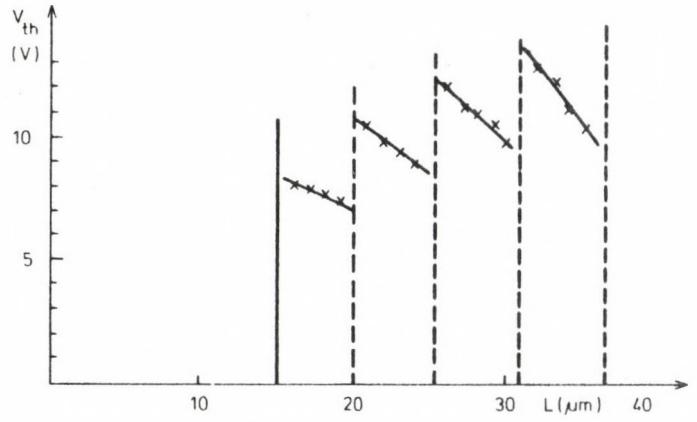

Fig. 10

Thickness (L) dependence of threshold (V_{th}) in a nematic-cholesteric mixture

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On cholesteryl-oleyl carbonate the influence of shear flow on the helical structure has been studied by optical methods. Up to a threshold the helix in only slightly distorted whereas above this threshold the optical properties change abruptly. The latter effect is assumed to be connected with the unwinding of the helix.

The study of smectics was performed first of all using dielectric measurements. The static dielectric constants of decyloxybenzylidene--hexiloxy-phenylester were determined in nematic, smectic A, and smectic C phases at different orientations as a function of the temperature *(Fig. 11)*. We measured the dielectric relaxation also in these phases up to 10 MHz.

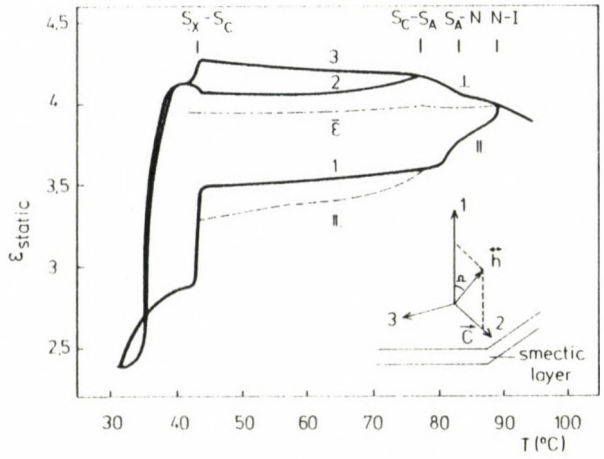

Fig. 11

Static dielectric constants of DOBHOP as a function of temperature in the 1,2,3 directions in the smectic C phase (S_C), and in the ∥ and ⊥ directions in the smectic A (S_A) and nematic (N) phases. The isotropic case is denoted by I

During this year a number of phase diagrams of two-component mixtures were determined. The liquid crystalline phases of the mixtures of nematogen and smectogen substances have been studied by calorimetry and depolarized light intensity. In the case of pp'-di-n-propyl-azoxybenzene the influence of the impurities on the polymorphic properties has been demonstrated.

As a continuation of the former molecular dynamic investigations, the molecular motion of the chlorine and of the di-butyl derivative of phenyl benzoyloxybenzoate was studied by incoherent neutron scattering. The spectra could be explained satisfactorily by the sphere random walk model, using two relaxation times.

The analysis of the NMR line shape of p-azoxyanisole led to the conclusion that the molecules are rotating around the director. This is

caused by the Maier-Saupé potential and the anisotropy of the moment of inertia of the molecules.

One member of the group spent 4 months in Alberystwyth, Wales, completing a study tour. She measured the dielectric dispersion of nematic, smectic A phases and that of mixtures from static values up to 100 GHz.

In cooperation with the Martin-Luther University, Halle, GDR, we synthesized optically active liquid crystals.

The dielectric constants of cholesterics have been measured in co-operation with the Institute of Crystallography, Moscow, USSR.

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RESEARCH ON METAL PHYSICS

I. Bakonyi, Éva Császár-Gilicze, C. Hargitai, T. Kemény, Éva Kisdi-Koszó, G. Konczos, K. Lázár, A. Lovas, G. Mészáros, I. Nagy, A. Sütő, Erzsébet Sváb, J. Takács, L. Takács, T. Tarnóczi, K. Tompa, J. Tóth, P. Tóth, Enikő Tóth-Kádár, Katalin Vajsz-Jámbor, B. Vasvári, I. Vincze, Katalin Zámbó-Balla

Investigations relating to the glassy metallic alloys containing transition metal and metalloid atoms and to the metal-gas reactions have been continued.

The technological research into the production of metallic glasses using the well-proved rotating brass disk method has been carried on in three directions.

The phenomena taking place during the cooling of the melt on the surface of the brass disk and the formation of the amorphous ribbon were

investigated with the help of high speed motion pictures. Using different shaped nozzles the relationships between the technological parameters and the geometry of the produced ribbons have been established. It was found that the melt temperature from which one can reach the glassy state with ease depends on the constitution of the melt. The results obtained in the case of binary iron-boron alloys are shown in *Fig. 12*. As to the geometry of the ribbon, our observations have proved that the ribbon thickness depends mainly on the peripheral velocity of the disk, that is, on the cooling rate of the quenching; its width is determined primarily by the nozzle diameter.

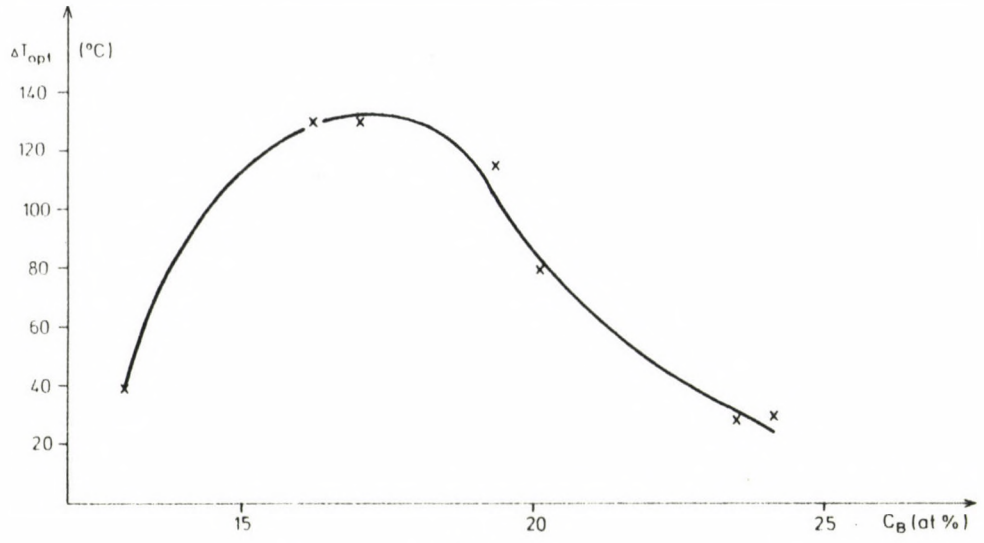

Fig. 12

Optimal temperature range ΔT_{opt} for the start of the splat cooling of iron-boron melts. (C_B is the concentration of boron in the melt)

The other part of the technological research seeks to discover the correlation between the preparation conditions and the different physical (magnetic, electrical and mechanical) properties. From results obtained so far, in *Fig. 13* the microhardness and coercive force values measured on as-cast ribbons are plotted against the peripheral velocity of the disk for an iron-boron metallic glass.

The main purpose of our magnetic measurements was the investigation of the thermal stability of the amorphous state. The effect of low temperature (200 °C) annealing on the coercive force was investigated in the case of binary iron-boron and an iron-cobalt-boron-silicon metallic glass of nearly zero magnetostriction.

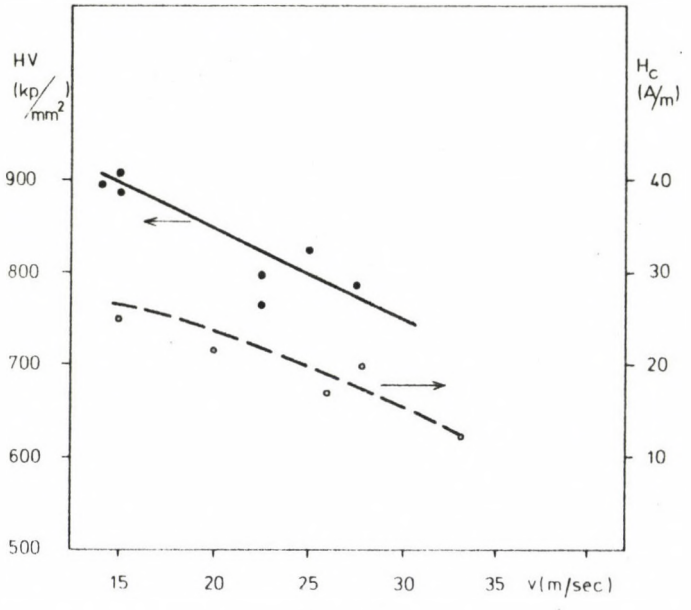

Fig. 13

Microhardness (HV) and coercive force (H_c) of as-cast iron-boron ribbons as a function of the peripheral velocity v of the disk

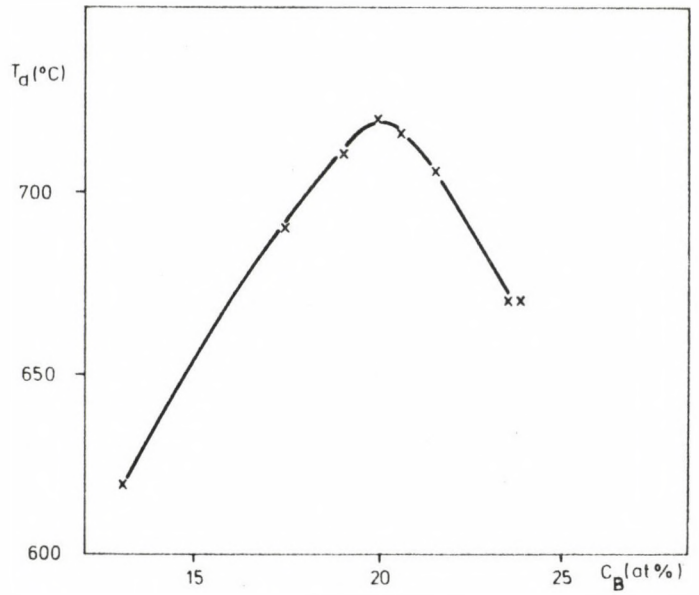

Fig. 14

Decomposition temperature (T_d) of the metastable Fe_3B alloy. (C_B is the boron concentration)

The amorphous-crystalline phase transition of Fe-B alloys in the concentration range 12.5-23.5 at% was pursued by thermomagnetic measurements. The decomposition of the metastable Fe_3B phase into two stable phases, α-Fe and Fe_2B, was investigated. It was found that the temperature of decomposition depends on the boron concentration *(Fig. 14)*.

We continued our work on the crystallization kinetics in metallic glasses utilizing isothermal measurement of transport properties and differential scanning calorimetry (DSC).

Crystallization kinetics were measured of Metglas 2605 iron-boron and some other $Fe_{100-x}B_x$ alloys. To determine the proportions transformed during isothermal annealings the data on electrical resistance changes were used. The resistance measurement method proved to be useful as a means of rapidly reviewing the crystallization process, and it supplies accurate activation energies. The results have been used to construct the TTT diagrams of iron-boron alloys.

The structure and crystallization of amorphous $Fe_{1-x}B_x$ ($0.1 \leq x \leq 0.25$) alloys have been investigated by Mössbauer spectroscopy and DSC. It was found that the first step of crystallization is the precipitation of α-Fe until the composition of the remaining glass reaches $Fe_{75}B_{25}$. In the second step this remaining glass transforms into metastable Fe_3B, which at higher temperatures decomposes into α-Fe and Fe_2B. On the basis of these results a quasicrystalline model based on a locally distorted off--stoichiometric Fe_3B lattice has been suggested.

The study of the Fe-Ni-B system was started by calorimetric and Mössbauer methods. The dependence of the crystallization temperatures and the heat of crystallization of these alloys on the iron-nickel ratio was determined in the case of two systems of different boron content. Both the calorimetric and Mössbauer measurements gave valuable information on the special short range order in these amorphous alloys.

The ^{31}P NMR Knight shift, the T_1 and T_2 relaxation times, and the linewidth have been measured at several frequencies in electrodeposited $Ni_{100-x}P_x$ ($17<x<27$) and rapidly quenched $Cu_{60}Ni_{22}P_{18}$ alloys. Our measurements revealed a great difference between the measured and calculated values of T_1 from the Korringa relation. This discrepancy shows that there is a great non-s character of the conduction electrons which supports the two conduction band model. In contrast with their T_1 characteristics none of these metallic glasses can be described by a single spin-spin relaxation time. The use of the Gill-Meiboom method allows at least two different spin-spin relaxation rates to be separated. The extreme values are T_{2min} = 180 μs and T_{2max} = 1500 μs for both alloy systems and are the same at the frequencies 16 and 36 MHz. The existence of two different T_2 values indicates that two kinds of local environments of ^{31}P nuclei must exist.

With regard to the metal-gas systems the kinetics of carburization and decarburization of alpha iron was studied for the reaction $CH_4 \rightleftarrows C_{\alpha Fe} + 2H_2$ using the ^{14}C isotope. The rate equation $u = \vec{k} p_{CH_4} - \overleftarrow{k} p_{H_2}^2 x_c$ was obtained for the oxygen-free surface of high purity iron. The reaction rates were found to decrease by one order of magnitude on doping the iron with 10 ppm antimony. At the same time, the form of the rate equation changed to $u = \vec{k}^* p_{CH_4} p_{H_2}^{-1/2} - \overleftarrow{k}^* p_{H_2}^{3/2} x_c$.

By measuring the electrical resistance changes we were able to study the kinetics of the decarburization process of some factory produced iron-nickel alloys. We found there to be considerable enhancement in the speed of decarburization with increasing nickel concentration.

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3. I. BAKONYI, K. TOMPA, E. TÓTH-KÁDÁR, A. LOVAS: NMR linewidth study in amorphous Ni-P and Cu-Ni-P alloys. Proc. Conf. on Amorphous Materials, Smolenice, Czechoslovakia 1978. (in press)

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8. J. BALOGH, I. VINCZE: Temperature dependence of the hyperfine field distribution in an amorphous ferromagnet. Solid State Commun. 25, 695 (1978)

9. T. KEMÉNY, B. FOGARASSY, E. TÓTH-KÁDÁR: Crystallization kinetics of metallic glasses. KFKI Report 78-10 (1978)

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***Institute of Metallurgy and Technology, Csepel Iron and Metal Works, Budapest

10. T. KEMÉNY, I. VINCZE, B. FOGARASSY, S. ARAJS*: Structure and crystallization of Fe-B metallic glasses. KFKI Report 78-56 (1978)

11. T. KEMÉNY, I. VINCZE, B. FOGARASSY, S. ARAJS*: On the stability and crystallization of Fe-B alloys. Proc. 3rd Int. Conf. on Rapidly Quenched Metals, Brighton, UK, 1978. (in press)

12. D.A. NEW*, S. ARAJS*, F.E. LUBORSKY**, T. KEMÉNY, I. VINCZE, B. FOGARASSY: Electrical resistivity of glass $(Fe_xNi_{100-x})_{80}B_{20}$ alloys at elevated temperatures. Proc. MMM Conf., Cleveland, Ohio, USA, 1978. (in press)

13. G. SOBE***, G. KONCZOS, J. KUNZE***, R. VOIGTMANN***: Kinetics of carburization and decarburization of α-iron in methane-hydrogen mixture. KFKI Report 78-57 (1978) (in German)

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24. I. VINCZE, T. KEMÉNY, S. ARAJS*: Quasi-crystalline structure of amorphous alloys. KFKI Report 78-54 (1978)

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+Institute of Physics, University of Zagreb, Yugoslavia

TECHNICAL DEVELOPMENT

ELECTRONIC MEASURING EQUIPMENT

O. Bakos, I. Eördögh, L. Farkas, P. Horváth, B. Lévay, I. Pálmai, F. Tóth

Possibly the most appropriate way of indicating our activities in physical and chemical research within the Institute, as well as detailing work relating to external orders, is to list the types of measuring units completed during the past year:

- transient recorders,
- power supplies for lasers,
- power supplies for magnets and solenoids,
- temperature controllers,
- Fabry-Perot interferometer stabilizers,
- automatic control units for Chochralski pullers,
- moisture testers,
- NMR marginal oscillators,
- peripheral interface units of various types for scanning electron-microscopes,
- digital clocks,
- box-car integrators,
- single phase lock-in amplifiers,
- two phase lock-in amplifiers,
- logarithmic amplifiers.

We have also been engaged in servicing a wide range of measuring equipment.

LOW TEMPERATURE MEASUREMENT TECHNIQUES

J. Balla, A. Pintér, I. Szakáll

For neutron spectroscopy measurements a new type of He cryostat has been developed in which the temperature of the specimen can be adjusted from 4.2 K to 300 K. The evaporation loss of the cryostat is 0.06 lit liquid He and 0.1 lit liquid nitrogen in one hour. The volume of gas used to cool the specimen can be varied between 15 and 1500 lit per hour. The specimen can be changed in some minutes without disturbing the thermal insulator vacuum system.

For Mössbauer effect measurements in strong magnetic fields and in a wide temperature range a gas-flow type measuring head has been developed in which the specimen is parallel to the direction of the magnetic

field. The specimen is cooled by liquid He or He gas. The equipment consists of three units: the measuring head, a flexible filling tube insulated thermally by vacuum-cover and containing a valve capable of controlling the speed of the liquid He, and a vessel of 40 lit cubic capacity for liquid He transport. The measuring head is connected to the top of the vertically arranged superconducting system. From the 40 lit vessel the liquid He flows through the flexible filling tube to the evaporator. The temperature range of the measurement is 4.2 to 300 K with gas-cooling and 4.2 to 1.5 K with liquid-cooling; the stability of the temperature is 0.05 K/hour and 0.005 K/hour, respectively. The main dimensions of the measuring cell are the following: inner diameter 25 mm, outer diameter 40 mm, length 1500 mm, the diameter of the window 15 mm.

The main units of the automatic level control equipment family, based on the principle of condensation for liquid nitrogen and liquid helium, have been developed. The working media of the instruments are oxygen and hydrogen for liquid nitrogen and for liquid helium, respectively. The accuracy of level control is 2 mm.

For the continuous measurement of the level of liquid He in a strong magnetic field a capacitive probe has been developed; this probe is a cylinder capacitor consisting of two thin-walled stainless steel tubes. The outer diameter of the probe is 11.13 mm. The change in the capacity of the capacitor is 18 pF for 500 mm probe-length and 30 pF for 800 mm probe-length.

The total amount of the cooling substances and the technical gas:

3,650 lit liquid helium
189,000 lit liquid nitrogen
3,400 m^3 dry nitrogen gas.

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1. I. EÖRDÖGH, P. HORVÁTH, I. PÓCSIK: Equipment for the investigation of fast transient processes. Proc. Nauchpribor SEV-78, Moscow, USSR, 1978. p. 39 (in Russian)

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3. J. BALLA, M. ERŐ-GÉCS, A. JÁNOSSY: Gas-flow measuring head for electron spin resonance spectrometer. KFKI Report 78-25 (1978)

4. Z. ÁRPÁDFI*, J. BALLA, I. KROMER*: Development of equipment for investigating the dielectrical properties of insulating materials at low temperatures. Proc. Conf. on Properties of Dielectrics and Materials for Electrical Transmission Lines, Moscow, USSR, 1978. p. 70 (in Russian)

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FOREIGN RELATIONS

LECTURES BY VISITING SCIENTISTS

P.A. Alexandrov (Kurchatov Institute, Moscow, USSR)
The influence of the radiofrequency field on the superfine structure in the paramagnetic crystal

G.S. Cargill III (IBM Research Laboratory, Yorktown Heights, New York, USA)
Research on amorphous materials in IBM Yorktown

Koung-an Chao (University of Linköping, Linköping Sweden)
New methods in the Kondo problem
Heavily doped and compensated semiconductors

Esther Conwell (Xerox Webster Research Company, Webster, New York, USA)
Electronic structure of 1D conductors

C. di Castro (Universitá di l'Aquila, Roma, Italy)
Arbitrariness and symmetry properties of the functional formulation of the Hubbard problem

J. Kudrnovsky (Institute of Solid State Physics, Prague, Czechoslovakia)
CPA calculation for the optical properties of semiconductors

H. Kuzmany (University of Vienna, Vienna, Austria)
Raman spectrum of 1D organic conductors

G.Pasold, R.Dersin (Robotron, Dresden, GDR)
Coherent optical character recognition

H. Schmidt (University of Hamburg, Hamburg, FRG)
Hydrogen in metals

A.P. Zhernov (Kurchatov Institute, Moscow, USSR)
Determination of electric resistivity and thermal resistivity of simple metals (Na, K) from first principles

L. Zuppiroli (CRNS, Fontenay aux Roses, France)
Effect of the irradiation on the charge transfer salts

STAFF MEMBERS ON STUDY TOURS

Ágnes Buka	University College of Wales, Aberystwyth, Wales	1 year
P. Fazekas	International Centre for Theoretical Physics, Trieste, Italy	6 weeks
G. Forgács	University of Albany, Albany, New York, USA	1 year
G. Grüner	University of California, Los Angeles, Calif., USA	1 year
J. Hajtó	University of Edinburgh, Edinburgh, Scotland	6 months
G. Konczos	Max Planck Institute, Düsseldorf, FRG	2 months
Nóra Menyhárd	Universität des Saarlandes, Saarbrücken, FRG	1 year
G. Mezey	California Institute of Technology, Pasadena, Calif., USA	1 year
G. Pető	Chalmers University of Technology, Gothenburg, Sweden	1 month
Katalin Pintér	Universität Halle, Halle, GDR	3 months
E. Praveczki	Joint Institute for Nuclear Research, Dubna, USSR	2 years
G. Solt	Université de Lausanne, Lausanne, Switzerland	2 years
J. Sólyom	University of Illinois, Urbana, Illinois, USA	1 year
A. Sütő	H.H. Wills Laboratory, University of Bristol, Bristol, U.K.	5 months
P. Szépfalusy	Universität des Saarlandes, Saarbrücken, FRG	1 year
J. Tóth	Joint Institute for Nuclear Research, Dubna, USSR	2 years
P. Tóth	Institute of Physics, Czechoslovak Academy of Sciences, Prague, CSSR	2 months
I. Tüttő	University of Virginia, Charlottesville, Virginia, USA	6 months

Katalin Vajsz-Jámbor	Wilhelm Pick Universität, Rostock, GDR	1 month
I. Vincze	University of Groningen, Groningen, The Netherlands	2 years
G. Zimmer	California Institute of Technology, Pasadena, Calif., USA	1 month

GUEST SCIENTISTS AND FELLOWS

P.D. Berezin	Lebedev Physical Institute, Moscow, USSR	6 weeks
A. Chyla	Technical Research Institute, Wroclaw, Poland	1 month
C. di Castro	Universitá di l'Aquila, Rome, Italy	1 month
M.F. Galiaudinov	Physical Institute, Kazan, USSR	2 months
F.B. Humphrey	California Institute of Technology, Pasadena, Calif., USA	1 month
L.P. Kazakova	A.F. Ioffe Physico-Technical Institute, Leningrad, USSR	1 month
J. Krzywinski	Institute of Physics, Warsaw, Poland	3 months
S.E. Matteson	California Institute of Technology, Pasadena, Calif., USA	3 months
E. Th. O'Dell	Imperial College, London, England	1 month
H. Schmidt	University of Hamburg, Hamburg, FRG	1 month
T. Suzuki	Tohoko University, Sendai, Japan	5 months
V.A. Vasil'ev	A.F. Ioffe Physical-Technical Institute, Leningrad, USSR	1 month

THESES

J. Sólyom	Application of scaling and multiplicative renormalization in solid state physics. (For the academic degree of Doctor of Physical Sciences)
P. Fazekas	On the possibility of a novel ground state in two-dimensional antiferromagnets. (For the academic degree of Candidate of Physical Sciences)

Katalin Kamarás	Physico-chemical investigations on electrically conducting donor - acceptor salts. (For Ph. D. degree)
Ali Jaffar Kishmiri	Transport properties of liquid and amorphous transition metals and their alloys. (For Ph. D. degree)
G. Mihály	Investigation of DC conductivity and TEP on organic charge transfer salts. (For Ph. D. degree)

PATENTS

J.Balla, L.Kovács*	He cryostat from module-elements for the investigation of different specimens in a wide temperature range with the variation of specimen-holders and specimen-coolers (MA-2683)
J.Bergou, L.Csillag M.Jánossy, K.Rózsa	Gas laser to increase the gain and power of the laser (MA-2861)
Gy. Eisler	Optomechanical system consisting of basic elements to provide positioning with more degrees of freedom (MA-2092)

*Technical University, Kosice, Czechoslovakia

RESULTS

INTERACTION OF ULTRASHORT LASER PULSES WITH ELECTRONS

Gy. Farkas, Z.Gy. Horváth

This year we began experiments in cooperation with scientists from József Attila University, Szeged, Hungary, to investigate the general properties of the resonance observed at the multiphoton photoelectric effect produced on the surface of gold by an Nd-glass laser. The aim of the experiments was that instead of using an Nd-glass laser, which can be tuned in a narrow range only, we set out to use a dye laser tunable in a very large spectral range. We have optimized the laser parameters, viz. intensity, tunability, spectral width, and the methods of detection. This gives us the immediate possibility of beginning the experimental investigations and it will be possible to verify over a much broader wavelength range than earlier the possible existence of the resonance at the two and three photon transition.

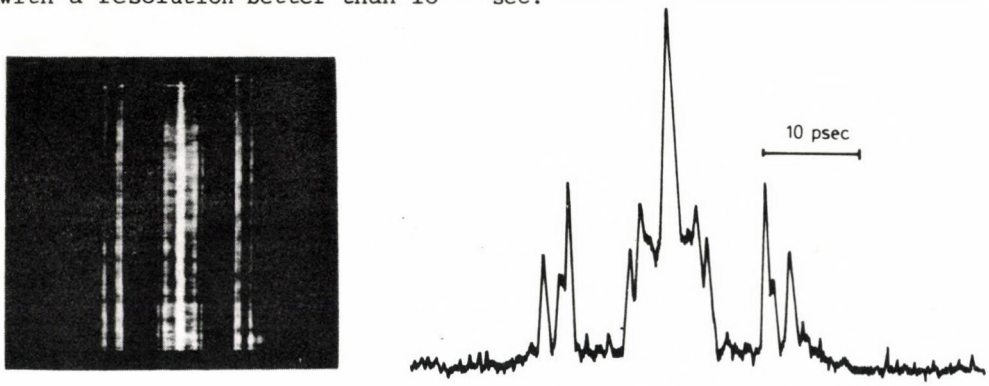
For the investigation of the X-rays of laser plasmas a dynamic vacuum target chamber system was made, operating to 2×10^{-5} Torr pressure, in which the target can be moved under the vacuum. The system has high voltage connections, laser windows, and optical and X-ray windows also.

We have built a bent crystal vacuum X-ray spectrometer for the X-ray region 0.3-14 Å. The average dispersion is 0.13 Å/mm and the measured resolution better than 10^{-2} Å. We can investigate the time dependence of the fast, plasma X-ray radiation with a resolution of 10^{-9}s; our home-produced pinhole camera-scintillation crystal image amplifying system removes the necessity for the slow film processing in the experiments.

By applying our ruby laser for the recrystallization process of ion implanted semiconductors by lasers, new results were obtained in the common measurements performed with our Institute's ion implantation team.

In the development of laser techniques we began, with Soviet help, the construction of an Nd-glass laser amplifier which will have an amplification factor of 800. Together with Armenian scientists we improved

the picosecond measuring system patented in 1977. As can be seen in *Fig. 1* we are able to detect the time behaviour of a single laser pulse with a resolution better than 10^{-13} sec.



(*a*) (*b*)

Fig. 1

Picture of a selected utrashort laser pulse on the screen of the picosecond measuring system (a) and its microdensitogram (b)

By using the technical possibilities provided by the Lebedev Physical Institute, Moscow, USSR, together with A. Kilpio and A.A. Malyutin we have built the first two-dimensional ("halo") laser which operates under new principles and which emits laser radiation not along a line, but in a plane (*Fig. 2*).

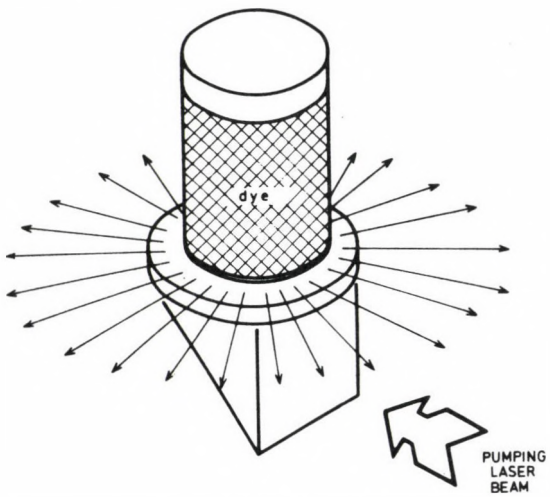


Fig. 2

Experimental arrangement of the 100 kW two-dimensional "halo" laser

The maximum pulsed power of this "halo" laser is 100 kW and its divergence in one direction is 2π rad having an intensity fluctuation smaller than 30% along the circle; in the perpendicular direction its divergence is 1.6×10^{-2} rad.

PUBLICATIONS

1. L.A. LOMPRE*, G. MAINFRAY*, C. MANUS*, J. THEBAULT*, GY. FARKAS, Z.GY. HORVÁTH: A new effect in multiphoton photoeffect of a gold surface induced by picosecond laser pulses. Appl. Phys. Lett. 33, 124 (1978)

2. GY. FARKAS: Multiphoton phenomena in photoelectron emission processes of metals at high laser intensities. In: Multiphoton Processes, John Wiley and Sons, New York, 1977, p. 81-100

NOBLE GAS MIXTURE HIGH VOLTAGE HOLLOW CATHODE LASER

J. Bergou, L. Csillag, M. Jánossy, K. Rózsa

In our earlier work cw laser operation was obtained at the 4694 Å and 4765 Å lines of Kr II and Ar II in He-Kr and He-Ar hollow cathode discharges. By the use of a modified - so-called high voltage hollow cathode - laser, we found new cw Kr and Ar ion laser transitions. Our present experiments were performed in a laser tube of 160 cm active length. Six anode rods were placed inside a cylindrical hollow cathode of 7 mm inner diameter, the remaining free diameter for laser oscillation being 3 mm. Excitation was by half wave rectified alternating current where the repetition rate was reduced to 12.5 Hz.

The observed new cw laser lines are of three types: lines not previously observed (A), lines which oscillated earlier only in pulsed positive column discharges (B), and lines observed for the first time in a He-Ar hollow cathode discharge (C). The wavelengths of the new lines in Å units are the following:

Kr II: 6510 (A), 5126 (B), 4583 (B), 4387 (B), 4318 (B)
Ar II: 6861 (A), 6483 (A), 4579 (C), 4545 (C).

The highest output power was measured at the 4694 Å transition of Kr II, it was 100 mW at 11 A discharge current and 870 V tube voltage. In He-Ar using 10 A and 700 V excitation, the output power was 21 mW at the 4765 Å line.

*C.E.N. de Saclay, Service de Physique Atomique, Gif-sur-Yvette, France

Gain of the strongest Kr ion lines was measured and was found to be the following within near optimum gas filling conditions: 9.5%/m (4694 Å), 2.5%/m (4318 Å), 0.5%/m (6510 Å). A strong competition was observed between the 4694 Å and 4318 Å lines, the latter is much stronger when the blue 4694 Å transition is suppressed. This is due to the common upper level of these lines. The excitation mechanism leading to population inversion in the cw noble gas mixture ion lasers was considered to be the collisions of the second kind between He 2^3S metastable atoms and ground state ions. We have shown, however, that in contrast to the pulsed positive column discharges the dominant process for creating ground state ions in a hollow cathode discharge is not Penning collision but electron impact ionization.

PUBLICATION

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LASER LENGTH MEASUREMENT SYSTEM

Gy.Z. Angeli, P. Jani, Á. Kiss

The development of a laser interferometric length measurement system for industrial use has been continued by our group.

The following functional units were designed and constructed during the last year:

- laser frequency stabilization unit,
- detector head unit,
- central electronic processing unit,
- circuits for monitoring the environmental data.

The frequency stabilization of the light source is performed by a sinusoidal-perturbation self-adjusting electronic control system. This has the merit criterion provided by the frequency - intensity characteristic of the single mode He-Ne laser (Lamb-dip). The control system activates a piezoelectric transducer which varies the length of the resonator.

The detector head converts the input optical signal into a digital pulse train, interprets the sense of motion, and detects the light intensity.

The main functions of the central electronic processing unit are the following:

- the pulse train from the detector head is counted and stored,
- the environmental data (ambient temperature, air pressure) are accepted,
- the data on material temperature and coefficient of thermal expansion are accepted,
- the actual wavelength in air is computed,
- the fringe count data are converted into metric units,
- the data are displayed.

To comply with the accuracy requirements for the laser interferometric length measurement system it was necessary to provide facilities for ambient temperature and air pressure measurement with the following specifications: continuous measurement, range 0-40 ^{o}C, 0.1 ^{o}C absolute accuracy, pressure range 730-790 Torr, 1 Torr absolute accuracy.

LASER PROCESSING

I. Czigány, I. Kertész

From the wide variety of practical tasks solved by CO_2- and Nd:YAG lasers in 1978 (based on the contract between the Institute and the State Office for Technical Development), we describe a new method for pinhole drilling. The Hungarian Optical Works needs pinholes of 10-15 μm diameter for their beam expanders. The laser drilling of small holes is generally carried out by pulsed lasers, but the drilling process can be optimized better by using repetitively Q-switched cw Nd:YAG lasers.

By solving the rate equations of a four level laser system by taking into account the finite lifetime of the - generally neglected - lower laser level, we were able to obtain much more realistic values for the half width ($\tau_{1/2}$) and peak power than by models used up to now. *Figure 3* shows the above parameters as a function of switching time (T) at a given pumping rate: 2.4-times above the threshold. For acousto-optic switching T is about 0.8 μs, which corresponds to 1.5 mJ pulse energy. According to our calculations for a 30 μm thick sheet of Ni (or Mo) the required hole of about 10 μm diameter can be drilled by 1-2 pulses, depending on the reflection.

In the focusing process the spherical aberration of the focusing lens and the divergence of the beam must be taken into account. In our case the divergence in multimode is Θ = 6 mrad and so with the f = 16 mm lens the spot diameter is too high (100 μm). Using TEM_{oo} operation Θ is

1-2 mrad but the spot diameter is still too large. As a result of expanding the beam diameter the divergence decreases but the aberration increases. In the optimized case, for the given lens the spot diameter can be about 12 μm. The pinholes drilled by the repetitively Q-switched Nd:YAG laser and focusing optics with optimized parameters are 11±1.2 μm in diameter with 2% ellipticity. The reproducibility dependens only on the material surface and the homogeneity.

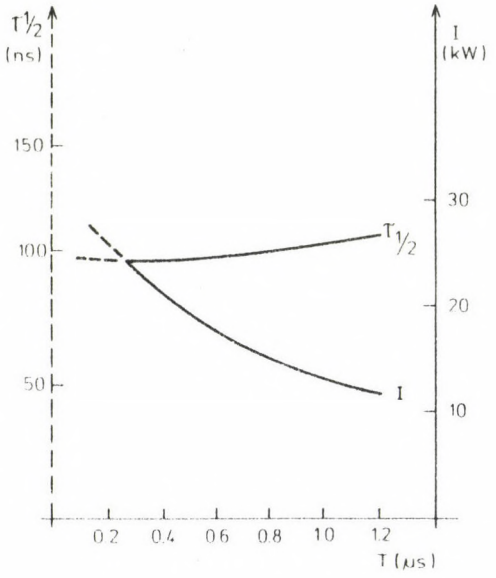


Fig. 3

The dependence of pulse half width (τ 1/2) and peak power (I) on switching time (T) at a given pumping rate (2.4 times above the threshold)

LIGHT SCATTERING OF TiO_2 THIN FILMS

K. Ferencz, A. Lutter

TiO_2/SiO_2 film systems are generally used for laser mirrors. The subsequent annealing increases the peak reflectivity and the width of the high reflection band of such mirrors (*Fig. 4*). It is disadvantageous that the annealing increases also the scattering losses (*Fig. 5*). We found that the scattering losses of the SiO_2 component are negligible compared with that of the TiO_2 component. The light scattering of the thin films is connected with the morphological structure of the layers. The increase in the light scattering of TiO_2/SiO_2 mirrors may be caused by the structural change of the TiO_2 layers during the annealing.

We investigated the 441 nm laser light scattering of different homogeneous TiO_2 layers evaporated onto 100, 250 and 350 ^{o}C substrates. *Figure 6* shows the angular distribution of scattered light intensity of a 540 nm thick TiO_2 layer before and after annealing and the statistical parameters of the surfaces. The experimental data were described by the theoretical curves computed according to the Elson model.

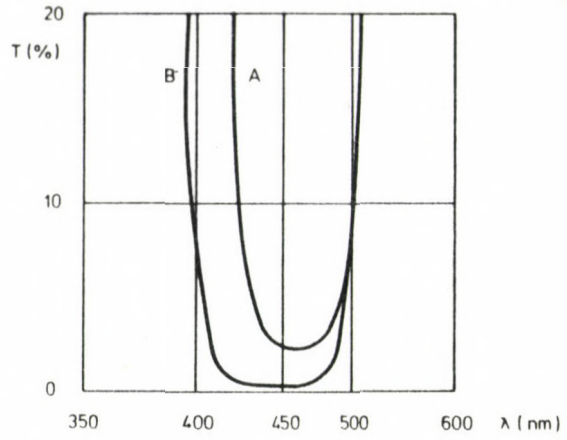


Fig. 4

Absorption spectrum of a $(HL)^7H$ TiO_2/SiO_2 mirror before (A) and after (B) annealing

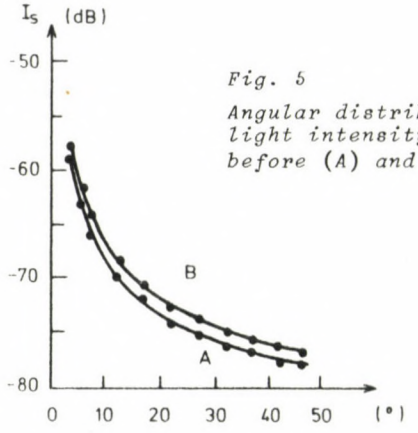


Fig. 5

Angular distribution of the scattered light intensity of a TiO_2/SiO_2 mirror before (A) and after (B) annealing

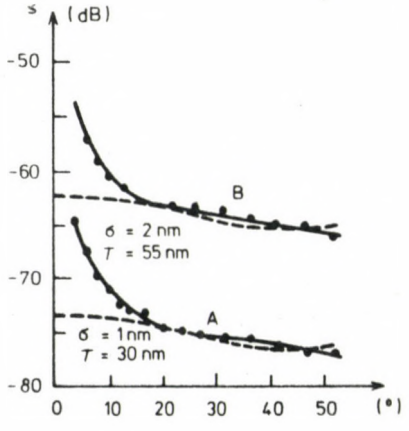


Fig. 6

Angular distribution of the scattered 441 nm laser light intensity (I_s) of homogeneous TiO_2 layer (full lines) fitted with the theoretical curves (broken lines) before (A) and after (B) annealing. (σ and T are the rms height and correlation length, respectively)

Figure 7 shows the light intensity scattered to a 2.39×10^{-4} sr solid angle during annealing of two homogeneous TiO_2 layers. The angle of scattering was $\Theta = 10^{\circ}$. Curve A in *Fig. 7* shows a step between 300 and 400 °C which can be identified with the appearance of the mixtured rutile - anatase phase in accordance with electron-microscopic structure investigations. The change belonging to this step is very fast showing the phase transformation character of the process. Between 500 and 600 °C there is a slow increase in the scattering. This step is explained by a recrystallization process which causes an accumulation of the scattering centres.

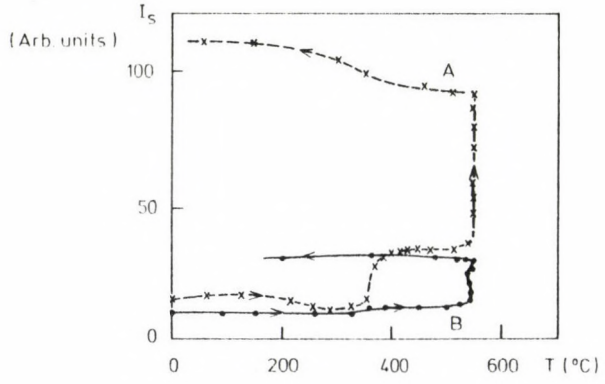


Fig. 7

Change of scattered light intensity of two homogeneous TiO_2 layers during annealing. The temperatures of the substrate during the preparation of the layer were 100 °C (A) and 350 °C (B) respectively

NANOSECOND EXCITATION SPECTROMETER

I. Horváth, E. Láng, J. Szőke, J. Tóth

This instrument is designed for the decay time measurement of electronic excited states.

The excitation light source is a thyratron controlled Model 435 nanosecond flashlamp (Applied Photophysics Ltd. London). The half-width of each excitation pulse is about 3 nsec for a deuterium or hydrogen filled lamp and at the 1% level is less than 8 nsec. Typical light output in photons per steradian per flash is about 10^8 depending on the gas filling. The repetition rate of the discharge is adjustable between 5 and 25 kHz.

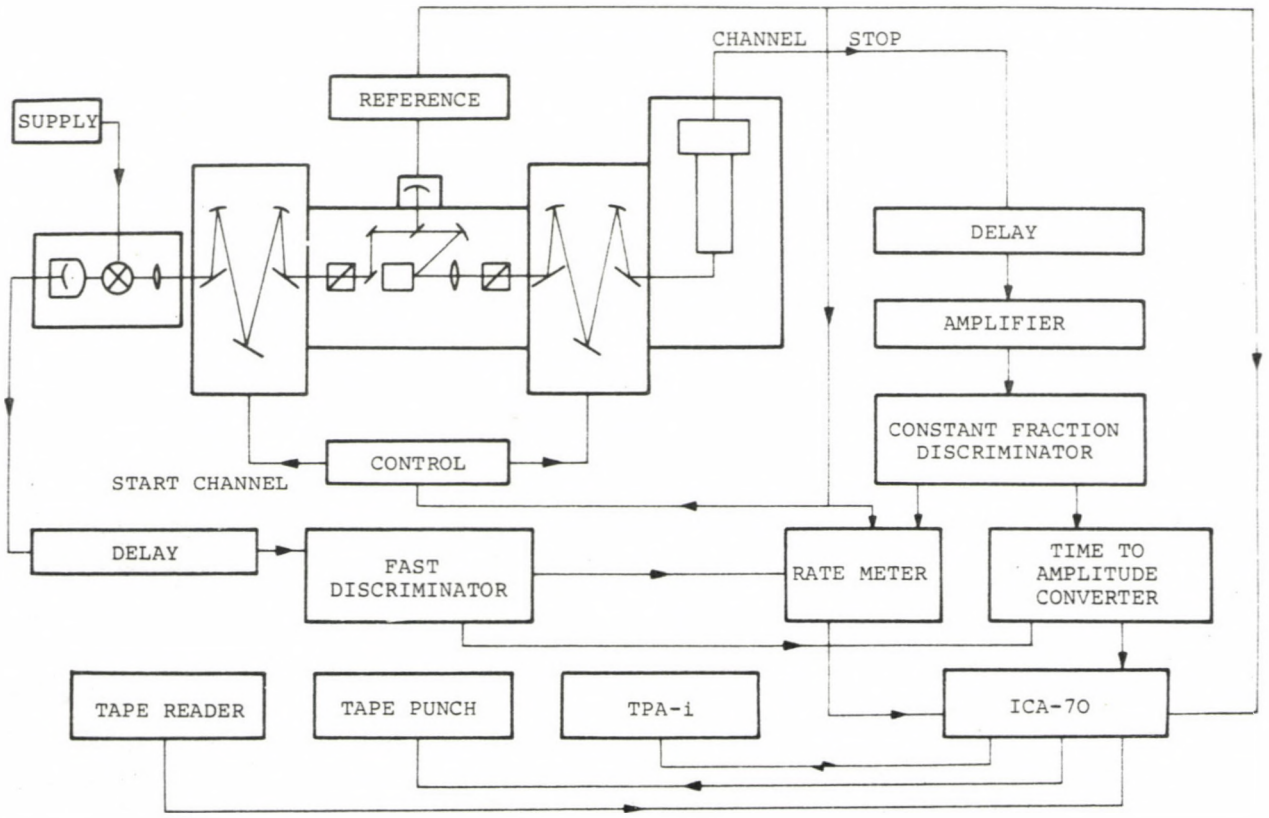


Fig. 8

Arrangement of the nanosecond excitation spectrometer

The optical and electronic detection system of the nanosecond excitation spectrometer is presented in *Fig. 8*.

A Czerny-Turner monochromator with 200 mm focus length has been developed in our laboratory (*Fig. 9*) and is inserted between the lamp and sample compartment thereby providing selective excitation. The emitted light is monochromatized by cut-off filters fitted to the material investigated.

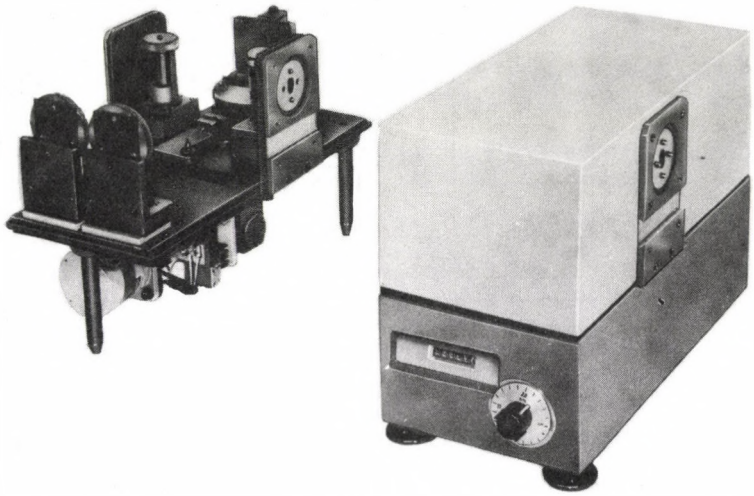


Fig. 9
Czerny-Turner monochromator with and without cover

The complete optimechanical part can be seen in *Fig. 10*.

The detector of the START channel is an RCA 1P28 photomultiplier placed in the lamp house; the detector of the STOP channel is a special high current fast photomultiplier (Philips 56DUVP).

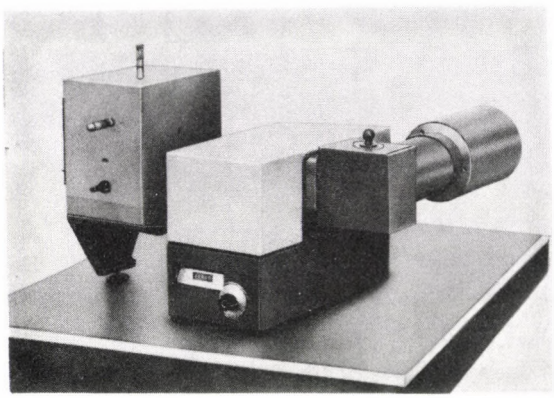


Fig. 10
Optimechanical part of nanosecond excitation spectrometer

The measurement is based on the time correlated single photon counting technique. Both START and STOP channels of the electronic system used for signal processing are built practically from the same standard NIM modules developed in the Institute. Each module is designed to perform a special task with standardized input/output parameters, signal levels, polarities, impedances, connectors, etc.

Photocurrent pulses of the photomultipliers are discriminated and shaped by appropriate fast constant fraction discriminators. Special delay circuits provide the synchronization of the signals in the channels. The time between the START and STOP signals is measured as a voltage amplitude by a time-to-amplitude converter. If the STOP pulse arrives during the "living time", the voltage amplitude is converted into digital form and stored in an ICA-70 multichannel analyser - also produced in the Institute - by using the AMPLITUDE mode (address storing).

To eliminate "pile-up" errors the light is attenuated sufficiently to ensure that only 1% of the START pulses will be effective at the output, because the detection of two or more photons from the same pulses causes a decreased decay time.

Digitally controlled high voltage supplies, delay circuits, and a ratio counter and a monitor have been developed in our laboratory. The complete electronic measuring system is shown in *Fig. 11.*

Decay curves measured by nanosecond excitation spectrometers are evaluated by a TPA-i small computer manufactured in the Institute. Data are transferred between the multichannel analyser and small computer in on-line mode in both directions.

The scheme of the evaluation methods of radiative decay curves is shown in *Fig. 12*; details of the method have been published in KFKI Reports 78-66 (in Hungarian) and 78-78 (in Russian).

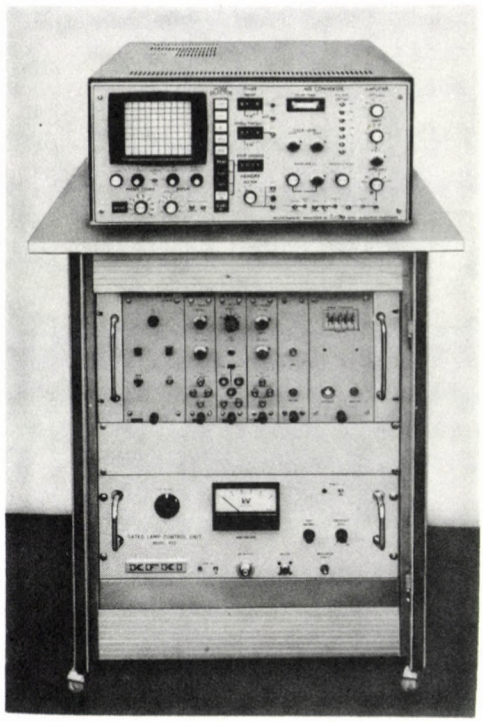
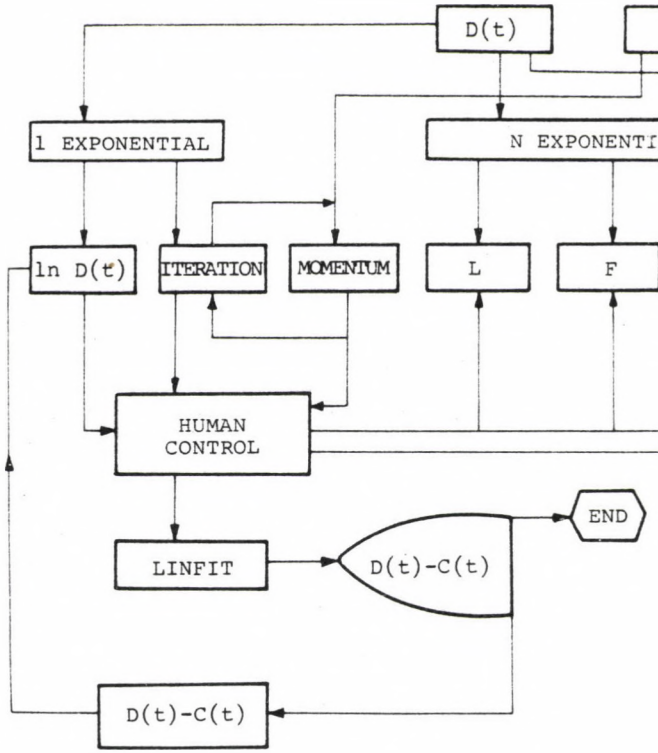


Fig. 11

Electronic measuring system of the nanosecond spectrometer



NOTES:

L	- Laplace transform
F	- Fourier transform
LSQ	- Non-linear least squares
FIT	- Fitting procedure
LINFIT	- Linear fitting procedure
DEC	- Deconvolution

Fig. 12
Evaluation scheme of decay curves

PUBLICATIONS

1. J. SZŐKE: Computer evaluation of radiation decay curves. KFKI Report 78-78 (1978) (In Russian); KFKI Report 78-66 (1978) (In Hungarian)

2. J. SZŐKE: Nanosecond decay time meter using time correlated single photon counting. KFKI Report 78-92 (1978) (in Russian)

3. L. LÁNG*, A. BARTECZKI*, G. HORVÁTH*, J. SZŐKE, M.VIZESI*, G.VARSÁNYI*: Absorption spectra in the ultraviolet and visible region. Vol. XXIII., Akadémiai Kiadó, Budapest, 1978

NEUTRON SPECTROSCOPY

L. Cser, N. Kroó, L. Rosta, Erzsébet Svéb, I. Vizi

Investigation of the collective excitations of liquid crystal materials has been continued by coherent neutron inelastic scattering. Constant energy and momentum transfer scans were obtained from a ~1 cm^3 volume single crystal of fully deuterated p-azoxyphenetole on the triple-axis spectrometer at the WWR-SM reactor of the Institute.

The dispersion curves of the phonons were recorded in two nearly perpendicular symmetry directions which correspond to scans perpendicular or parallel to the long axis of molecules in the crystal lattice. Longitudinal and transversal branches as well as optical modes were observed in both directions. The measurements were carried out at room (*Fig. 13*), and liquid nitrogen temperatures.

The dispersion curves of collective modes obtained in nematic p-azoxyanisole in the direction perpendicular to the long axis of molecules (see Yearbook '77) where the intermolecular interactions are preserved more strongly and the dispersion relations of phonons in the crystalline p-azoxyphenetole show a very similar character.

It turns out from this comparison that the nematic state has strong crystal-like properties which lend additional support to the cluster-model developed by us for the refinement of the presently accepted nematic theory.

The next step of the copper-based alloy programme was that a $Cu_{0.95}$ $Ni_{0.05}$ sample was studied in the framework of a close cooperation with the Kurchatov Institute, Moscow, USSR. The phonon dispersion curves have been measured on the triple-axis spectrometer in the main symmetry directions.

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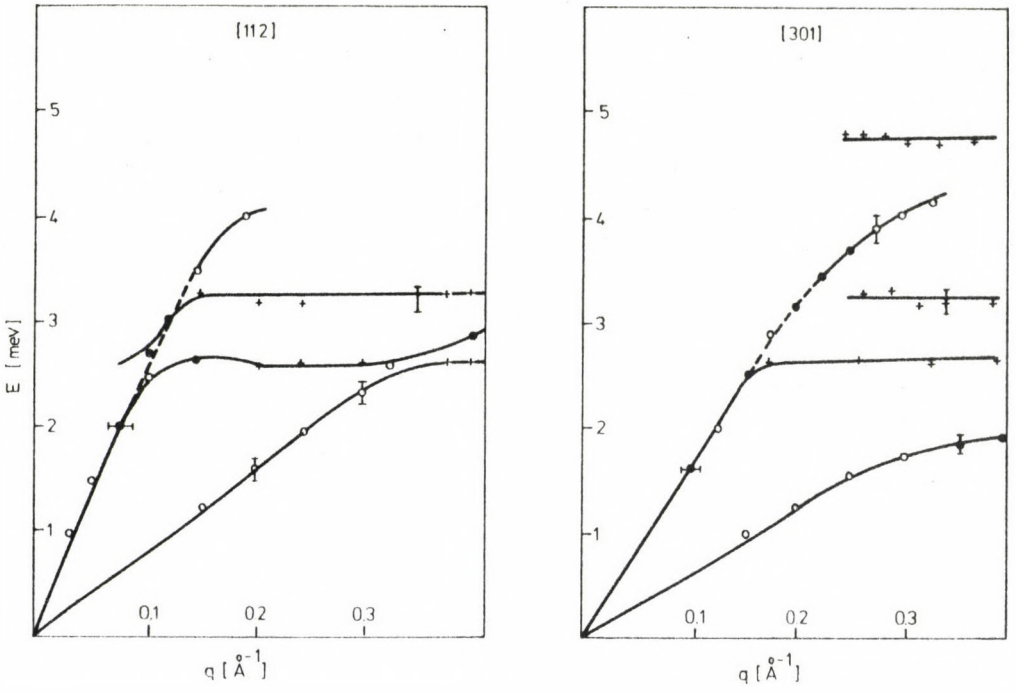

Fig. 13

Phonon dispersion curves in p-azoxyphenetole at room temperature in symmetry directions parallel [112] and perpendicular [301] to the long axis of molecules in the crystal lattice (o-acoustic, + -optical branches)

Neutron scattering measurements were carried out on a new and a 120 hours' worked gas turbine blade, to investigate the aging of the turbine blades in consequence of use. From the small angle scattering spectra it was established that the scattering of the used turbine blade is more intense than in the case of the new one; this means that the concentration of the inhomogeneities increased during use. These measurements showed, as well, that the size of the inhomogeneities changes along the turbine blade. The inhomogeneities are largest at the middle of the turbine blade where the loading is greatest.

From the neutron diffraction measurements performed on these turbine blades it was established that the intensity of the investigated (111) and (200) reflections, and the ratio of these reflections is different in the new and in the used blades; this fact indicates that the texture changes during use (*Fig. 14*).

Neutron diffraction investigations were carried out on Fe-Co and Fe-Co-X (where X=Cr, Mo, V 1-2 at%) polycrystal samples after various sorts of temperature annealing. From the measurements it was possible to determine the order parameter S, characterizing the ordering of alloys (*Fig. 15*). These results were compared with those obtained by investigating the mechanical properties of the same samples.

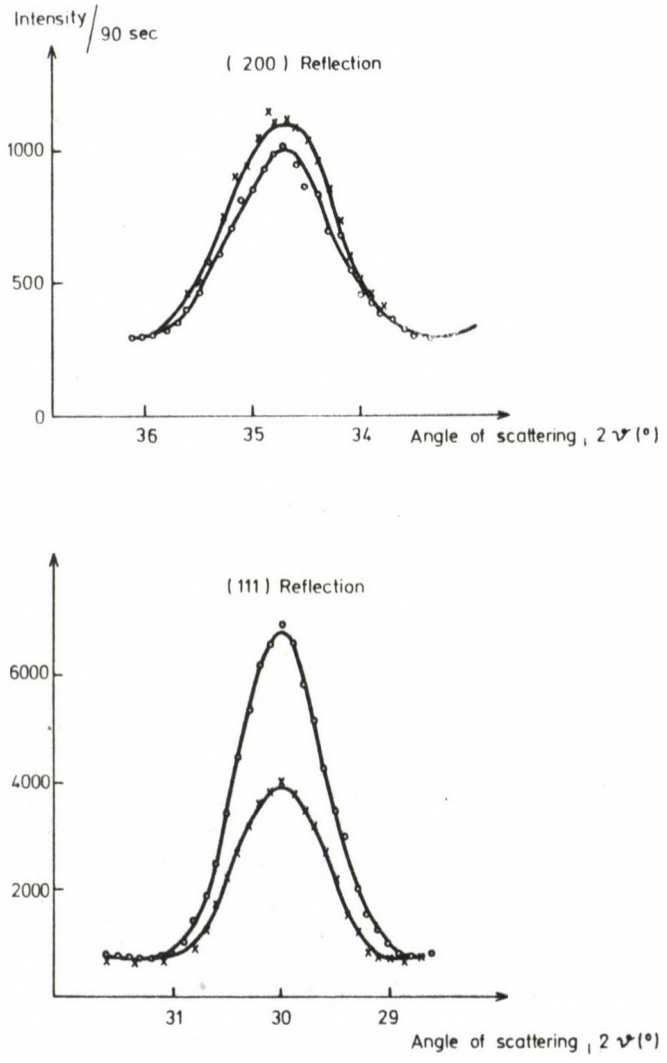

Fig. 14

Neutron diffraction spectra of the (111) and (200) Bragg reflections of a new (x) and a 120 hours' worked (o) turbine blade

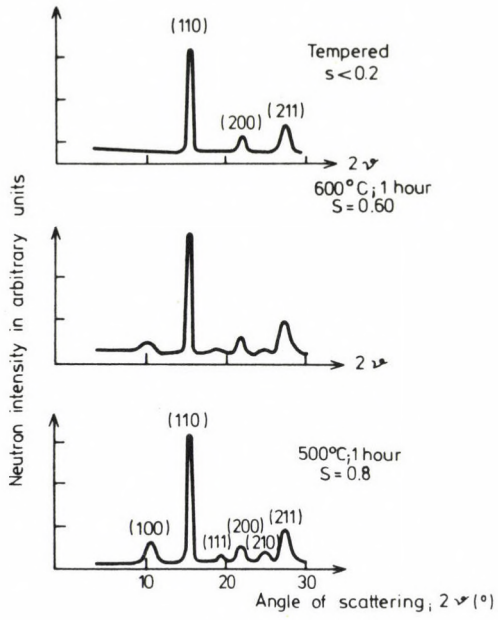

Fig. 15

Neutron diffraction spectra of Fe-Co alloy after annealing

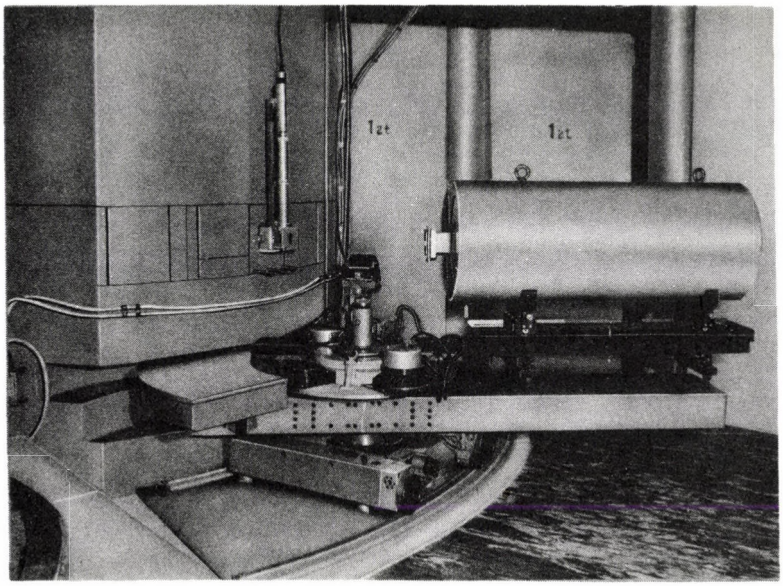

Fig. 16

Neutron diffractometer working at the No.4 channel of the WWR-SM reactor in the Institute

In the framework of the collaboration with the Neutron Physics Department of the Joint Institute for Nuclear Research, Dubna, USSR, a series of investigations of several biological molecules were performed by means of small angle scattering of neutrons. Among others, differences between the shape and dimensions of early and late phases of pig anti-Dnp immunoglobulins (IgG) were discovered. It was shown that the distance between the active centres of early phase IgG is equal to 276 ± 15 Å and that of the late phase is 210 ± 18 Å. On the basis of our results a model explaining the different precipitation behaviour of the two investigated IgG can be constructed.

A neutron diffractometer made in the Institute was put into operation at the N°. 4 channel of the WWR-SM reactor (*Fig. 16*). The apparatus gives the possibility to change the wavelength of the monochromatic beam scattered on the investigated sample, and to measure the diffraction spectra of single crystals as well.

A so-called two crystal small angle scattering arrangement was constructed and adapted to the neutron diffractometer.

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1. L. BATA, V.L. BRONDE*, V.G. FEDOTOV*, N. KROÓ, L. ROSTA, J. SZABON, L.M. UMAROV*, I. VIZI: Solid state polymorphism of p-azoxyanisole. Mol Cryst. Liq. Cryst. 44, 71 (1978)

2. N.A.CHERNOPLEKOV**, N.KROÓ, P.P.PARSHIN**, L.ROSTA, A.YU.RUMYANTSEV***, I. VIZI, M.G. ZEMLYANA**: Lattice dynamics of copper-based alloys. Proc. IAEA Symp. on Neutron Inelastic Scattering. Vienna, 1977, Ed. IAEA, IAEA-SM-219/95 (1978) p. 481

3. K.P.BELOV***, A.M.KODOMTSEBA***, E.KRÉN, M.M.LUKINA***, V.N.MILOV***, ERZSÉBET SVÁB: Magnetic and neutron diffraction investigations on the reorientation transitions in cobalt doped yttrium orthoferrite. Zh. Eksp. Teor. Fiz. (Sov. Phys.-JETP) T.72. 1, (1977) (in Russian)

4. L. CSER, F. FRANEK+, I.A.GLADKIKH, R.S. NEZLIN++, J. NOVOTY+ and YU.M. OSTANEVICH+++: Distance between two binding sites of the same antibody molecule, a neutron small-angle scattering study of pig anti Dnp antibody complexed with Mono-Cnp-Dextran. FEBS Lett. 93, 312 (1978)

*Solid State Research Institute, Chernogolovka, USSR
**Kurchatov Institute, Moscow, USSR
***State University, Moscow, USSR
+Institute of Molecular Genetics, Czechoslovak Academy of Sciences, Prague, CSSR
++Institute of Molecular Biology, Moscow, USSR
+++Joint Institute for Nuclear Research, Dubna, USSR

FOREIGN RELATIONS

LECTURES BY VISITING SCIENTISTS

M. Stefanova	(Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria) cw laser oscillations on the Kr II 469.4 nm and Kr II 431.8 nm lines in a hollow cathode He-Kr discharge
S. Kartaleva	(Institute of Electronics, Bulgarian Academy of Sciences, Sofia, Bulgaria) Unusual features of 632.8 nm He-Ne generation in a copper hollow cathode laser
M.I. Savadatti	(Karnatak University, Dharwar, India) Excitation mechanism of C_2 and $(CN)_2$ bands
P. Tuovinen	(Helsinki University of Technology, Helsinki, Finland) Laser research at Helsinki University of Technology
I.V. Golosovski	(Nuclear Research Institute, Leningrad, USSR) Research possibilities at Leningrad high flux reactor
E.A. Vinogradov	(Spectroscopic Institute, Moscow, USSR) Instrumentation problems in the Spectroscopic Institute of the Academy of Sciences, USSR
H. Vlahovici	(Institute of Atomic Physics, Bucharest, Romania) Luminescent spectra of some naphthalene derivatives at low temperature
L. Dountchev	(Department of Spectroscopy, University of Sofia, Sofia, Bulgaria) Luminescent decay time investigations on rare earth compounds

STAFF MEMBERS ON STUDY TOURS

F. Mezei	Laue-Langevin Institute, Grenoble, France	3 years
Gy. Rubin	Joint Institute for Nuclear Research, Dubna, USSR	3 years
Gy. Zsigmond	Joint Institute for Nuclear Research, Dubna, USSR	2 years
L. Cser	Joint Institute for Nuclear Research, Dubna, USSR	6 years

Gy. Farkas	C.E.N. de Seclay Service de Physique Atomique, Gif-sur-Yvette, France	1 month
L. Csillag	Helsinki University of Technology, Helsinki, Finland	1 month

GUEST SCIENTISTS AND FELLOWS

A. Kilpio	Lebedev Physical Institute, Moscow, USSR	1 month
I.V. Tartakovski	Solid State Research Institute, Chernogolovka, USSR	1 month
I.V. Golosovski	Nuclear Research Institute, Leningrad, USSR	6 weeks
S.B. Sogomonyan	Solid State Research Institute, Ashtak, USSR	3 months
P. Tuovinen	Helsinki University of Technology, Helsinki, Finland	5 months

RESULTS

ANALYSIS FOR SOLID STATE RESEARCH

L. Bakos, J. Bogdnes, Mária Csajka, A. Elek, Erzsébet Kelen-Füzesy, F. Molnár, Á.Z. Nagy, Ibolya Sziklai-László, Éva Szirmai-Kulus, Visiting research workers: Mária Lőrincz, H.Rausch, A.Salamon, J.C.Saria

For the development of semiconductor devices sodium, copper, gold and boron profiles in silicon and silica matrices were determined by neutron activation analysis. The measurements were evaluated on the basis of the k_o technique, developed in previous years in a cooperation with the Institute for Nuclear Sciences, Rijksuniversiteit, Ghent, Belgium. The results of neutron activation analysis are being compared with the results of microprobe analysis, and with the autoradiographic method. These investigations were jointly performed with Tungsram, Budapest, and the Research Institute for Telecommunication, Budapest.

The sodium, copper, gold, and manganese contents of various electronic grade waters were regularly investigated. Several elements were determined in reactor cooling water by activity measurements; these elements were ^{24}Na, ^{41}Ar, ^{88}Kr, ^{91}Sr, ^{92}Sr, ^{131}I, ^{133}I, ^{133}Xe, ^{138}Cs, ^{140}Ba, ^{140}La, ^{142}La and ^{239}Np.

In cooperation with the Research and Planning Institute for the Aluminium Industry, Budapest, work was continued on the determination of the oxygen content in aluminium. Based on the requirements of previous years our laboratory was reconstructed and specially set-up for low-level oxygen determination.

An anion exchange microchromatographic method for the separation of phosphate, phosphite and hypophosphite ions in plating solution, has been developed.

In cooperation with the Csepel Iron Works, Budapest, we carried out high precision iron determinations in copper. The iron was separated from copper by the cation exchange technique and was titrated by ethylene-diamine tetra-acetic acid with potentiometric end-point indication.

PUBLICATIONS

1. L. BAKOS, E. KELEN, Á.Z. NAGY, B.VORSATZ*: Determination of oxygen content in aluminium. COMECON Symposium on the Industrial Application of Isotope Techniques, Leipzig, GDR, 1978. Paper No. 115 (in Russian)

2. L. BAKOS, E. KELEN, Á.Z. NAGY, B. VORSATZ: Application of activation analysis in metallurgy using neutron generators. ibid. Paper No. 113 (in Russian)

3. L. BAKOS, M. CSAJKA, L. CSER, A. CSŐKE, N.N.DOGADKIN**, A. ELEK, K. KULCSÁR, Á.Z. NAGY, D.L. NAGY, E. SZABÓ, B. VORSATZ, É. ZEMPLÉN: Investigation of the composition of the "Luna-16" lunar sample. The Soviet-American Conference on Cosmochemistry of the Moon and Planets, Moscow, USSR, 1974. NASA, Washington D.C. 1977. p. 277

DEVELOPMENT OF ANALYTICAL METHODS

Mária Csajka, A. Elek, Mária Ürdögh, G. Pernecki, A. Simonits,
Visiting research worker: A. Salamon

Measurements for the k_o factors were continued and the k_o values of 15 analytically important radioactive isotopes were determined. This work was performed in cooperation with the Institute for Nuclear Science, Rijksuniversiteit, Ghent, Belgium.

The possibilities for cerium content determination in iron were investigated by fast neutron activation. The spectrum of a fast neutron irradiated iron sample containing cerium is shown in *Fig. 1*. The detection limit for cerium is as low as 30 ppm under the best conditions of the determination.

Using a Van de Graaff generator various metalloxides were irradiated by proton, deuteron and alpha particles in the energy range 2-3 MeV. Samples were placed into a vacuum chamber and the X-ray emission of the samples was measured by an energy dispersive system. The measured samples were qualitatively analysed on the basis of X-ray spectra. We utilized the various ranges of energy of the particles, to give relative values for layer thickness. We were able to draw conclusions on the distribution according to depth of the elements from the absorption loss of X-ray radiation.

Molybdenum in organic matrices was determined by isolation of the ^{99}Mo activity; α-benzoin oxime was used as reagent. In this case only tungsten reacts along with molybdenum. After precipitation with 2% alcoholic α-benzoin oxime, brominated water was added to the mixture; in

*Heavy Industries Polytechnic University, Miskolc, Hungary
**Vernadskii Institute for Geochemistry and Analytical Chemistry, Moscow, USSR

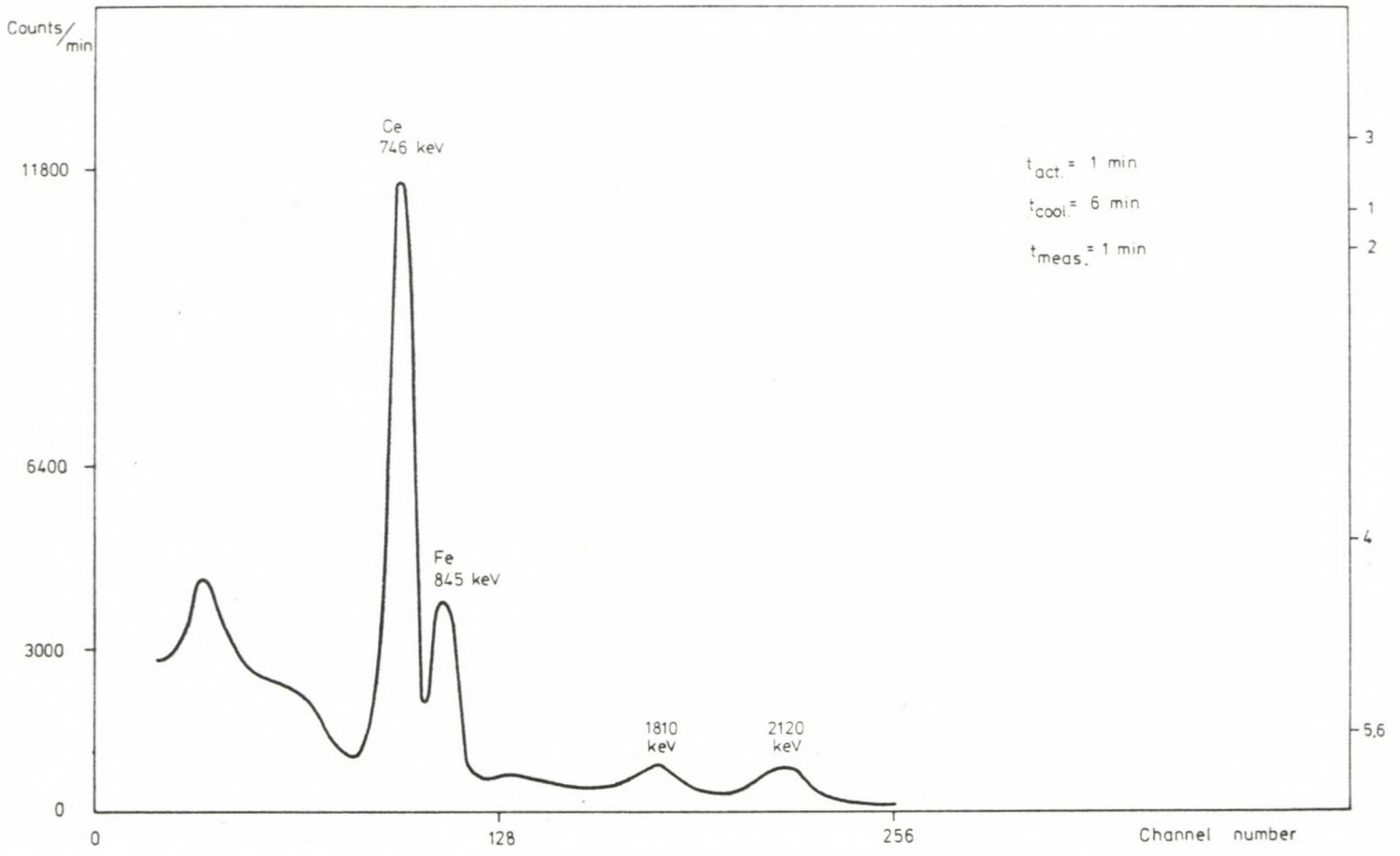

Fig. 1

Typical gamma spectrum of cerium ($t_{1/2}$ = 55 sec) and iron ($t_{1/2}$ = 2.58 h) containing sample activated by fast neutrons

this way the excess bromine oxidizes the possible reduced molybdenum. The gamma-spectra were measured by a Ge/Li detector combined with a multichannel analyser. The tungsten content of the samples can be determined simultaneously with molybdenum. *Figure 2* shows the gamma spectrum of a Mo-α-benzoin oxime precipitate.

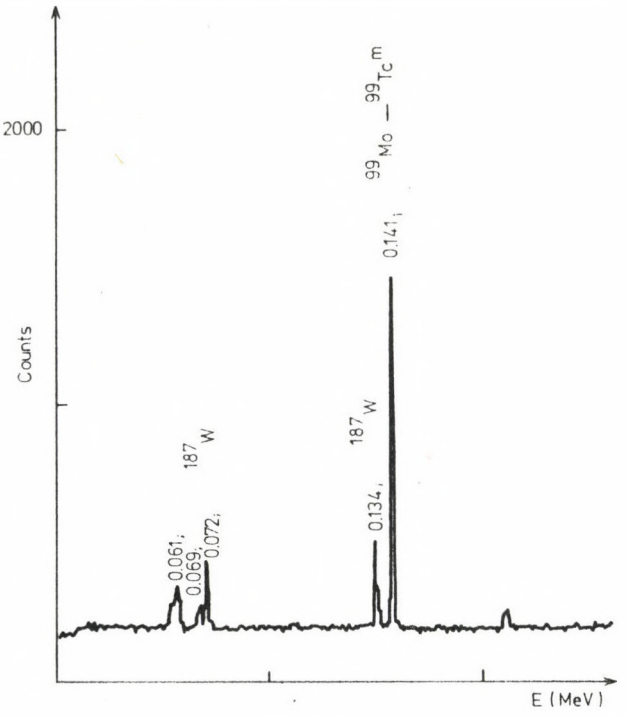

Fig. 2

Gamma spectrum of a Mo-α-benzoin oxime precipitate

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1. M. CSAJKA: Simultaneous radiochemical separations. Proc. 5th Symp. on Recent Developments in Activation Analysis, Oxford, England, 1978. Paper No. 40

2. F. DE CORTE*, L. MOENS*, J. HOSTE*, A. SIMONITS, A. ELEK: The use of k_0-factors as a tool for a critical evaluation of thermal and epithermal (n,γ) cross-sections and of absolute gamma intensities, ibid. Paper No. 53

* Institute for Nuclear Sciences, Rijksuniversiteit, Ghent, Belgium

3. L. MOENS*, F. DE CORTE*, J. HOSTE*, A. SIMONITS, A. ELEK: Reactor neutron activation analysis with the aid of a new comparator technique based on k_o factors.ibid. Paper No. 52

4. M. ÖRDÖGH: A complex method for the neutron activation analysis of biological materials. KFKI Report 78-36 (1978)

5. I. SZIKLAI-LÁSZLÓ, M. ÖRDÖGH: Retention of ^{32}P activity interfering with the neutron activation analysis of trace elements in biosamples. KFKI Report 78-46 (1978)

6. M. ÖRDÖGH: A complex neutron activation method for the analysis of biological materials. Radioanal. Chem. 46, 26 (1978)

AGRO- AND BIOANALYSIS

L. András, A. Csőke, A. Fehér, M. Fodor, P. Gróz, P. Kálmán, L. Pázmándy, Z. Pokó, Éva Zemplén-Papp

On-site investigations to check the applicability of a new autoPRODET device were carried out on fodder mixers of pig farms and of horse-breeding stables to determine the respective nitrogen and chlorine contents. The results were checked by the traditional Kjeldahl method. To evaluate the nitrogen and chlorine contents for the fodder samples we prepared calibration curves with the aid of the standard addition method, using urea $CO(NH_2)_2$ and NaCl salt for the N and Cl containing compounds. *Table I* and *Fig. 3* show typical values for calibration.

Table I

STANDARD SAMPLE FOR HORSE FODDER

No.of sample / *Method of measurement*	*1*	*2*	*3*	*4*	*5*
Calculated+ *crude protein (m%)*	*14.9*	*22.0*	*29.1*	*36.2*	*43.3*
Kjeldahl crude protein (m%)	*14.9*	*22.2*	*29.7*	*36.4*	*42.5*
autoPRODET crude protein (m%)	*14.4*	*22.2*	*29.8*	*36.2*	*42.9*

+The crude protein content of the basic sample was 14.86% as determined by Kjeldahl method (three separate destructions with three parallel titrations on each). The crude protein content of the other samples was obtained by consecutive addition of urea of high nitrogen content (nitrogen content 46.6%).

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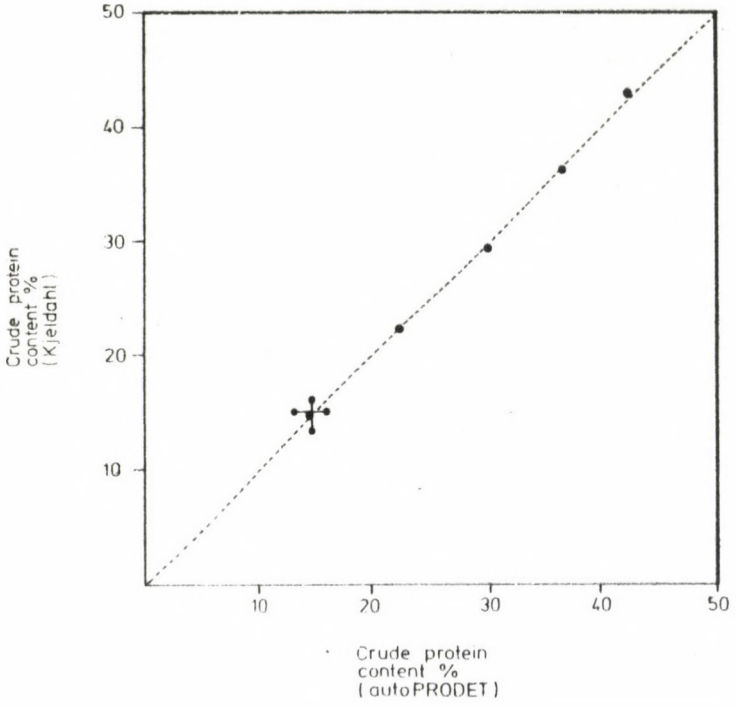

Fig. 3

Comparison of crude protein content data as measured by the Kjeldahl and the activation method

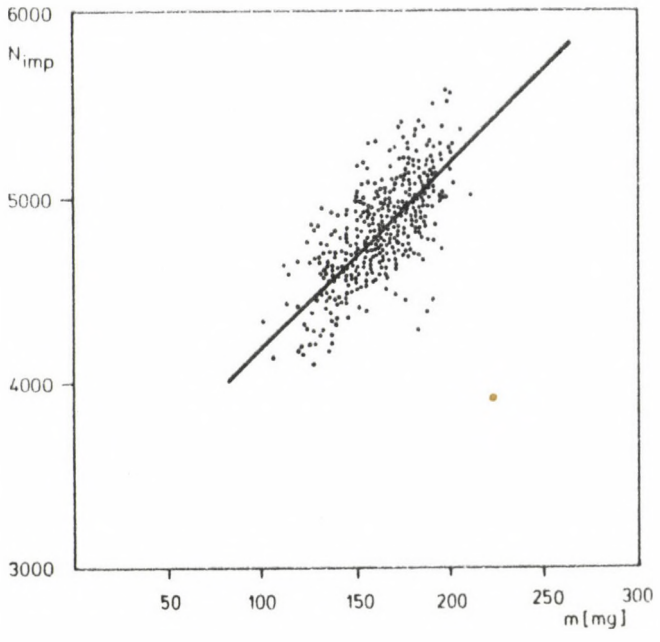

Fig. 4

Mass of seeds (m) vs. total count in the nitrogen channel (N_{imp}). The fitted curve represents the middle value of population and is characterized by:
a_0 = 3134 imp,
a_1 = 10.44 imp/mg,
r_0 = 0.64 (measuring time: 60 s, population No.4-418 samples)

At the Laue-Langevin Institute, Grenoble, France, we performed the non-destructive nitrogen determination of single seeds. These experiments, based on the $^{14}N(n,\gamma)^{15}N$ nuclear reaction, were carried out at one of the neutron guides of the High Flux Reactor. Several thousands of seeds were analysed; of these, 240 were sown and subsequently harvested. The evaluation of the results of production is in progress.

Figure 4 shows the total count in the nitrogen channel vs. the mass of seeds for one population and *Fig. 5* the deviation of protein content from the mean value of the population in relative %.

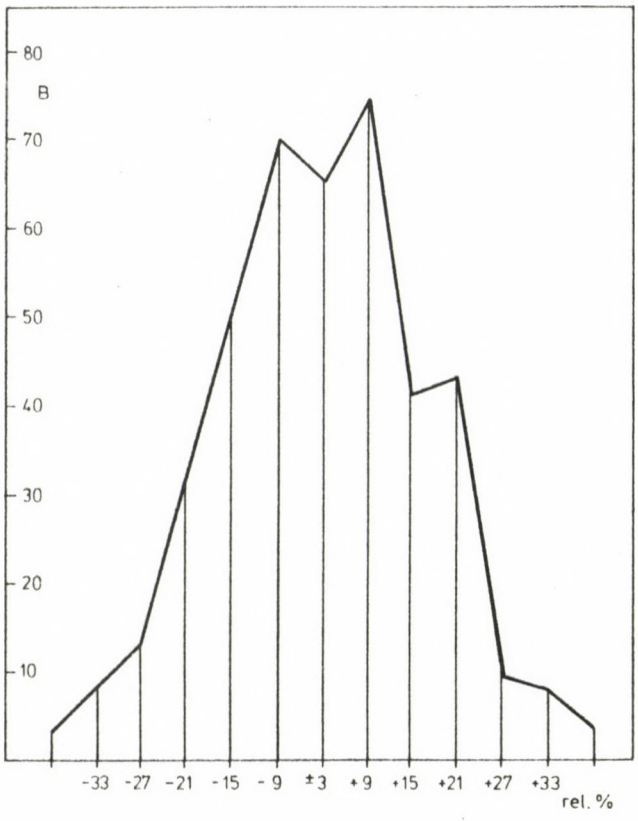

Fig. 5

Frequency distribution B vs. rel. %. The rel. % is the deviation of the crude protein content of the single seed from the population's mean crude protein content. Population No.4-418 samples

PUBLICATIONS

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*University of Agricultural Sciences, Gödöllő, Hungary
**Institute of Isotopes of the Hungarian Academy of Sciences, Budapest

MASS SPECTROMETRY

J. Frecska, L. Matus, I. Nyári, I. Opauszky

The use of the MS 702/R (A.E.I., England) high resolution spark source mass spectrometer for the determination of impurities in high quality Al, Cu and Ga has been continued. These measurements serve both research and development.

In our earlier work we were able to make spark source mass spectrometry (SSMS) quantitative by determining the relative sensitivity factors (RSF) of impurities in an Al matrix. We have found a practically linear relationship between the logarithm of RSF and the boiling point temperature of impurity elements if the electrodes are cooled by liquid nitrogen during sparking. Our later measurements have shown that this rule holds also for Fe and Cu matrices.

In cooperation with the Zentralinstitut für Isotopen und Strahlenforschung, Leipzig, GDR, we have carried out some investigations on the applicability of the electrical detection system (EDS) in SSMS for the determination of trace elements in geological samples using the isotopic dilution technique. The EDS proved to be useful especially for those lines where no multiplets occur. For survey analysis, however, photographic detection remains more favourable.

The evaluation of the photographic plates is quite time consuming therefore we have developed the prototype of an evaluation system which - having depicted the lines of interest for the analysis by storing in an appropriate memory the corresponding x-values (mass numbers) - automatically presents the blackening values on a recorder and/or in digital form. The calculation of concentrations can be done by an appropriate computing system.

ISOTOPE EFFECTS

Borbála Gellai, Hédy Illy-Vajda, Gy. Jákli, G. Jancsó

Investigations were started in cooperation with A. Van Hook at the Chemistry Department, University of Tennessee, Knoxville, Tenn., USA, in order to improve the cell model which is generally used for the evaluation of the vapour pressure isotope effect (VPIE) in condensed systems. As a first attempt the computations were performed for various isotopes of water. The continuum model was assumed and by randomly choosing the -O...H- distances by the Monte Carlo method a large number of random molecule configurations were generated first. The effect of the closest

molecule neighbours on a given water molecule were taken into account by using the Lippincott Schroeder potential function and thus the OH stretching force constant could be obtained as a function of the random -O...H- distances.

This approach seems to be highly suitable because the largest contribution to the VPIE arises from the shift in the OH stretching force constant on condensation. Since the applied model can be regarded as an improved approximation to the description of the experimentally observed frequency distribution, a better agreement can be expected between the experimental and the theoretical VPIE values, if not the individual vibrational frequencies but an appropriate statistical average of the random normal frequencies is used in the calculations. The results obtained are in good agreement with the experimentally observed VPIE even for the $H_2{}^{16}O/H_2{}^{18}O$ system.

As a continuation of our earlier investigations on the VPIE of water, the effect of deuterium substitution on the vapour pressure of both ^{16}O and ^{18}O labelled isotopic water molecules was determined. The vapour pressure differences between the $H_2{}^{16}O\text{-}D_2{}^{16}O$ and the $H_2{}^{18}O\text{-}D_2{}^{18}O$ water samples were measured by using an apparatus equipped with a differential capacitance pressure gauge; the absolute pressures of the samples were also determined. Although for the VPIE of the $H_2{}^{16}O\text{-}D_2{}^{16}O$ system precise data are available in the literature, this system had to be reinvestigated in order to eliminate any systematic error in the calibration of the pressure gauge and the thermometer.

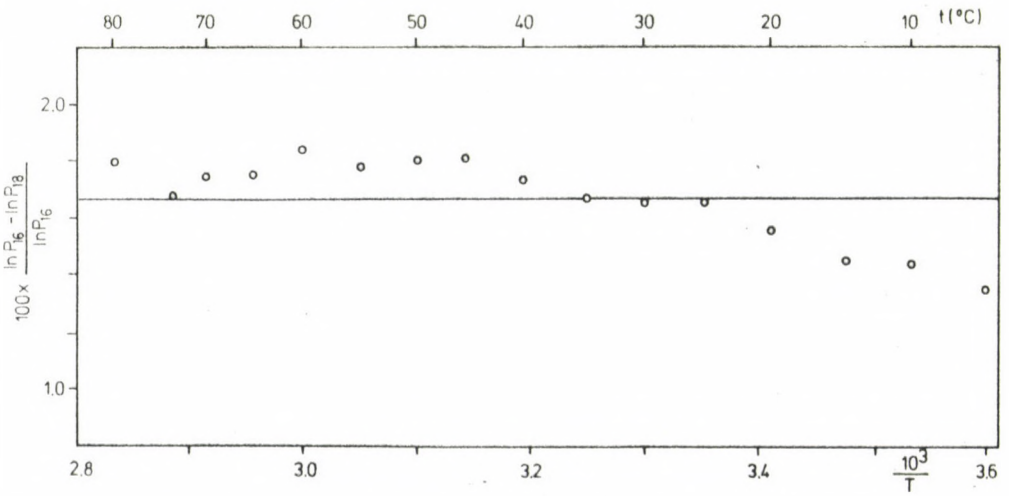

Fig. 6

Vapour pressure difference between the $H_2{}^{16}O\text{-}D_2{}^{16}O$ and $H_2{}^{18}O\text{-}D_2{}^{18}O$ systems. ($P_{16} = P_{H_2{}^{16}O}/P_{D_2{}^{16}O}$; $P_{18} = P_{H_2{}^{18}O}/P_{D_2{}^{18}O}$; T: temperature in K)

Whereas in the ice phase (-50 to 0 °C) no differences were found in the VPIEs of the two isotopic systems within our experimental precision (less than 1 rel.%), in the liquid phase the VPIE of the $H_2{}^{16}O$-$D_2{}^{16}O$ is definitely higher than that of the $H_2{}^{18}O$-$D_2{}^{18}O$. It can be seen in *Fig. 6* that this difference is 1.67 ± 0,3% and it does not change in the temperature range covered.

In the framework of the Solubility Data Project of IUPAC, literature values on the solubility of a number of inorganic compounds in D_2O were compiled and critically evaluated.

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HOT ATOM CHEMISTRY

Klára Berei, Ágnes G. Csató-Nagy, L. Matus, L. Vasáros

The reactions of high energy ^{38}Cl and ^{125}I in organic systems of different physical states were studied as a continuation of our earlier studies. Comparing the behaviour of liquid and crystalline C_6F_6-CCl_4 mixtures, we showed that hot chlorine atoms were able to react exclusively with their parent compound, CCl_4, if they were in the crystalline phase, i.e. they were unable to escape from their immediate environment of microcrystalline structure. This is in agreement with our earlier observations on crystalline mixtures and explains what was previously found; namely, that the yields of excitation decomposition and isomerization were practically independent of the composition of the mixtures.

The hydrogen and halogen exchange reactions of hot ^{125}I atoms as produced by electron capture were investigated in gaseous chlorobenzene and ortho-difluorobenzene, in liquid bromobenzene and the three isomeric fluorochlorobenzenes and finally in solid para-dichlorobenzene. This work is complementary to that carried out at the Joint Institute for Nuclear Research, Dubna, USSR, which deals with the chemistry of At atoms formed by electron capture.

It is being investigated whether hot ^{211}At is charged when reacting with chlorobenzene. To this effect several chemically inert solvents were used with ionization potentials higher than, equal to, or lower than that of At and it was investigated how the solvent affected the yields.

The electrophylic substitution of thermal At atoms on benzene was studied. Atomic At was shown to replace benzene hydrogens with a yield of 50-60% if the solution contained acetic acid and K-bichromate or Na-peroxydisulphate.

A detector for gas chromatography measuring continuously the radioactivity of the effluent, and another one for high pressure liquid chromatography based on the measurement of the change in dielectric permittivity were developed.

The vapour phase composition of $GeSe_2$ was investigated by high temperature mass spectrometry measuring the heat of sublimation and bond dissociation energy; $\Delta H^{subl}_{720} = 46$ kJ/mol and D(Ge-Se) = 602 kJ/mol were found:

As a continuation of our earlier studies on ion-molecule reactions by mass spectrometry a double chamber ion source was developed for the investigation of reactions between hydrogen ions and metal atoms.

In cooperation with the Brookhaven National Laboratory, Upton, New York, USA, the investigation on the molecular geometry of bridged ferro-

cene derivatives was continued. Penta- and mixed tri- and tetra-methylene bridged ferrocene derivatives, that is, derivatives containing both tetramethylene and trimethylene bridges both adjacent and nonadjacent, were prepared and investigated by Mössbauer spectroscopy. As expected, linking of the cyclopentadienyl rings by tetra-and penta-methylene bridges did not cause as large a change in the Mössbauer parameters as was observed in the trimethylene bridged derivatives (see Yearbook '77 p. 133). All the results are as expected. The QS values found for the mixed tri- and tetra-methylene derivatives fall between those of the bistrimethylene and bistetramethylene derivatives.

Recently, crystallographic data for some of these compounds or their derivatives have become available. This allowed us to establish a strong correlation between the iron-ring distance and the Mössbauer parameters. This correlation is illustrated in *Fig. 7* where the differences between the Mössbauer parameters are plotted against the differences between the iron-ring distances of the compounds studied. A change in distance of 0.01 Å gives an average change of 0.05 mm/s for the QS and 0.018 mm/s for the IS.

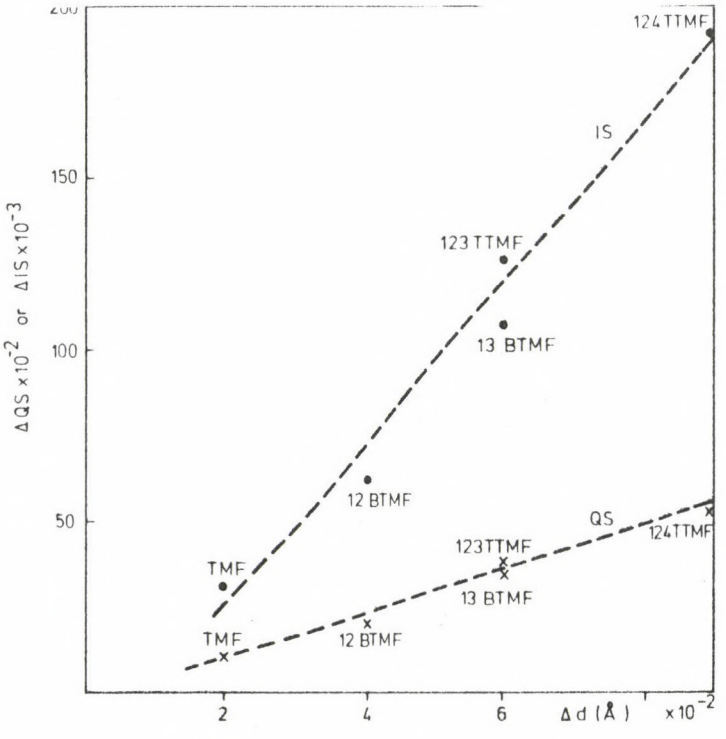

Fig. 7

Correlation between the Mössbauer parameters of trimethylene bridged ferrocene derivatives and the iron-ring distances of these compounds

RADIATION AND ELECTRON CHEMISTRY

Gy. Hutiray, Inna Kules, L. Nyikos, T. Pajkossy, Magdolna Roder, R. Schiller, Sz. Vass

The dependence of free ion yields on solute concentration in irradiated hydrocarbons was treated. Based on a two-state theory of excess electrons in liquids developed earlier the problem was tackled in terms of ion-electron recombination probabilities. Only those electrons were thought to obey Onsager's law of recombination which were localized, i.e. either trapped by the matrix or scavenged by the solute. The theoretical expression was found to be in good agreement with the observations obtained for iso-octane and tetramethylsilane in the presence of CCl_4 (collaboration with the Interuniversitair Reactor Instituut, Delft, The Netherlands).

A model was suggested for the understanding of the subnanosecond reaction kinetics of hydrated electrons in water. The fast escape and self-trapping of the electrons were thought to cool down the neighbouring molecules to such an extent that they become frozen. Heat conduction releases the solvated electrons from their early self-frozen state, a process which takes some 10-100 psec. This time coincides with the experimentally observed induction period of hydrated electron reactions.

The photoelectrochemical behaviour of semiconducting n- and p-type crystalline CdTe and n-type Fe_3O_4 (magnetite) was investigated with a view to chemical reactions brought about by electron or hole injection from the semiconductor surfaces into water. The effects of electrolyte composition, light intensity and wavelength were studied by voltammetry and by differential capacitance measurements. The broad optical absorption spectrum of the substances and the reasonable efficiency of their transformation of light into chemical energy might lend some hope for a possible practical application, particularly with cheap and stable magnetite grown by thermal oxidation.

The accumulation of radioactivity in the inactive part of the primary circuit of an atomic reactor was calculated. A system of differential equations, which accounted for dissolution, activation, decay, adsorption and desorption of the elements in the construction materials, was proposed. The existence of stationary solutions was proven, numerical solutions for the steady states given, the time required to approach steady state estimated. Further the analytical solubility of a simplified system was discussed and analytical solutions were given.

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2. M. RODER: On the radiation stability of some liquid crystals. Radiochem. Radioanal. Lett. 33, 389 (1978)

FOREIGN RELATIONS

LECTURES BY VISITING SCIENTISTS

B.S. Yakovlev	(Institute of Chemical Physics, Academy of Sciences of the USSR, Moscow, USSR) Transport and reactions of excess electrons in hydrocarbons	

STAFF MEMBERS ON STUDY TOURS

L. Nyikos	Interuniversitair Reactor Instituut, Delft, The Netherlands	18 months
J. Bogáncs	Joint Institute for Nuclear Research, Dubna, USSR	6 years
Klára Berei	Department of Chemistry, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA	1 year
Ágnes G.Csató-Nagy	Brookhaven National Laboratory, Upton, New York, USA	6 months
L. Vasáros	Joint Institute for Nuclear Research, Dubna, USSR	4 years

GUEST SCIENTISTS AND FELLOWS

B.S. Yakovlev	Institute of Chemical Physics, Academy of Sciences of the USSR, Moscow, USSR	1 month
M.J. Griffith	Institute for Nuclear Physics, Academy of Sciences of Cuba, Havana, Cuba	4 months
R. Diaz	Institute for Nuclear Physics, Academy of Sciences of Cuba, Havana, Cuba	6 months

*Institute of Chemical Physics, Academy of Sciences of the USSR, Moscow, USSR

INSTITUTE FOR
ATOMIC ENERGY
RESEARCH

RESULTS

REACTOR PHYSICS

F. Adorján, L. Bod, T. Czibók, J. Gadó, Z. Gyimesi, A. Keresztúri, A. Kondor, Gy. Kosály, K. Krinizs, I. Lux, M. Makai, L. Meskó, I. Pázsit, G. Pór, Z. Szatmáry, M. Telbisz, L. Turi, J. Valkó, P. Vértes, I. Vidovszky, J. Zsoldos

Reactor physics experiments on the critical assembly ZR-6 were discontinued at the end of last year, the reactor was dismantled and reconstruction was started in order to perform, at elevated temperature and pressure, experiments beginning in 1979. Parallel with the reconstruction several inactive experiments were made to investigate the behaviour of the critical assembly under different operational and anomalous conditions.

The laboratory equipment, especially that connected with the techniques of activation measurements, was highly improved by the introduction of the PDP 11 computer and CAMAC system for on-line data collection. Eight independent activity measuring channels and one Ge(Li) semiconductor detector can be coupled to the computer system. A typical measuring channel consists of an Automatic Pneumatic Sample Changer with a scintillation counter together with the usual electronic devices interfaced to the CAMAC system.

The high degree of flexibility of the CAMON (CAmac MONitor) code system allows the user to divide the memory field arbitrarily among the measuring channels and to control the system by simple keywords. For the data from the semiconductor detector the computer system works as a multichannel analyser without disturbing the other measurements. The great amount of measured data is stored, together with other additional information, on floppy disks in a suitable form for further evaluation.

The BIPR code prepared in the Kurchatov Institute, Moscow, USSR, for the physics calculations of the WWER-440 power reactors, was adopted for the ES 1040 computer, Calculations were performed for the first campaign of a WWER-440 reactor block, based on Soviet data and on our

data obtained from BETTY pin cell burn-up calculations. The time dependence of the concentration of boric acid dissolved in water during the first campaign is shown in *Fig. 1.*

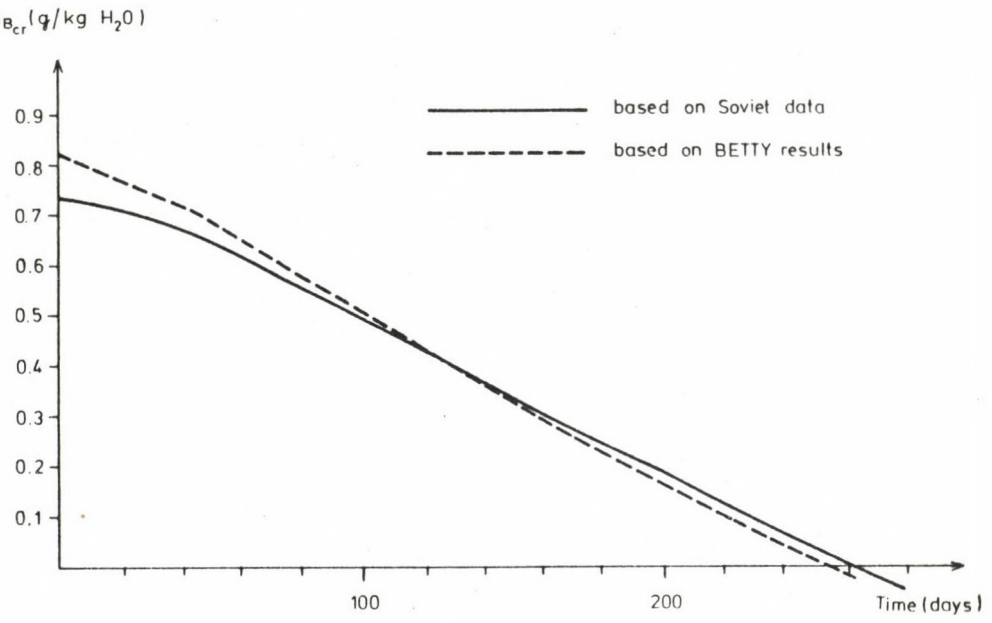

Fig. 1
Time dependence of critical boron concentration (C_{Bcr})

The whole reactor physics code system was transferred to the ES 1040 computer. Comparisons of calculational results with experimental data obtained from ZR-6 critical facility measurements give evidence of the high quality of the calculational model suggesting, at the same time, the necessity for certain further refinements. As an example of the good agreement and the need for further improvement, the measured and calculated ratios of the $R(^{Np}_{Dy})$ spectral index in the vicinity of absorber rods and water holes to their asymptotic values are shown in *Fig. 2.*

Nuclear data analysis and adjustment techniques elaborated in the previous year were successfully applied. It turned out from the analysis that the nuclear data uncertainties can explain most of the minor discrepancies of the calculational results found in clean critical assemblies studies.

Theoretical investigations were carried out in the field of Monte Carlo neutron transport methods. Some new estimation procedures were developed and a systematic study of the most common variance reduction techniques was performed.

Theoretical results in the field of reactor dynamics and diagnostics concern the interpretation of in-core neutron flux fluctuations for diagnostic purposes.

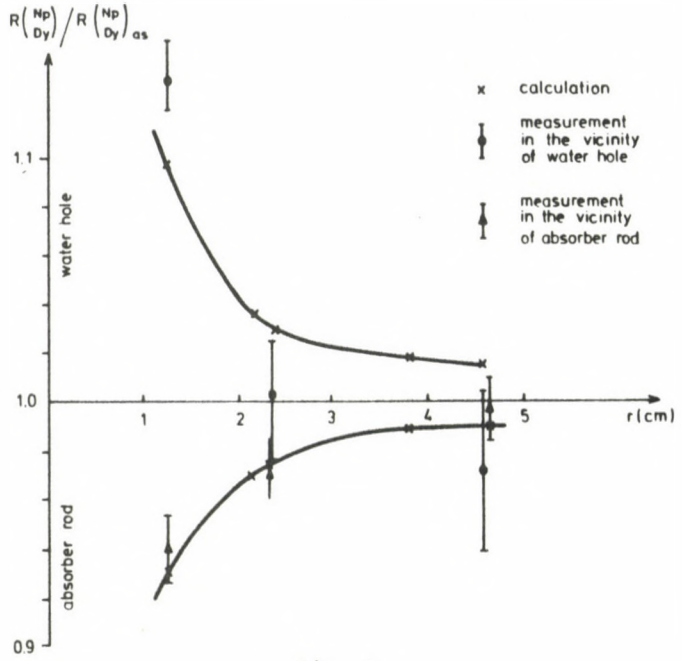

Fig. 2

Space dependence of $R(^{Np}_{Dy})$ *in the vicinity of lattice perturbations*

In the framework of a wide-range preparation for a series of reactor diagnostic experiments to be performed at a power station the following activities are mentioned: participation in the experimental study of sound wave propagation in pulse tubes; participation in the construction of a pressure measuring system which is to be connected to a special fuel assembly; the development of a general noise analysis program for the ES 1040 computer.

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THERMOHYDRAULICS

T. Beszeda, Gy. Egeli, Gy. Ézsöl, Gy. Gyenes, T. Katona, E. Maetz, L. Maróti, L. Perneczky, L. Szabados, I. Tóth, I. Trosztel, J. Vigassy, P. Windberg

An important part of the research program connected with the development of WWER type reactors is the improvement of the cooling of peripheral rods in the fuel bundle. In the framework of Soviet-Hungarian cooperation it is investigated how the degree of perforation on the shroud influences the cooling of the rods or the critical heat flux. From the WWER-1000 rod bundle, the dotted parts shown in *Fig. 3* were selected for modelling purposes. In *Fig. 4* the good agreement of measured and calculated results are shown for test sections without perforations - in order to have reference data.

There is joint work with the experts of the Zentralinstitut für Kernforschung, Rossendorf, GDR, in the field of acoustic and temperature noise. In the framework of Rheinsberg Diagnostic Project preparations, we have designed and manufactured the pressure, pressure noise and flow-rate measuring unit for the diagnostic bundle. The acoustic transfer characteristics of impulse tubes were determined in order to investigate the possibility of signal transfer from the reactor vessel (*Fig. 5*).

The correlation between the pressure and temperature noise was investigated for different flow patterns, and the features of local boiling noise were determined for saturated and subcooled boiling at the incipience of boiling.

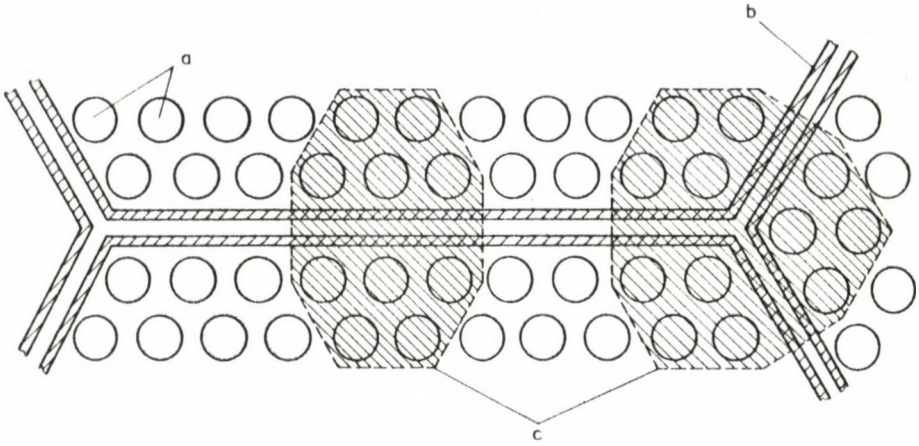

Fig. 3

Parts of WWER-1000 rod bundle:
a) fuel elements; b) wall of bundle; c) parts selected for modelling

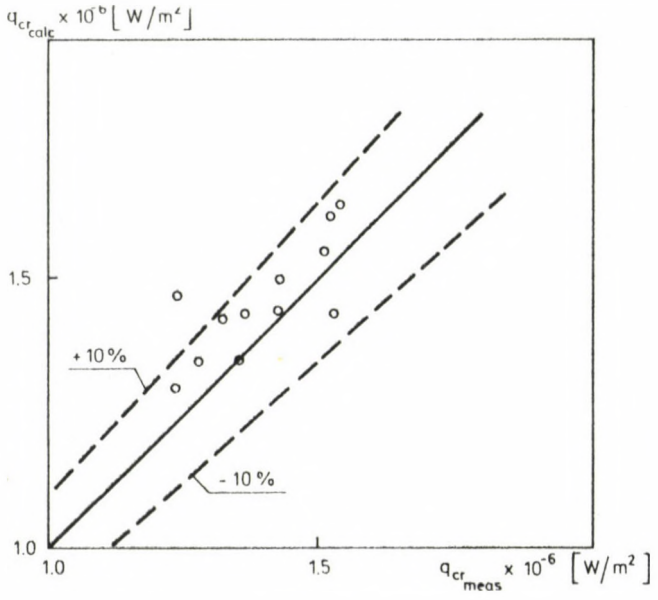

Fig. 4

Comparison of measured $q_{cr_{meas}}$ and calculated $q_{cr_{calc}}$ critical heat flux values, at zero perforation

In the field of computer code development, the transfer of programs was completed from the ICL 1905 to the ES 1040 computer. In that there is now no shortage of computer capacity we have been able to adapt more codes. The adaptation of DYNOTTO, the coupled neutron kinetics-thermal hydraulics program, and the RELAP-4-Mod.3 blow-down code were completed;

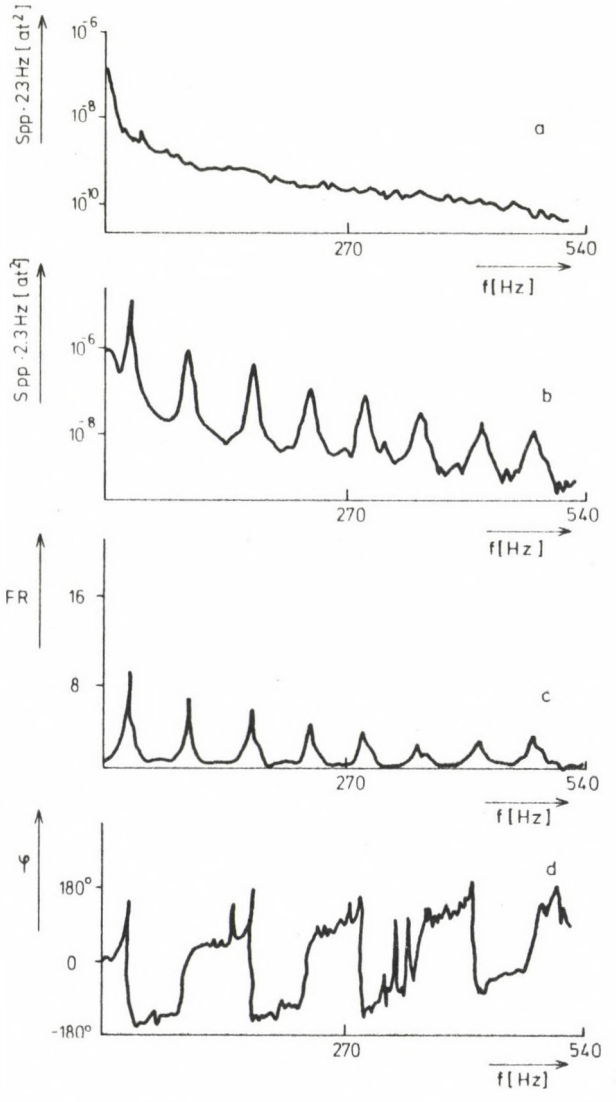

Fig. 5

Acoustic transfer characteristics of impulse tubes

a) power spectrum of input signal; b) power spectrum of output signal; c) frequency characteristics; d) phase

the ASTERIX, the xenon oscillation code, is at present being processed. As a means of combining the HOTRAN-3 which models 3 cooling channels in the active core, and our pressurizer dynamics code, we completed the first version of the PAPRICA code for investigating the dynamic behaviour of primary circiuts.

In the framework of blow-down research the thermal non-equilibrium code was extended to describe high superheats, and thermal wall effects studies were initiated on the homogeneous blow-down code, developed for our own purposes.

The department took part in the safety calculations of the WWR-SM research reactor, necessary for the reconstruction work.

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**O.K.B. Gidropress, Podolsk, USSR
***Zentralinstitut für Kernforschung, Rossendorf, GDR

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COMPUTERIZED REACTOR CONTROL

Laura Bürger-Pátkai, A. Gossányi, J.S. Jánosy, K. Nyéky, J. Péter, Gy. Sándor, G. Szabó, E. Végh, E. Zobor

This year we reached the second phase of our experimental computer control system, i.e. we closed the control-loop, thereby enabling full control of the 5 MW WWR-SM research reactor of our Institute. The realization work in this field began in 1975 when an ES 1010 process computer was installed. We reached the first phase, i.e. a data acquisition and information system, in the autumn of 1976, and the closed-loop operation started in July 1978.

The control system employs a hierarchical control approach, by which the complex reactor system is partitioned into loosely connected simple subsystems, controlled by local controllers under the supervision of a higher level coordinator. At present there are two subsystems, a nuclear, and a primary cooling one. These subsystems use very simple models whose parameters are on-line identified every 16 seconds. This solution provides fast algorithms, which feature is very important in realtime systems where the time requirement of the procedures is one of the most important parameters.

According to the experimental characteristics of our system it has the following control modes:

- manual control,
- backup control, when a conventional analogue controller operates,
- set-point control (SPC), when the computer controls the reference value of an analogue controller,
- direct digital control (DDC), when the computer directly drives, with time modulated signals, the control valves.

At present two parameters are regulated, namely the power of the reactor and the outlet temperature in the primary cooling circuit.

The operation of the computer system is checked by a very simple watch-dog circuit. Once every second this circuit receives a pulse from the computer when the control program of the nuclear subsystem is terminated. If it does not get its pulse in the proper time, the watch-dog circuit gives back the control to the backup controller.

The real-time programming was carried out in the PROCESS-24K process control system. In this system all the tasks of the computer need about 20 % of the CPU time.

In order to improve the availability and to increase the reliability of our control system, we have begun to develop a dual-processor system. This self-checking computerized process control system is due to be ready by the end of 1980.

Our department is taking part in the computerized alarm analysis of the main units of the Paks Nuclear Power Plant. This year we finished the modelling and the failure analysis of the volume compensator unit. As a result of our examination we have proposed some changes in the control of this unit.

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*Computer and Automation Institute, Budapest

TECHNICAL DEVELOPMENT

MEASUREMENT TECHNIQUE FOR STOCHASTIC PROCESSES - ACOUSTIC EMISSION MEASUREMENTS

P. Pellionisz, A. Péter, L. Zeke

Fracture mechanics and stress corrosion cracking processes were monitored by the acoustic emission method. Correlations between the acoustic emission parameters and the characteristics of the investigated materials (toughness, fracture-mechanics values) were studied at different temperatures. The primary incubation time was successfully monitored at stress corrosion phenomena. In the course of these investigations some new measurement processes and systems were developed.

The technical parameters and the basic outlines of a four-channel acoustic emission (A.E.) measuring system have been worked out. The development of the A.E. amplifiers is in an advanced state. As a continuation of the previous year's activity some modules (Fourier Transformer NE-640, CRT Monitor NE-641, Digital Interface NZ-675) were manufactured, which are the latest additions to the previously developed Stochastical Analyser.

SPACE ELECTRONICS

I. Apáthy, I. Szemerey

Two scientific measuring apparatuses developed and made by us were on board space objects in 1978:

- On the satellite "Prognoz-7" an instrument named "Plasmag" for measuring the direction and energetic distribution of the solar wind has been orbiting since October 1978. Our electronic unit controlled by a Z-80 CPU improves the data collection efficiency and performs a data--conversion for the telemetry *(Fig. 6)*

- On the geophysical rocket "Vertical-7" launched in November 1978, our solar UV-radiation monitoring unit was utilized with success *(Fig. 7)*.

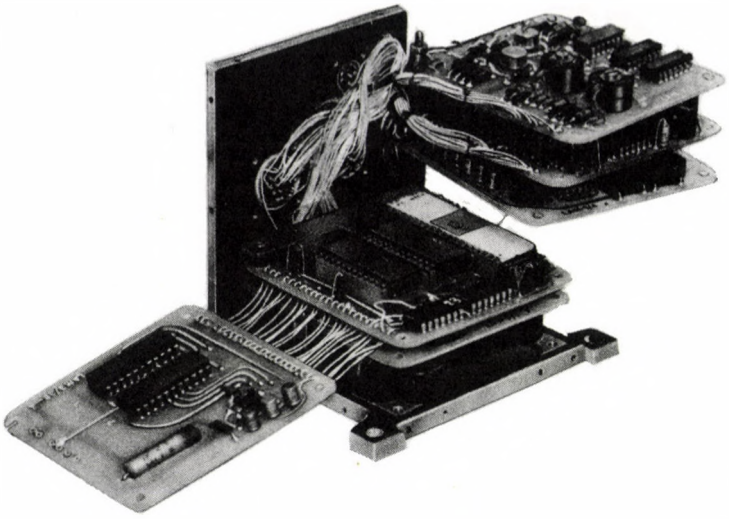


Fig. 6
Electronic unit of the instrument "Plasmag"

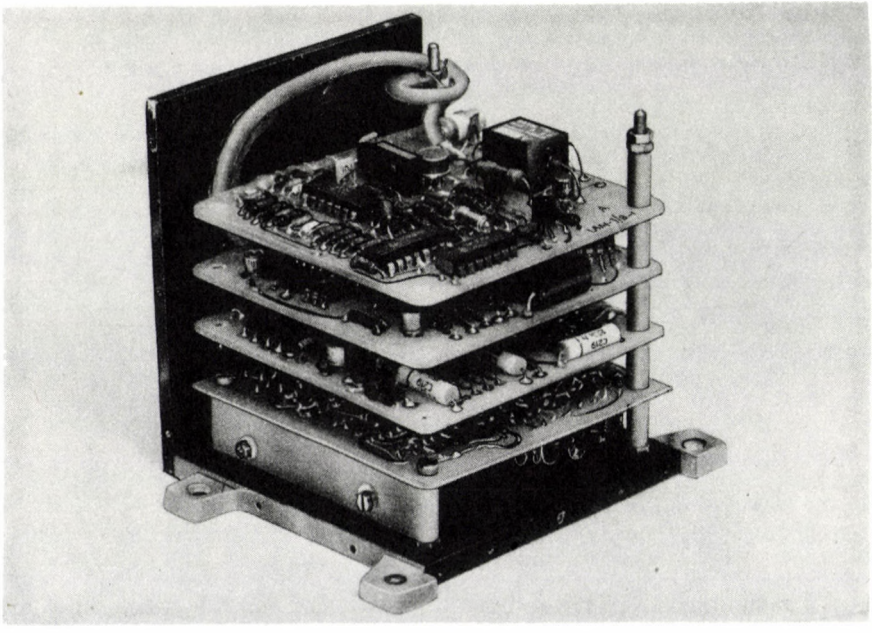


Fig. 7
Electronic unit of the solar UV-radiation detector

PUBLICATIONS

1. I. APÁTHY, I. SZEMEREY: New scientific measuring apparatus for space research developed in the Central Research Institute for Physics, II. Int. Conf. Spaceborne Electronic Instruments, Frunze, USSR, 1978. (in press) (in Russian)

2. I. APÁTHY, T. GOMBOSI, I. SZEMEREY, G.I. VOLKOV*, K.I. GRINGAUZ*, et al.: Instruments for directional charged particle measurements using electronic scanning systems, II. Int. Conf. Spaceborne Electronic Instruments, Frunze, USSR, 1978, (in press) (in Russian)

INSTRUMENTATION FOR REACTOR PHYSICS AND TECHNIQUES

A. Baranyai, P. Pellionisz, L. Várhalmi, J. Zsidó

In 1978 we continued the manufacturing and development activity in the field of reactor instrumentation. As a result the laboratory exemplar of an analogue reactivity computer has been developed and a new, modern nuclear safety system has been manufactured for the Training Reactor of the Technical University of Budapest. The electronic parts of these systems were built up from the units of the Instrument System for Nuclear Industry developed by us. The technical documentation of the Multichannel Radiation Monitor instrument family has been taken over by the Hungarian MTA-KUTESZ institute as in the near future more than 25 instruments must be manufactured.

During 1978 we began to develop and build a microcomputerized reactor-physical parameter monitoring system. The complete set up is based on the CAMAC real-time peripheral system and the Instrument System for Nuclear Industry. The function of the system is the on-line measurement and the corresponding evaluation of the reactivity coefficients both at zero-reactors and at the physical start-up of the blocks of the Paks Nuclear Power Plant.

PUBLICATIONS

1. A. BARANYAI, P. PELLIONISZ: Modular instrument system for nuclear power plants. IXth Int. Symp. on Nuclear Electronics, Dubna, USSR. Report-11182 (1978)(in Russian)

2. P. PELLIONISZ, A. BARANYAI: Reliability improvements of nuclear reactor instrumentation. 2nd Symp. on Nuclear Power Plant Control and Instrumentation, Cannes, France. IAEA Report SM-226/18 (1978)

*Space Research Institute, Moscow, USSR

3. F. ADORJÁN, B. FIALOVSZKY, L. VÁRHALMI: Small-computer controlled arrangement with pneumatic sample changer for the measurement and evaluation of radioactive samples. Symp. on Industrial Application of Radioisotopic Methods. Leipzig, GDR, (1978) p. 78 (in Russian)

4. L. VÁRHALMI, B. BENCZE, M. GÁRDOS, B. VORSATZ*, L. VARGA**, I. TEMESI**: Measurement systems for industrial neutron generator activation analysis. Experience of operation. ibid. p. 22

WWR-SM RESEARCH REACTOR

S. Balogh, P. Borbély, L. Frankl, L. Goda, Z. Honti, Gy. Lugosi, Gy. Mucskai, M. Tóth, G. Vizdos

In 1978, the WWR-SM reactor worked according to schedule and operated for 3177 hours thereby ensuring research work in the fields of solid state physics, nuclear physics, activation analysis and biology and also the production of radioactive isotopes. This operating time is 3.8 % higher than the stepped-up one of the preceding year.

The heat power of the reactor varied between 4.0 and 4.9 MW according to the core-configuration. At these power levels, by different core-configurations, the following average values of the maxima of the thermal neutron fluxes were obtained: in the vertical irradiation channels 4.5×10^{13} n $cm^{-2}s^{-1}$ and in the neutron traps $7.6\text{-}8.6 \times 10^{13}$ n $cm^{-2}s^{-1}$.

The main parameters of the reactor for 1978 were:

Operating time (hours)	3177
Interruptions due to breakdown (minutes)	
- from internal faults	0.0
- from external faults	180
Number of breakdowns	5
Thermal energy produced (MWd)	650
Burn-up of ^{235}U (g)	845
Working time of horizontal channels (hours)	8686
Number of irradiations in the pneumatic irradiation system	400
Number of irradiated tubes (isotope production)	770
Tube-hours	169095

In 1978, two core-configurations were used, one consisting of 143 and the other of 166 (single) fuel assemblies. The principle was pre-

*Technical University, Miskolc, Hungary
**Duna Iron Works, Dunaujváros, Hungary

served further so as to maintain the useful flux level at a constant value while keeping the heat output for the given configuration to a minimum value. During the operation of the reactor the burn-up level of the fuel assemblies was maintained as far as possible at the maximum value making use of core rearrangements and by the adoption of an appropriate fuel policy. In 1978, 21 (single) fuel assemblies were taken out of the core the average burn-up level of which was as high as 54.1 %.

The components and equipment of the reactor have become more and more worn out during their 19 years of reliable operation and need an increasing amount of maintenance work. Last spring the vanes on the impeller of the cooling ventilator of the reactor became faulty calling for the immediate intervention of an outside firm. The repair work necessitated a one-week stoppage of the reactor operation, but this was made up by the staff of the reactor during the same month. In May we experienced, for the first time in the life of the reactor, a failure in the tightness of a fuel assembly. The reactor operated according to schedule, but at an increased level of control and at week-end off-times we located, with the help of the Health Physics Department, the failed fuel assembly and removed it from the core. After this defect the dosimetric control system was enlarged by new measuring chains and our regulations and controls were tightened.

In addition to ensuring the accident-free operation of the reactor we took an active part in establishing the closed-loop cycle of the computerized reactor control system and in the fulfilment of the necessary trial operation.

In 1978, the staff of the Research Reactor also took part in elaborating the principles on which the reconstruction will be based.

FOREIGN RELATIONS

LECTURES BY VISITING SCIENTISTS

H. Nishihara	(Department of Nuclear Engineering, University of Kyoto, Sakyo-ku, Kyoto, Japan)
	Atomic energy research in Japan Two phase flow studies at Kyoto University
G. Reffo	(Comitato Nazionale per l'Energia Nucleare, Centro di Calcolo, Bologna, Italy)
	Nuclear data evaluation activities in CNEN Bologna

F. Mayinger	(Technische Universität Hannover, Hannover, FRG)	
	General aspects and status of knowledge in nuclear safety	
	Research work concerning blow-down and emergency core cooling of light water reactors	
R. Semeria	(Centre d'Études Nucleaires de Grenoble, Grenoble, France)	
	Status of the French nuclear energy program	

STAFF MEMBERS ON STUDY TOURS

T. Katona	Zentralinstitut für Kernforschung, Rossendorf, GDR	3 months
L. Meskó	Institut für Kerntechnik, Technische Universität Hannover, Hannover, FRG	16 months
I. Vidovszky	Institut für Reaktorentwicklung, Kernforschungsanlage Jülich, Jülich, FRG	8 months

GUEST SCIENTISTS AND FELLOWS

I. Palacio Soler	Instituto de Investigaciones Nucleares Habana, Cuba	6 months
H. Nishihara	Department of Nuclear Engineering, University of Kyoto, Sakyo-ku, Kyoto	1 month

THESES

G. Kosály	Theoretical investigation of the local and global components of the neutron noise in a LWR system. (For the academic degree of Doctor of Physical Sciences)
J. Gadó	Asymptotic burn-up calculation of nuclear reactors. (For the academic degree of Candidate of Physical Sciences)
I. Lux	Monte Carlo estimation of reaction rates in neutron physics. (For the academic degree of Candidate of Physical Sciences)

A. Kereszturi	An integral measurement-based analysis of a nuclear data library used in neutron physics calculations. (For Ph. D. degree)
J. Zsoldos	Study of parametrization problems in the calculational model of WWER-440 power reactors. (For Ph. D. degree)

RESULTS

WHOLE-BODY COUNTING AND GAMMA SPECTROMETRY

A. Andrási, Éva Beleznay, P. Zombori

The different codes of the COMPFIT computer program elaborated for organ-dose estimation based on profile-scanning measurements were tested.

A PDP 11/34 type computer has been installed for various kinds of calculation and recording purposes in radiation protection as well as data acquisition. The present hardware configuration is equipped with 32K word memory capacity, dual floppy disk, alpha-numerical and graphical display and paper tape peripherals.

DOSIMETRY STUDIES

L. Koblinger, J. Pálfalvi, P.P. Szabó

Nuclear accident dosimeters of 5 Hungarian and 2 Czechoslovak groups were irradiated in the biological irradiation channel of the WWR-SM research reactor of our Institute. A detailed evaluation of the neutron and gamma dose data of the different dosimeter systems was carried out in 1978 and good agreement was found.

The adjoint Monte Carlo code REBEL-2, written originally for the calculation of the exposure rates in dwelling rooms, has been extended for the calculation of the doses absorbed in several critical organs of an anthropomorphic phantom. The calculated ratios of the organ doses to the exposure, i.e. the shielding factors, can well be used in the radiological interpretation of measured exposure rates.

Our $CaSo_4$:Dy thermoluminescent dosimeters were sent to the Third International Intercomparison of Environmental Dosimeters which was held in Houston, Texas, USA. It turned out that the TL signal of the $CaSO_4$:Dy dosimeters was dependent on the energy of the environmental radiation. Therefore the energy dependence of the $CaSO_4$:Dy in different shielding

materials was studied. The best capsule to decrease the large energy dependence of $CaSO_4$:Dy TLD is the Cu capsule of 1 mm wall thickness.

At the proton accelerator in Dubna, USSR, the sensitivity of different TL materials (such as LiF, LiF-7, LiF-6, $CaSO_4$:Dy, CaF_2:Dy) was investigated in the proton energy range of 80 MeV - 660 MeV.

PUBLICATIONS

1. L. KOBLINGER: Calculation of exposure rates from gamma sources in walls of dwelling rooms. Health Physics 34, 459 (1978)

2. J. PÁLFALVI: Nuclear accident dosimetry measurements. Czechoslovak-Hungarian intercomparison, Budapest, Hungary, 1977. KFKI Report 78-65 (1978)

3. L. KOBLINGER, I. LUX: Comparison of the efficiencies of track length and collision density estimators for three simple geometries. KFKI Report 78-41 (1978)

ENVIRONMENTAL MONITORING AROUND NUCLEAR POWER PLANTS

A. Andrási, Éva Beleznay, J. Biró, S. Deme, I. Dudás, I. Erdélyvári, I. Fehér, Gy. Lancsarics, J. Molnár, P. Ormai, Éva Pados-Farkas, M. Rövid, Gabriella Szabady-Szende, P. Zombori

We have investigated the influence of the radon content in the surrounding air of the AHMED low background gamma spectrometric device on the background of the instrument.

A Ge(Li) semiconductor spectrometer has been put in operation for gamma-spectrometric analysis of environmental samples containing very low radioactivity. The measurements are controlled and the data are collected and processed by a multichannel analyser-programmable calculator system produced by the Works for Electronic Measuring Gear, Budapest.

An apparatus was constructed to study the efficiency of some granular adsorbent materials in removing iodine and methyl iodide from air under various temperature, humidity and air velocity conditions.

We have investigated the effect of Rn + daughters background on measuring ^{131}I in charcoal and have worked out a heating system to decrease the Rn content of charcoal.

Some of the measuring and sampling methods which will be used in the Paks Nuclear Power Plant were developed. The prototype of the measuring and sampling stations planned to be used in the environment of the atomic power station was prepared and its testing was begun.

RADIATION PROTECTION SERVICE

A. Andrási, J. Biró, I. Erdélyvári, J. Molnár, Éva Pados-Farkas

The personnel, the working places and the whole area of the Research Centre were routinely controlled; the tasks in connection with isotope handling and with the central records concerning radiation were duly performed by the Radiation Protection Service in order to safeguard the workers from health hazards, and to protect materials and goods from radiocontamination.

Similarly to earlier years, the dose received by the majority of persons (99 %) working in radiation hazardous places did not exceed the maximum permissible dose for a month, i.e. 400 mR (see *Table I*).

Table I

DISTRIBUTION OF WORKERS WITH RESPECT TO GAMMA DOSES RECEIVED (THE DOSES WERE MEASURED BY FILMS)

Year	Dose				Total number of workers monitored
	below 400 mrad	400-1500 mrad	1500-5000 mrad	above 5000 mrad	
1961	283	15	1	-	299
1962	295	12	2	-	309
1963	357	9	1	-	367
1964	350	7	-	-	357
1965	335	7	-	-	342
1966	367	10	1	-	378
1967	358	4	1	-	363
1968	357	10	-	-	367
1969	377	4	1	-	382
1970	322	2	-	-	324
1971	359	7	-	-	366
1972	405	1	-	-	406
1973	319	1	-	-	320
1974	348	3	-	-	351
1975	304	3	-	-	307
1976	342	-	-	-	342
1977	373	2	-	-	375
1978	361	1	-	-	362

PUBLICATION

1. Activities of the Health Physics Department of the Central Research Institute for Physics. 1971-1977. (Compiled by L. Koblinger) KFKI Report 78-85 (1978)

FOREIGN RELATIONS

STAFF MEMBERS ON STUDY TOURS

P.P. Szabó	Joint Institute for Nuclear Research, Dubna, USSR	3 months
J. Pálfalvi	BHABHA Atomic Research Centre, Bombay, India	3 months

GUEST SCIENTISTS AND FELLOWS

Sonia Vizoso	Instituto de Investigaciones Nucleares, Academia de Ciencias Habana, Cuba	2 months

RESEARCH INSTITUTE
FOR MEASUREMENT
AND COMPUTING
TECHNIQUES

RESULTS

COMPUTING FACILITIES

K. Bánáti, T. Benkő, Magda Bodnár, L. Diósi Zs. Dobolyi, T. Gaál, Irina Gladkikh, Erika Lovas, Livia Major, A. Nagyházi, F. Telbisz, Éva Vass, Magda Zimányi

The computer centre of the Institute has operated the following computer configurations:

- ICL 1905 computer equipped with 32K words core memory, 6 magnetic tape decks and slow peripheral units;
- TPA 70 computer equipped with 16K words core memory, CDC cartridge disk and slow peripheral units;
- TPA 1140 computer equipped with 32K words core memory, MOM disk and slow peripheral units;
- TPA/i computer equipped with 8K words core memory, two DRI disk units, two magnetic tape decks and slow peripheral units;
- ES 1020 computer equipped with 128 Kbyte core memory, 4 exchangeable disk units, 4 magnetic tape decks and slow peripheral units;
- ES 1040 computer equipped with 1 Mbyte core memory, 24 exchangeable disk units, 8 magnetic tape decks and slow peripheral units. This configuration has been extended this year by an ES 7054 plotter and by the installation of an interactive system which consists of a TPA 70 minicomputer with 24K words core memory as a front-end processor, 10 display units (one of them is now serving as an operator's console), two matrix printers and paper tape I/O units;
- The interactive terminal system of the network CEDRUS, developed in the Institute, was opened for users in the last quarter of the year.

With regard to the installation of the plotter, two hardware and two software specialists have received special training in Prague, Czechoslovakia.

The operation of the ES 1020 computer was terminated in August. Similarly, the ICL 1905 computer, after twelve years of operation, stopped working from the end of the year.

For the ES 1040 computer, the operating system OS has been newly generated in order to increase effectivity, thereby more appropriately meeting the demands of the scientific environment. An advisory service provided continuous help for the users. In addition, lectures and seminars on the software facilities were organized on a regular basis. The programming library has been extended by making available several internationally recognized libraries such as the CERN Library and the Computer Physics Communication Program Library.

COMPUTER SCIENCE AND APPLIED MATHEMATICS

G. Ács, J. Bagyinszki, S. Doleschall, I. Faragó, Éva Farkas, Borbála Gellai, C.J. Hegedüs, Gy. Lőcs, G. Németh, L. Varga, Éva Vass

Studies on programs of verified design, especially in the case of parallel programming, were continued. Acquisition and adaptation of accessible software tools for program verification have been started.

Investigations were carried out in connection with the formal description of the semantics of programming languages using Knuth's method of the inherited and synthesized attributes.

We have continued investigations on the structure of classes of many-valued logics; the complete lattices of linear classes over a finite ring of order square-free have been given.

A computer generated local structure model of water in the liquid phase was studied in collaboration with the Department of Chemistry, the University of Tennessee, Knoxville, Tennessee, USA. Using the Monte Carlo method and taking the effects of the closest molecule neighbours into account, we have generated a large number of random molecule configurations. The digital estimation of the frequency probability distribution function can be used to calculate a more realistic value of certain thermodynamic parameters.

Some mathematical problems of the nonlinear wave-wave interaction in plasma have been investigated. Limit cycles of the governing differential equation were determined by numerical methods.

An oil reservoir simulator has been developed which is mathematically a system of nonlinear partial differential equations. The ten governing equations include the

- mass conservation of ten fluid components,
- experimental laws that describe the transport process active in the reservoir (Darcy law, Fick law),
- relations describing accurately the thermodynamic properties of the three-phase fluid (gas, oil, water) system.

A code of about 2000 FORTRAN statements yields the solutions that were utilized in predicting the performance of the Budafa-West oil field.

There were some investigations carried out on computing the demagnetization field due to symmetrically magnetized bodies of different shapes for modelling magnetic bubble structures.

The convergence of a previously developed algorithm for positive linear approximation was proven.

PUBLICATIONS

1. Á.ÁG, G. NÉMETH, Gy. PÁRIZS: Topological structure of the non-linear mode-coupling model equations in a plasma. KFKI Report 78-39 (1978)

2. C.J. HEGEDÜS, E. DELLA-TORRE*: On the efficient calculation of magnetic bubble functions. J. Appl. Phys. 49, 942 (1978)

3. C.J. HEGEDÜS: Complete elliptic integrals. Hewlett-Packard User's Library, Program No. 2377D (1978)

SYSTEM SOFTWARE

A. Arató, Gabriella Békési, Katalin Burány, Zs. Dobolyi, T. Gaál, Z. Gálfi, M. Horvai, A. Horváth, Mária Ivanyos, J. Kiss, K. Kovács, Mariann Kővári, Erika Lovas, Gy. Lőcs, I. Mező, M. Nagy, M. Pap, M. Salamon, I. Sarkadi-Nagy, Teréz Sarkadi-Nagy, G. Takács, F. Telbisz, J. Telek, J. Tibor, Erzsébet Vass, Magda Zimányi

The interactive text editor, as the first phase in the development of CEDRUS (Conversational Editor and Remote User's Support, previously named OREMUS), was completed during the year. It is working under OS/MVT, allowing interactive text editing, and job preparation and submission of programs by its users. The same system, besides serving customers, helps to operate the ES 1040 computer by providing a reliable fast display console which is equipped with a hard copy unit. Experimental use of the system started in May 1978 and it has been working regularly full time since October 1978.

Some software development work to enhance the services of the OS operating system on the ES 1040 computer is in progress. As the utility programs in OS are rather clumsy and tedious to use, it was decided to

*Dept. of Electrical Engineering, McMaster University, Hamilton, Ontario, Canada

introduce some new file utilities in order to provide more flexible and extended file handling facilities. Some of these programs are now in general use.

To provide sensible plotter services for users, we have developed the R-PLOTTER subroutine package for the newly installed DIGIGRAF (ES 7054) plotter device. (The R-PLOTTER package was originally developed for the ES 1020 computer running under DOS and a Computer Instrumentations Limited incremental plotter.)

The STAGE2 general purpose macroprocessor has been implemented on the ES 1040 computer.

The documentation of the TPA 70 disk operating system (MINOR/D) and three new User's Manuals have been completed.

The PLOT-10 Terminal Control System has been adapted to a TPA 70 configuration that is interfaced to a TEKTRONIX 4012 display.

A new version of the TPA 70 FORTRAN system has been worked out which utilizes a PDP compatible hardware Floating Point Unit.

A start was made in the development of some new program packages for TPA/i computers and for members of the TPA 8 computer family (TPA/L,TPA/S), which can be utilized for connecting these machines to a computer network.

Implementation of the CATY-80 program language has been complemented thereby providing the facility for testing CAMAC modules in a BASIC like language on an Intelligent Crate Controller that is itself based on an Intel 8080 microprocessor.

Some activity has been directed towards increasing the capabilitites of the TPA 1140 minicomputer. The newly developed MIRTUS real-time executive is a prospective candidate for organizing control in a communication processor. The BLOKOS language is under development. This language makes the solution of small-scale closed-loop control problems easy. The user can quickly produce a program from the control and information structure of the process because the language directly implements the most frequently used notions of control theory. In addition, a BLOKOS program may encompass FORTRAN and Assembly segments, too.

The LOS and FOBOS operating systems have been documented and a joint test of the FOBOS system has been prepared and performed in connection with its becoming a component of the Unified System of Minicomputers (SM).

In cooperation with the Hungarian VIDEOTON Co., some progress has been made in designing minicomputers for the second generation of SM.

PUBLICATIONS

1. I.A. GLADKIKH, A.B. KUNCHENKO*, Yu.M. OSTANEVICH*, L. CSER: Study on small angle scattering of neutrons in axial-symmetric geometry. Report JINR, P3-11487, Dubna, (1978) (in Russian)

2. A. ARATÓ, E. LOVAS, M. SALAMON: MINOR/RT Operating System User's Manual. KFKI-1978-779 (1978)

3. Z. GÁLFI, M. IVANYOS, K. KOVÁCS, E. LOVAS, I. MEZŐ, M. NAGY, G.TAKÁCS, J. TELEK, J. TIBOR, M. SALAMON: MINOR/D System Programs. Supplementary Manual, Vol.1. KFKI-78-652 (1978)

4. Z. GÁLFI, M. IVANYOS, K. KOVÁCS, E. LOVAS, I. MEZŐ, M. NAGY, G.TAKÁCS, J. TELEK, J. TIBOR, M. SALAMON: MINOR/D System Programs. Supplementary Manual, Vol.2. KFKI-78-744 (1978)

APPLICATION PACKAGES

A. Arató, M. Bak, K. Balajthy, L. Buday, Ilona Dercsényi, L. Diósi, Zs. Dobolyi, T. Gadl, Irina Gladkikh, M. Horvai, A. Horváth, L. Ivanyos, Mária Ivanyos, J. Kiss, Katalin Kulcsár, Z. Paddnyi, M. Pap, B. Papp, Mária Rigó, Éva Scherer, P. Soós, Z. Szemereki, J. Szlankó, S. Trencséni, G. Turchányi, Judit Vámos, Magda Zimányi

A considerable amount of work went into transferring to the ES 1040 computer programs that previously ran on other computers (ICL 1905 and ES 1020).

The SIRIUS program package for evaluating spectra was extended by new components and it now fully replaces its predecessor on the ICL 1905. It consists of modules for the following purposes:

- conversion of data from paper tape to a standard magnetic tape format,
- copying, editing, listing and plotting of data that are stored on magnetic tape,
- evaluation of gamma spectra,
- evaluation of Mössbauer spectra.

The Selective Dissemination of Information (SDI) services were provided in the previous years by using the old computer ICL 1905. This job has now been reorganized for the ES 1040 computer. Working under DOS, the INSPEC, CAC and INIS data bases were scanned for relevant scientific information.

*Joint Institute for Nuclear Research, Dubna, USSR

At the end of the year, the number of searched themes was about 200 and that number kept increasing week by week. In order to better harmonize with the standard operation of the ES 1040, a variant of this package is working under OS from the end of the year.

A program package for inventory management and control has been transferred from the ICL 1905 to the ES 1040 computer; it has also been considerably extended.

The REDUCE2 formula manipulation language was put to use for solving problems in theoretical high energy physics.

In order to increase the application facilities of the ES 1040, the employment of cross compilers has been started in a project for software development of mini- and microcomputers. The PL-11 (developed in CERN) and the CR-8080 cross assemblers have been installed, extended and tested on the ES 1040. The PL-11 high level assembly language supports the software development of the TPA 1140 minicomputer, and the CR-8080 macro assembly language supports the software development of Intel-8080 microprocessor based systems.

The following application systems, based on TPA/i minicomputers, are worthy of mention:

- The data acquisition system called TIFO-T for monitoring the tank park of the Tisza Oil Refinery at Leninváros, Hungary. This has now been completed;

- The implementation of a new measurement and control system, called TIFO-K. This work has been started;

- The cooperation with Claudius-Peters GmbH, Hamburg, FRG, relating to the provision of a computer control system for filling railway tanks, has been brought to a successful completion;

- The data acquisition system of the Szeged-Algyő (Hungary), Oil-field - work on which has been continued.

Also, some minor programming efforts have been spent and consultations have been held in connection with other current projects of the Institute.

PUBLICATION

1. M. HORVAI, Z. PADÁNYI, P. SOÓS: TPA/i minicomputers for measuring, data acquisition and processing, and process control in industrial applications. Proc. Int. Symp. MECO'78 - Measurement and Control, Athens, Greece, 1978 (in press)

FOREIGN RELATIONS

STAFF MEMBERS ON STUDY TOURS

Irina Gladkikh	Joint Institute for Nuclear Research, Dubna, USSR	6 years
Borbála Gellai	University of Tennessee, Knoxville, Tennessee, USA	1 year
C.J. Hegedüs	McMaster University, Hamilton, Ontario, Canada	16 months
L. Varga	Brown University, Providence, Rhode Island, USA	5 months
M. Zsenei	Joint Institute for Nuclear Research, Dubna, USSR	6 years

RESULTS

DEVELOPMENT OF CAMAC MODULES AND SYSTEMS AND THEIR LABORATORY APPLICATIONS

L. Almási, J. Biri, M. Blasovszky, P. Bördén, N. Buchmüller, P. Giese, Gy. Kertész, I. Mohos, T. Nemes, J. Reho, J. Sarkadi, Katalin Somlai, L. Somlai, Gy. Stancsich, Zs. Zárándi, K. Ziegelmann

Module development

During the course of the past year the number of our CAMAC modules was increased significantly. These new modules are: dual amplitude and shape discriminator, four-channel integrating ADC, dual floating D/A converter, industrial digital multiplexer of 3 types (viz. with relay, with the inputs of AC and DC respectively), digital multiplexer/demultiplexer controller, CAMAC-MODEM (200 Baud), high voltage (15 kV) optoisolator.

The Intel 8080 microprocessor based intelligent system has also been extended with two new memory modules (4Kbyte+start and 16Kbyte), the branch extender driver and the floppy disk interface.

Systems

Throughout last year we developed further our CAMAC system devices. For the purpose of extending the data collecting system - installed around the T-7 tokamak equipment at the I.V. Kurchatov Institute of Atomic Energy, Moscow, USSR, in 1977 - a measuring and archivation system was elaborated for the diagnostic and technological parameters of the T-7. The system contains a TPA-i small computer with 24K words operative memory; the background memory comprises magnetic disks and tapes. Two CAMAC systems and an ICA-70 analyser measure and evaluate the 200 analogue and 150 digital channels.

The Computerized Chemical Laboratory (*Fig. 1*) supplied to the servicing station of the state farm organization at Baranya County for soil analysis - was completed with a central measuring data collecting system which provides a computer independent operation for the promotion of the actual development work. In this system - when the computer is en-

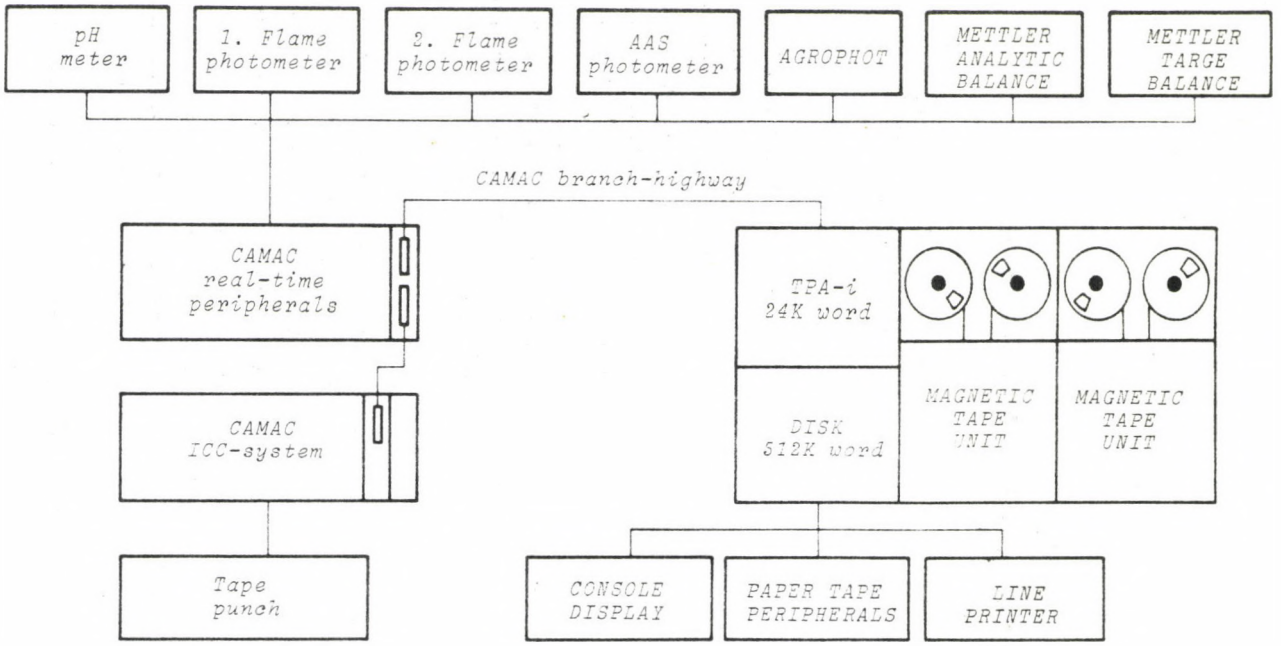


Fig. 1
Block diagram of the Computerized Chemical Laboratory

gaged or out of work - the chemical peripherals (pH meter, atom-absorption photometer, flame photometers, aggressive photometer, and digital--analytical balances) can be controlled by unchanged operating algorithms without breaking the connection points. The dual method of control is provided by the CAMAC Branch Highway with the Intelligent Crate Controller (ICC) on one side, and the TPA/i small computer on the other.

In the case of the TPA/i controlled "on-line" measurements the user programs were written in OS-i language and they occupy an 18K words memory. The checked daily measuring results - after having been transformed to physical values - can be stored on disk.

The programs of the ICC controlled off-line measurements are written in Intel 8080 Assembler language and take place in ROM memories. The program occupies 12 Kbytes. The digitalized values of the results of the measurements are punched on paper tapes arranged in unified blocks. Normalization and evaluation of the measured data can subsequently be provided by the computer.

Software

The development of the software for the CAMAC system has been continued with special regard to the requirements of the microprocessor intelligent system. The new variant of the previous BASIC interpreter has been prepared. It works more rapidly and is complemented by logical bit-operations. A smaller, high-speed translating BASIC (CATY-80) with a less complex arithmetical specification has also been produced.

In order to increase the efficiency of the CAMAC system the DOS-80 operating system was worked out; this is based on floppy disks and uses direct memory access.

PUBLICATIONS

1. L. ALMÁSI, J. BIRI, I. MOHOS, T. NEMES, J. REHO: Application of CAMAC systems in scientific measurements. Int. Conf. on Scientific Measurements and Methods, Moscow, USSR. 1978. (in press) (in Russian)

2. T. NEMES: Microprocessor based autonomous programmed system in CAMAC standard. Preprint JINR 10-11232, Dubna, (1978) (in Russian)

3. T. NEMES: Interface of papertape reader FS1500/1501 and perforator PERFOMOM 30. Preprint JINR 10-11696, Dubna, (1978) (in Russian)

INDUSTRIAL APPLICATIONS OF SMALL COMPUTERS

K. Balajthy, J. Cser, P. Görög, J. Kenessei, L. Kerényi, J. Kovács, L. Kövesheqyi, J. Mayer, Gy. Mikóvári, Z. Padányi, Z. Stéger, E. Szebényi, Z. Szemereki, Z. Szetey, L. Szőnyi, S. Trencséni, Gy. Vashegyi

The effective use of small computers for industrial application continues to provide a great deal of food for thought - which thought has resulted in the following computerized systems being realized:

(a) Data acquisition and process control systems for power plants.

The trial operation of the first of the four-block computerized system being set up at the Tisza Power Plant has been successfully completed. The most significant result of the continuous operation is that the power plant technology control is based on the information obtained by the computer system.

The services of the system are real-time because of the signals coming from the technology and generating operation mode changes. The devices of man-machine communication in the control room provide a simple and rapid means of operator intervention if needed.

(b) Computerized systems for controlling the test beds when checking Diesel engines in the Motor Works of Kama, USSR.

The increased qualitative requirements set against up-to-date engines make the final instrumental checking necessary. The instrumental test beds are connected to a computerized system the task of which is to check and qualify the engines according to the program. Twelve test beds belong to one computer. Last year our commission to provide a 15 test bed controller configuration was fulfilled and the test programs and the systems were delivered.

(c) Computerized control of technology for the pipeline and rail transportation and the storage of gas and oil products.

The supervisory system of the tank farm for storing the oil products and the computerized system for the open-loop control of the material transportation have been installed in the Tisza Oil Refinery. At the same place, the computerized system for the automatic filling of the containers was realized within the framework of a cooperation with the firm Claudius Peters of the FRG. The system controls automatically the positioning of the containers and the filling of materials of the required quality and amount.

DEVELOPMENT OF SMALL COMPUTERS

D. Ambrózy, Gy. Balatoni, F. Báti, B. Biró, T. Bozsó, A. Csákány, E. Hamza, J. Harangozó, L. Holtzer, L. Joó, Judit Kántor, P. Karádi, Róza Kertes, Gy. Komlós, I. Kővári, G. Lőrincze, M. Marton, Gy. Messing, Z. Nyitrai, P. Patóh, E. Reé, J. Sulyán, P. Szabó, L. Sztankó, K. Szücs, Gy. Tamás, Katalin Tarnay, T. Török, F. Vajda, Klára Varga

Further advances were made with the TPA 1140 devices which had already been developed in 1976 and 1977; e.g. the communicational peripherals and the software modules were improved. In addition to the already interfaced peripherals (produced in the socialist countries), disks and magnetic tape units made in the western countries were also interfaced, and higher capacity core and semiconductor operative memory modules were made ready. TPA 1140 systems are widely utilized - as is proved by the various fields where the configurations installed in 1978 can be found, viz. scientific-technical calculations, configurations for laboratory and industrial data collection, etc. (*Fig. 2*). There are systems for solving administration tasks too. An appropriate example is the interactive data input configuration which was made for the Research Centre of the Hungarian Ministry of Finance.

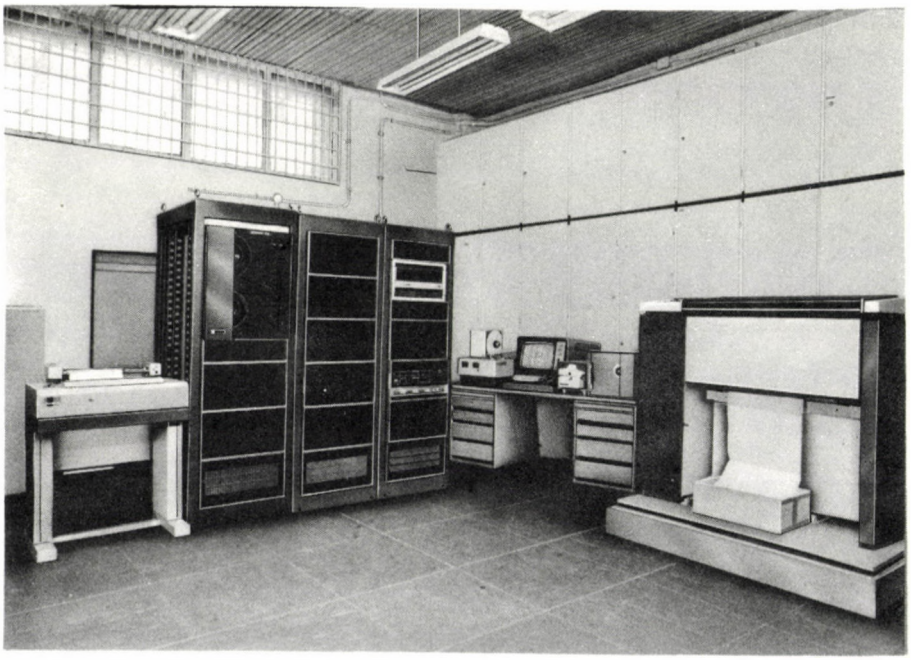


Fig. 2
TPA 1140 system

The elaboration of test sets for bubble memory devices has been continued within the framework of our Institute's special programme.

During 1978, a wafer tester was completed. Its major parts are: a rotating field generator with sinusoidal start-stop operation, current generators of adjustable amplitude and flow angle for bubble handling, bias jump generator for the determination of the bias margin, bias field generator, and a complex control. The wafer tester is also suitable for testing major-minor loop organized chips. Its control enables a 20 step program to run. The program can be constructed with the help of a 20x20 pin matrix enabling bubble handling or quick commands without field rotating requirements. The test program is adjustable in a simple way because of the pin matrix.

An intelligent crate controller based testing equipment is also being built as this is suitable for more complicated bubble investigation.

Activities concerning the use of small computers in education have been continued. Different groups of students faced the computer which contained a teaching program of a certain part of the subject matter (*Fig. 3*). Judging by our experience computer aided education is parti-

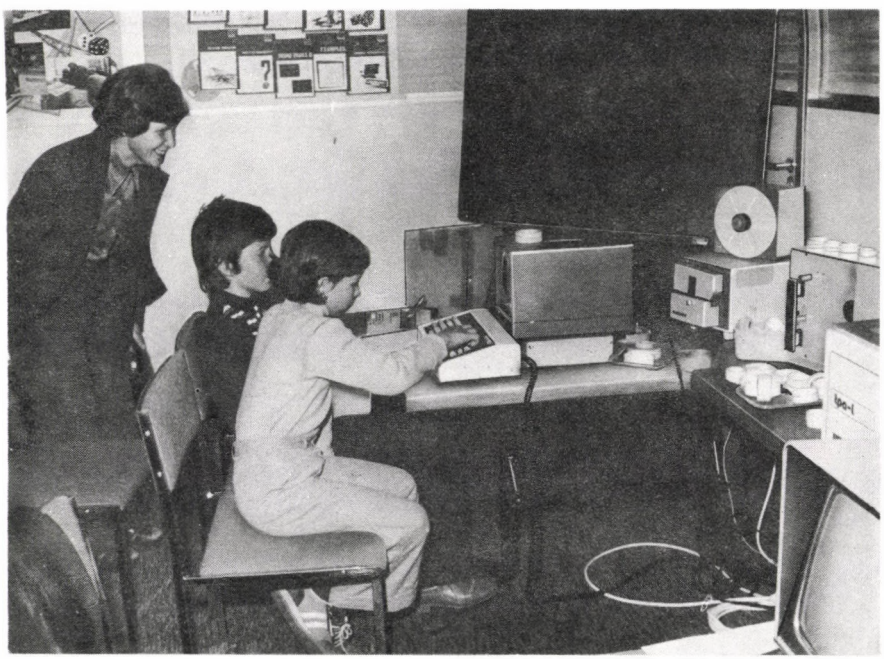


Fig. 3

Computer aided education project for elementary school pupils

cularly advantageous for those who are less gifted academically and who thus need more time. Our teaching program library has increased considerably, about a dozen of our reports were published with the teaching programs of different subject matters and their didactical description. During the past year several lectures and demonstrations were delivered on computer aided education within the framework of the collaboration with the Hungarian Scientific Society of Measurement and Automation Organization.

So far as the investigation of complicated systems is concerned we were mainly engaged with computer network problems. Our work proceeded in two directions: on the one hand we examined the condition of equilibrium of the network with theoretical methods and made a comparison between the modern model of the theory of games and the already classic computer network models.

On the other hand we designed such a computer simulation model of the network which imitates even the measurement and checking of the network. Thus, the actual effect of the network examination on the network itself can really be evaluated immediately prior to beginning the actual measurement.

PUBLICATIONS

1. J. HARANGOZÓ: Protocol definition with formal grammars. In: Computer Network Protocols, A. Danthire, Ed., North-Holland Publ. Co., Amsterdam, 1978, p. F6-1

2. J. HARANGOZÓ: Formal representations of the protocol hierarchy. Proc. of EUROCOMP '78, London, England, 1978. (in press)

APPLICATION OF MICROPROCESSORS

Gy. Ambrózy, F. Báti, G. Bóna, S. Ebergényi, I. Erényi, P. Karádi, L. Leveleki, Magdolna Lovászi, J. Miskolci, I. Rényi, L. Sándor, T.L. Sándor, M. Szalay, F. Vajda

Last year the research activities linked with the up-to-date application of microprocessors and other LSI units were continued.

With regard to the investigational fields which are already developed our approach has been to enhance the qualitative aspects rather than the quantitative ones.

First of all we completed our systems both in hardware and in software to clarify their place in the system of computing techniques equipment. The EMU-11 - which is a TPA 1140 computer emulated by the application of

the Intel 3000 microprocessor family - was equipped with a complete peripheral system (*Fig. 4*). All of the system programs have been tested and the computers utilizing these were demonstrated with a considerable degree of success at several exhibitions at home and abroad.

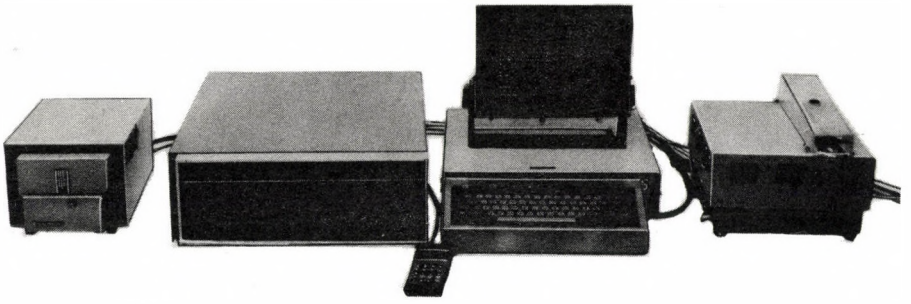


Fig. 4
EMU-11 microcomputer

We have also made considerable progress in the field of microprogramming and have constructed the microprogrammed floating point unit of the EMU-11.

The Z-80 microprocessor based general microprocessor development system was also completed. The operating system and the controller unit for the Hungarian made floppy disks have been made ready too. A wide range of different purpose applications has been formulated to utilize these including a task-oriented microcomputer, a PROM programmer, a word processing system, etc.

Apart from the previous symbol representation mode of the Intel 8080 based intelligent colour display terminal, a so called curve plotter mode was realized with the help of which four different curves can be displayed on a 256x256 raster scan (*Fig. 5*). A Display Basic program has been developed for both the TPA/i and the TPA 1140 computers enabling the user to handle the colour display terminal by programs written in BASIC language.

Research work is in progress concerning the application of our multimicroprocessor system in the field of image processing. As new modules, a high speed analogue/digital converter and a high capacity semiconductor memory have been developed for this purpose. With the help of these the digitization and storage of a camera shot can be further processed.

The manufacture of limited quantities of the TPA-L/32 microprocessor based small computers has started. Different user variants were elaborated utilizing the basic machines already developed. Three particular fields of application are emphasized here:

- TPA-L based, multiterminal teaching systems using the TEASYS program system. Such systems were demonstrated in operation at fairs in Helsinki, Lagos, Zagreb, and in the House of Techniques in Budapest;
- measuring and data collecting systems realized by linking an ICA-70 analyser and a TPA-L type computer;
- TPA-L based, interactive data preparatory system used for the COS/i data processing operating system;

The systems utilize TDP-05 display terminals (KFKI produced) (4-6 pieces), floppy disks (4 pieces), a matrix and a line printer. These devices can be extended by cartridge disks and magnetic tape units.

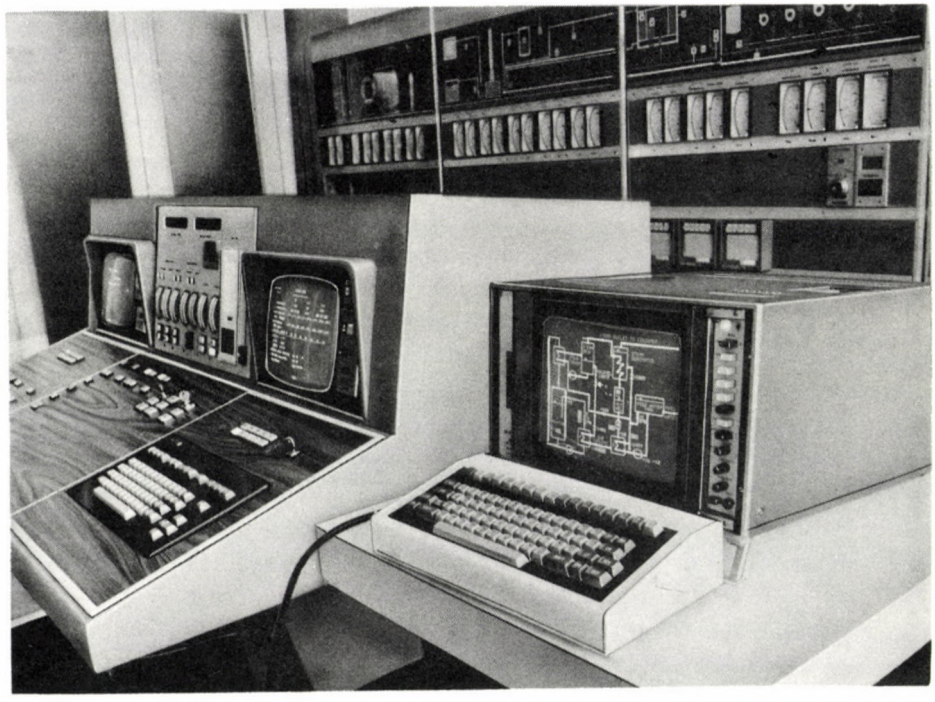


Fig. 5

Application of the intelligent colour display at the nuclear reactor of the Institute

In 1978 an agreement between our Institute and the Telecommunication Engineering Cooperative organization was signed concerning the future production of the TPA-L type small computers by the latter organization.

PUBLICATIONS

1. G. AMBRÓZY, J. MISKOLCI, F. VAJDA: Small computer built with INTEL bit-sliced microprocessor system. Proc. MIMI'78 Zürich, Switzerland, Acta Press Anaheim, Calgary, Zürich, 1978. p. 3

2. I. ERÉNYI: Development tools for designing and debugging microprocessor based systems. ibid. p. 58

3. I. RÉNYI, T.L. SÁNDOR, F. VAJDA: Effects of microprocessor techniques on display terminal architecture. Proc. Electronic Displays '78 Conf., London, England 1978, Session No. 4, p. 30

TECHNOLOGICAL RESEARCH

J. Bagyinszky, M. Bak, Margit Benkő, Gy. Binder, I. Borsos, B. Forgách, E. Gaál, A. Hegedüs, L. Honthy, A. Jávor, A. Karacs, Á. Révész, Zs. Szabó, A. Téby, P. Tóbiás

Last year saw the installation of the ADMAP-2 drawing machine for the computer aided plotting of printed circuits. Apart from this we began the reconstruction of a more satisfactory light spot projector which can be applied in a larger field than previously.

The technology of electroless permalloy deposition was developed for the well defined metal covering production of bubble memory chips. Work is now going on to determine the photoresist compatibility, as well as to determine the finest pattern size.

In integrated circuit technology we began the design of a laboratory for the preparation and inspecting of the masks necessary for the production of integrated circuits and we have begun purchasing the technical equipment needed for this laboratory. The electroless technology aided preparation of the chrome layer of the masks is also being developed.

With the help of the LOBSTER program system, simulation tests were carried out on the inner structure of the different LSI circuits designed and investigated in the Institute. Similarly, we have modelled systems of our own design and built of SSI and MSI elements.

It was considered necessary to extend the element set of the simulation system: this was done with the special MOS elements necessary for LSI modelling, and on the other hand with the models of further MSI elements. Within the framework of a scientific cooperation we implemented

the LOBSTER system in the Cybernetic Institute of the Ukrainian National Academy as well as in the Computing Centre of the National Planning Office of Hungary.

The FROG program system was worked out for the mask design of microelectronic - primarily for bubble memory - systems. This program system has also been used for solving actual problems (both in Hungary and in Bulgaria).

Within the framework of the cooperation with the Technical University of Delft, The Netherlands, the high-level mask drawing program system named MASKER was adapted to work on our ES 1040 computer.

PUBLICATION

1. A. JÁVOR: A representation of fuzzyness in discrete simulation. Problems of Control and Information Theory 7, 111 (1978)

FOREIGN RELATIONS

LECTURES BY VISITING SCIENTISTS

H. Schmid	(General Electric, Binghamton, N.Y., USA) Monolithic processing hardware - An overview
B.V. Fefilov	(Joint Institute for Nuclear Research, Dubna, USSR) The U-400 accelerator measuring-control equipment
I. Kolpakov	(Joint Institute for Nuclear Research, Dubna, USSR) Design of big CAMAC systems

STAFF MEMBERS ON STUDY TOURS

M. Zsenei	Joint Institute for Nuclear Research, Dubna, USSR	6 years
G. Kalmár	Joint Institute for Nuclear Research, Dubna, USSR	4 years
I. Miller	Joint Institute for Nuclear Research, Dubna, USSR	4 years
T. Keresztfalvi	Joint Institute for Nuclear Research, Dubna, USSR	5 years
F. Poysl	Joint Institute for Nuclear Research, Dubna, USSR	3 years

J. Harangozó	Joint Institute for Nuclear Research, Dubna, USSR	5 years
E. Serf	Joint Institute for Nuclear Research, Dubna, USSR	4 years
T. Nemes	Joint Institute for Nuclear Research, Dubna, USSR	3 years
Gy. Szabó	Joint Institute for Nuclear Research, Dubna, USSR	3 years
P. Farkas	Joint Institute for Nuclear Research, Dubna, USSR	3 years
I. Haintz	Service Station, Berlin, GDR	4 years
P. Kárpáti	Service Station, Bombay, India	4 years
E. Kindzierszky	Interatominstruments, Warsaw, Poland	4 years
Gy. Stancsich	Daresbury Laboratories, Daresbury, England	3 months

GUEST SCIENTISTS AND FELLOWS

Nguen hak Tchi	Joint Institute for Nuclear Research, Dubna, USSR	1 month

THESIS

J. Harangozó	Formal representation of computer network protocols. (Thesis for the academic degree of Candidate of Technical Sciences)

DEVELOPMENT ENGINEERING

RESULTS

MEDICAL DIAGNOSTIC QUESTIONNAIRE FOR SCREENING CARDIOPULMONARY DISEASES AND RELATED NEUROSES

*A. B. Nagy, K. Ghyczy**

A self-administered medical diagnostic questionnaire (MDQ) helps in selecting the appropriate examination methods used in the laboratory for electrocardiology, mechanocardiography and ergometry of the MÁV Therapeutical Institute for Lung Diseases.

The aim in formulating the questionnaire was to introduce a clinical screening procedure immediately preceding or simultaneous with the medical examination in order to increase the efficiency of the latter. The principle is to collect, evaluate and subsequently to group the patient's data into diagnostic categories by a means which is independent of the physician responsible for the diagnosis.

The MDQ contains 117 items worded as statements. If the statement is relevant to the particular patient he has two possibilities to choose from in replying to the items. There are two branchings and three items with several possible replies so that the patient has to make a choice from at least 67 questions.

The validity of the MDQ has been checked by comparing the computer diagnosis with the medical findings. The latter are inferred both from the data of the medical history and from the results of medical tests. This comparison permits the most important qualifying parameters of the MDQ, i.e. its sensitivity and specificity, to be evaluated.

The "diagnostic-automat" is actually the KFKI TPA/i type computer, as operated with a program written in Focal language.

The program is called ODS. It works in the learning phase as a data processor and calculates the relative frequency of the replies selected from MDQs of medically diagnosed patients. As a result of the calcula-

*MÁV Therapeutical Institute for Lung Diseases, Budapest

tion it assigns a diagnostic weight to each item. The weights are given by 117 numbers which constitute the diagnostic profile.

In the decision phase the ODS works as a decision-making algorithm. In pattern recognition terminology this means that it works as a "Committee Machine". The algorithm fits the individual "yes" replies of the input MDQ to the diagnostic profile of the category in question.

The most interesting results of the validation procedure carried out for more than 400 patients are given in *Table I.*

Table I

Diagnostic category	*Sensitivity*	*Specificity*
Pulmonological	*89 %*	*98 %*
Cardiological	*95 %*	*86 %*
Hypertension	*82 %*	*87 %*
Neurotic	*81 %*	*92 %*
Other disease	*87 %*	*88 %*
Healthy	*93 %*	*95 %*

ELECTRONIC UNITS FOR LABORATORY SUPERCONDUCTING MAGNETIC SYSTEMS

V. Halász, K. Mórocz, J. Tombor, Gy. Turányi

In cooperation with the I.V. Kurchatov Institute of Atomic Energy, Moscow, USSR, our group is concerned with developing units for laboratory superconducting magnetic systems. The instruments below, which form a complex measuring system but can also be used independently, were completed in 1978:

- Low temperature thermometer operating with carbon resistance sensor
- Reference current source
- Universal signal channel switch

The main features of the low temperature thermometer (*Fig. 1*) are:

- Dissipated power on the sensor less than 1 pW
- Measuring range: 0.1 to 5 K; 5 to 30 K
- Numerical four decade temperature reading
- 220 Ohm, 0.125 W Alain-Bradley carbon resistor
- Direct K reading possibility due to built-in arithmetic for the linearizing of characteristics

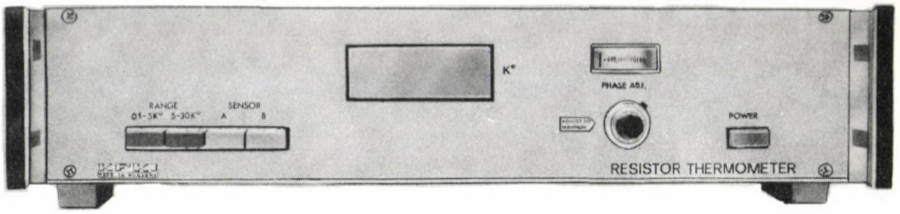


Fig. 1

Thermometer for measuring low temperatures

PUBLICATIONS

1. J. TOMBOR, GY. TURÁNYI: Electronic measuring and control devices of superconducting magnetic systems. In: Catalogue of the Exhibition of Superconducting Magnetic Systems, Moscow, USSR, (1978)

2. J. BOLYKY, A. SZABÓ: Design principles of a new computer aided ECG analysis program. Proc. DECUS, Copenhagen, Denmark, p. 387 (1978)

3. J. BOLYKY, P. KÁLMÁN*, Gy. KOZMANN, O. PÁRTOS*, F. SZLÁVIK, GY. VIGYÁZÓ**, L. VOITH**: A computer analysis of the first heart sound in individuals with normal heart. Acta Med. Hung. 34, 27 (1978)

4. S. BÉKÉSI, GY. KOZMANN: Body surface mapping of electro-mechanical cardiac fields. Biosignal '78, Brno, Czechoslovakia, p. 50 (1978)

5. A. B.NAGY, T. WOLF: Clustering method for mixed-type /continuous and binary/ samples. ibid. p. 24

6. A. B.NAGY: Diagnosing ischaemic heart diseases by respiratory sinus arrhythmia produced by prescribed respiration. Biosigma '78, Paris, France, p. 394 (1978)

7. GY. KOZMANN, Z. ANTALÓCZY***, I. BUKOSZA***, Á. SZÉKELY***: New electrocardiological infarct criteria in the presence of left bundle branch block. Proc. 5th Int. Congr. Electrocardiology, Pitman Medical, London, (in press)(1978)

FOREIGN RELATIONS

STAFF MEMBERS ON STUDY TOURS

J. Németh	Joint Institute for Nuclear Research Dubna, USSR	2 years

*"Tétényi" Hospital, Budapest
**National Institute of Physical Education and Sports, Budapest
***Postgraduate Medical School, Budapest

RESULTS

EQUIPMENT FOR TESTING GAS RESIDUES

P. Beron, B. Egri, L. Házkötő, L. Jerzsabek, A. Rényi, A. Simon, J. Török**

This equipment is suitable for a laboratory investigation of phase equilibrium between natural gas and its residues. From the equilibrium--phase test of the samples conclusions can be drawn regarding exploitability, i.e. the economic viability.

The main parts of the equipment *(Figs. 1 and 2)* are as follows:

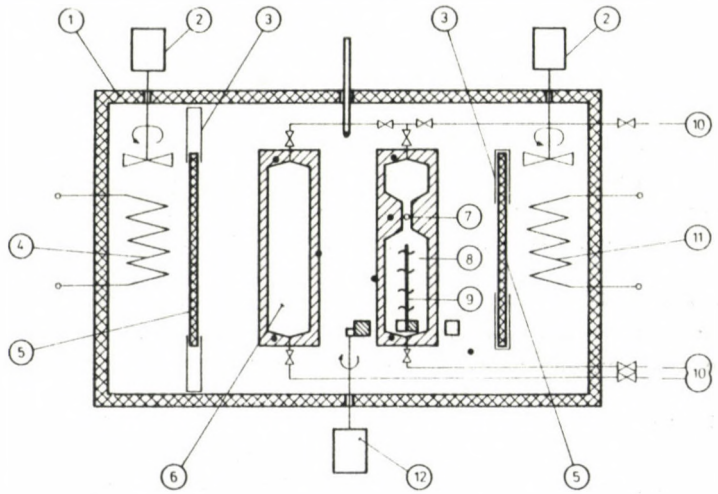


Fig. 1

Schematic plan of gas-residue testing equipment

1 - thermostat case; 2 - ventilator; 3 - gap lock; 4 - heater; 5 - screening wall; 6 - auxiliary cell; 7 - sighting window; 8 - measuring cell; 9 - magnetic stirrer; 10 - high pressure valves and ducts; 11 - cooling coil; 12 - motor unit for stirrer; • - temperature sensors

*Industrial Research Laboratory for Mining of Oil and Natural Gas, Budapest

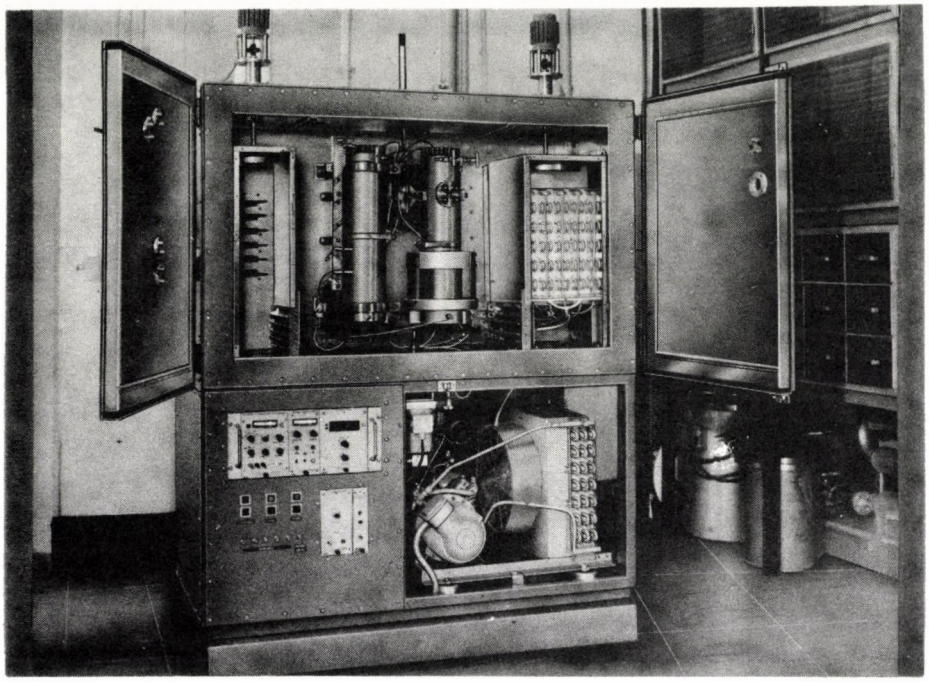


Fig. 2
Equipment for testing gas residues

MEASURING CELL WITH SIGHTING WINDOW

Divided-space cell, the phase limit can be watched through a sighting window. A stirrer driven from outside is used so that the equilibrium between the phases takes place rapidly.

AUXILIARY CELL

It serves to increase the available volume; it is similar to the measuring cell except that it has no sighting window and no stirrer.

THERMOSTAT

This is designed to set a specific temperature. It includes a heating and a cooling unit. The air-current, in the internal space, is ensured by ventilation.

The pressure of the samples to be investigated can be produced using a mercury pump.

SPECIFICATION

Temperature range of testing	-20 °C to + 180 °C
Max. pressure of testing	58860 kPa
Volume of the measuring cell	1500 cm^3
Volume of the auxiliary cell	1800 cm^3

The cells are made of corrosion resistant steel.

PASCAL TYPE NM-226 PNEUMATIC SAMPLE CHANGER WITH 64- OR 32-CUP SAMPLE PLATES

B. Bak, I. Bartucz, F. Engard

The PASCAL pneumatic sample changer *(Fig. 3)* performs the moving, sampling, stirring of 5 or 10 ml volume samples prepared for instrumental analysis by, for example, photometer, flame photometer, AA spectro-photometer, pH meter, etc. The equipment is suitable for general or special (agricultural, clinical, etc.) chemistry laboratories. The single program steps are stored in ROM-s. The selection of the required program takes place by means of up-to-date sensor switches. It has a built-in code-reader for electronic sample identification. The control of the operational steps is solved by means of electro-pneumatic control elements for great reliability; e.g. in the case of electric and/or air-power shortage, stand-by status is realized automatically.

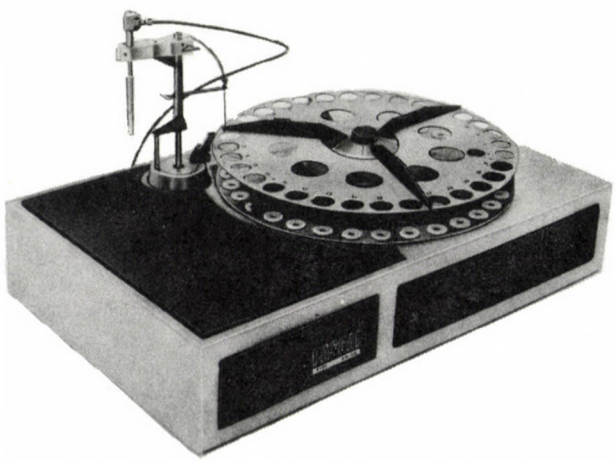


Fig. 3

The PASCAL pneumatic sample changer with 64- or 32-cup sample plates

Modes of operation:

- external controlled operation: the start of every single step is initiated by an external unit,
- continuous operation: after a definite delay the next stepping signal is automatically generated.

TECHNICAL SPECIFICATIONS

Sample size	Sample capacity	Sample plates
5 ml	256	4x64 positions, 0-255 cont. code
10 ml	256	8x32 positions, 0-255 cont. code

Determination of the proper step size takes place automatically when the sample plate is put into its position.

Sampling frequency:	max. 240 samples/hour
Sample identification code output:	8 bit binary (TTL)
Mains requirements	
electrical:	220 V $^{+10\ \%}_{-15\ \%}$; 50 Hz
air:	500 $\pm$ 100 kPa
Dimensions:	420x670x140 mm
Weight:	$\sim$400 N

SOME NEW ELEMENTS OF THE KFKI OPTOMECHANICAL SYSTEM

Gy. Eisler, F. Fekete, T. Lippényi, G. Steiner

The first two elements of the KFKI optomechanical system were described in the "Yearbook '77". Some further elements were developed in 1978, so now positioning systems for optics of optional degrees of freedom can be built in both interferometric and normal grades of accuracy with the aid of different, standardized adapters.

The specifications of the elements are as follows:

Angular positioner of interferometric precision *(Fig. 4)*:

Range:	0 - 360° (coarse) $\pm$ 1° (fine)
Measuring range:	$\pm$ 10'
Scale resolution:	$\pm$ 3"
Reproducibility:	1"
Dimensions:	95x120x40 mm

Clear aperture:	∅ 40 mm
Load capacity:	100 N
Weight:	5 N

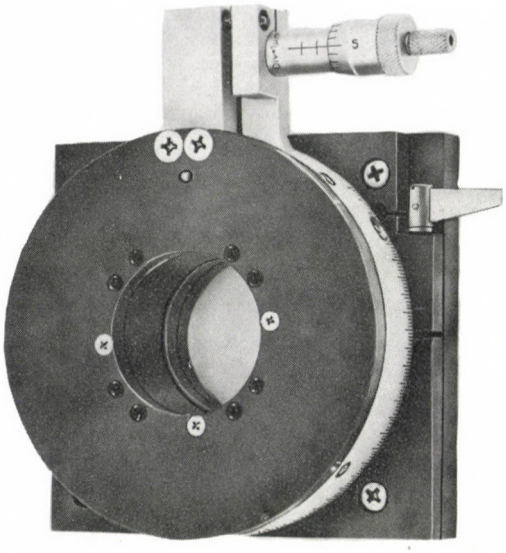


Fig. 4
Angular positioner of interferometric precision

Gimbal mount *(Fig. 5)*:

Range:	$\pm 3^{\circ}$
Scale resolution:	
normal accuracy:	30"
interferometric accuracy:	3"
Reproducibility:	1"
Dimensions:	145x142x72 mm
Clear aperture:	∅ 60 mm
Load capacity:	5 N
Weight:	10 N

Step-motorized translator of great load capacity *(Fig. 6)*:

Range:	50 mm
Scale resolution:	2 µm
Resolution with stepping motor	5 µm
Reproducibility:	2 µm
Dimensions:	235x120x70 mm
Load capacity:	500 N
Weight:	20 N

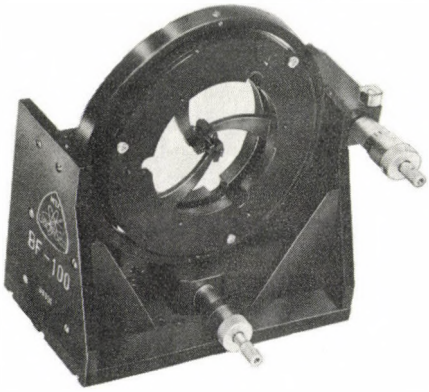
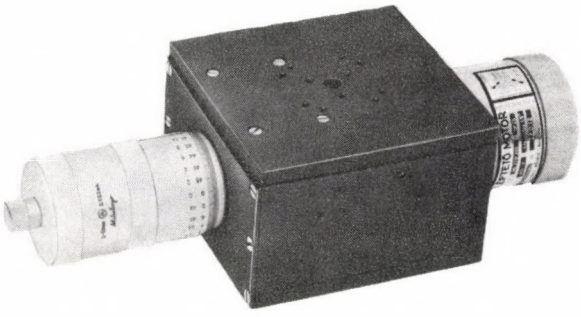


Fig. 5
Gimbal mount

Fig. 6
Step-motorized translator of great load capacity



Specifications of the electronic control unit:

- It can be controlled by external apparatus.
- Speed (steps per second) in three ranges: 0.4 ÷ 400 Hz

I.	0.4 ÷ 4 Hz	continuous control
II.	4 ÷ 40 Hz	
III.	40 ÷ 400 Hz	

- Mode of operation is step by step or continuous, after selection of the direction of rotation.
- Signal of the end position.
- Up to 9999 programable steps.
- One or three phase induction, if needed.

PUBLICATIONS

1. M.F. RÁNKY, B. EGRI: Some aspects of point to-point analysis of high--speed film recordings. Research Film 9, 394 (1978)

2. M.F. RÁNKY: Diagnostics of gear assembly - a new approach using impact analysis. I.S.V.R. Technical Report No.100, Southampton, (1978)

3. M.F. RÁNKY, Gy. SEBESTYÉN*, Á. FÁY**: Cavity vortex shedding behind bodies. Polyphase flow in turbo-machinery. A.S.M.E., San Francisco, California, USA, p. 291 (1978)

FOREIGN RELATIONS

STAFF MEMBERS ON STUDY TOURS

M. Szalók	Joint Institute for Nuclear Research, Dubna, USSR	4 years
E. Kiss	Joint Institute for Nuclear Research, Dubna, USSR	2 years
M.F. RÁNKY	Institute of Sound and Vibration Research, University of Southampton, Southampton, England	4 months

*Technical University, Budapest
**Ganz Mávag Works, Budapest

INDEX TO MEMBERS OF THE SCIENTIFIC STAFF

* Ch: Chart of Organization

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Kiadja a MTA Központi Fizikai Kutató Intézet
Felelős kiadó: Szabó Ferenc főigazgató
Műszaki szerkesztő: Marosszéki Kálmánné
Engedélyszám: 45764 Törzsszám: 79-607
Példányszám: 1250
Készült a KFKI sokszorosító üzemében
Budapest, 1979