annual report 1977

institut max von laue · paul langevin
156 X · 38042 grenoble cedex · france tél.(76) 97·41·11

Application for use of I.L.L. facilities.

All research proposals should be sent to the Office of the Scientific Secretary :

B. MAIER
Institut Laue-Langevin
156X
38042 Grenoble Cedex
France

Tél. (76) 97.41.11 poste 82.44

Appropriate forms are obtainable on request from this office.
The closing dates for acceptance of applications are as follows :
August 31 and February 15.

All proposals are submitted to the Scientific Council for approval.

The general regulations of the ILL and all information necessary for carrying out an experiment at the HFR will be sent to the applicants upon acceptance of their proposals.

It should be noted that the ILL in general provides free of charge the neutron beams and standard measuring equipment, such as existing spectrometers, counters, standard cryostats and shielding equipment. Other special equipment, in particular samples, must be provided by the user.

The ILL pays for travel and subsistence of one experimentalist per experiment for personnel from laboratories of the 3 member countries.

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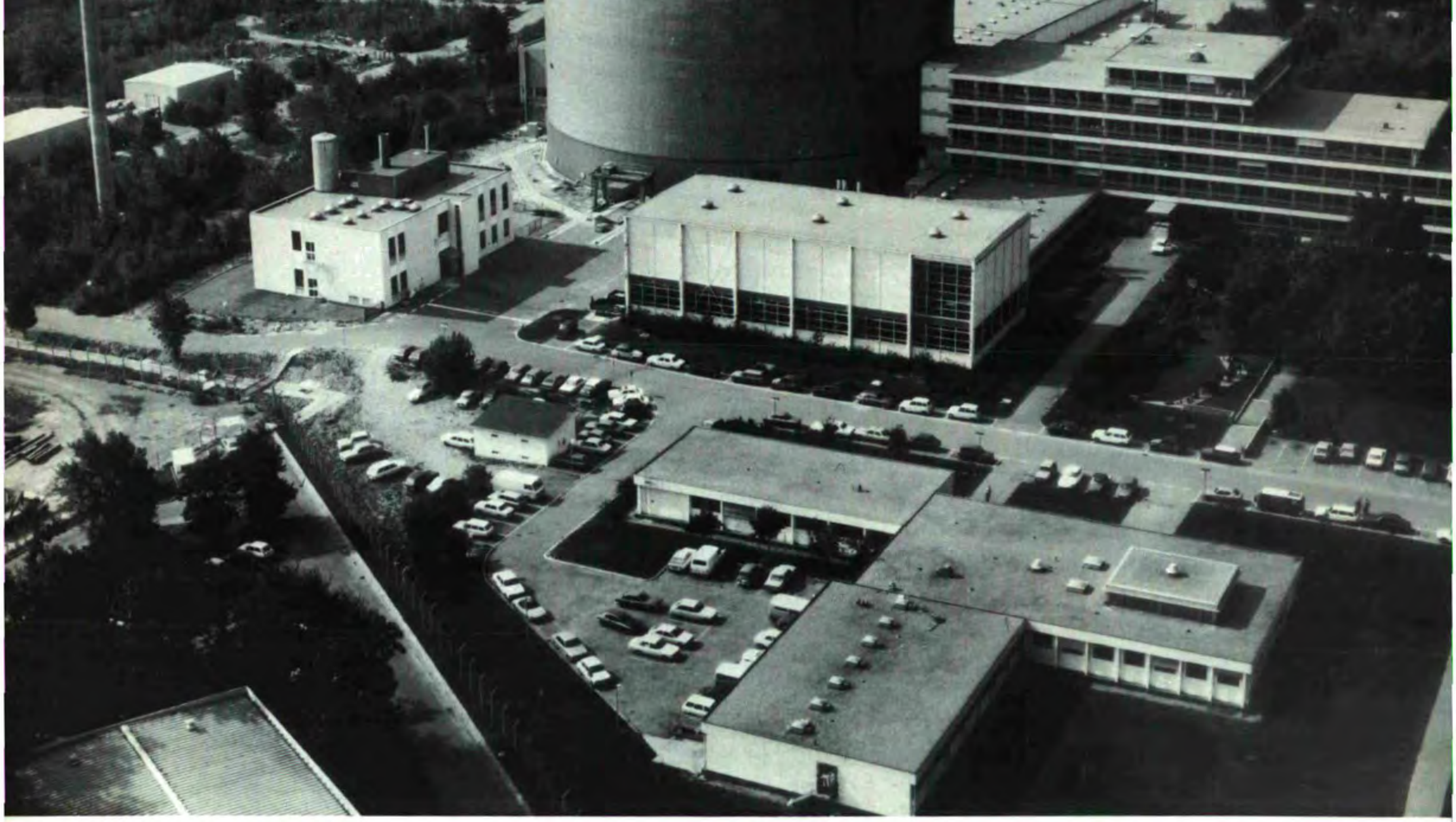

Aerial view of the ILL looking towards the river Drac

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external organisation of the institut laue·langevin 1977

associates of the institut

great britain	france	west germany
SCIENCE RESEARCH COUNCIL (SRC)	COMMISSARIAT A L'ENERGIE ATOMIQUE (CEA) CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS)	GESELLSCHAFT FÜR KERNFORSCHUNG KARLSRUHE (GfK) *

steering committee

(at its last meeting)

- L. Hobbis
- J. Enderby
- J. Paton
- M. Robins - Vice-Chairman

- J. Winter - (CNRS)
- P. Creyssel - (CNRS) Chairman
- J. Horowitz - (CEA)
- M. Pascal - (CEA)

- L. Genzel
- W. Hofbauer
- W. Schött
- W. Klose

audit commission

- R. Mead
- D. Barr

- J. Gouzien
- G. Auffret

- W. Becker
- W. Riess

*With effect from 1.1.78 Kernforschungszentrum Karlsruhe(KFK)

scientific council

(at its last meeting)

- E. Bertaut — CNRS Grenoble
- H. Bilz — MPI Stuttgart
- E. Bradbury — Portsmouth Polytechnic
- D. Cribier — CEN Saclay
- J.-P. Ebel — Strasbourg
- R. Elliott — Univ. Oxford
- J. Enderby — Univ. Bristol
- E. Fischer — Univ. Mainz
- A. Guinier — Univ. Paris Sud
- W. Hoppe — MPI Martinsried
- P. Kienle — TU München
- A. Leadbetter — Univ. Exeter
- H. Maier-Leibnitz — Dt. Forschungsgemeinsch. Bonn
- E. Mitchell — Univ. Reading
- P. Rigny — CEN Saclay
- H. Stiller — KFA Jülich
- T. Waddington — Univ. Durham
- J. White — ILL - Chairman
- J. Yoccoz — IN2P3, Paris

SUBCOMMITTEES OF THE SCIENTIFIC COUNCIL

Nuclear Physics	Excitations	Crystal Physics and magnetism	Crystal Structure détermination	Liquids	Imperfections	Biochemistry	Phys. Chemistry	Instruments
Armbruster	Coles	Bacon	**Bertaut**	Brenig	**Elliott**	Blow	Ballard	Farnoux
Bouchiat	**Comes**	**Bertaut**	Dachs	Cowley	Haasen	**Bradbury**	**Benoit**	Gläser
Faissner	Dransfield	Dachs	Fender	**Guinier**	Quere	Holmes	Bienfait	Mitchell
Gizon	Gläser	Goodenough	Jagodzinski	Hansen	Schmatz	Hoppe	Ertl	Roult
Kienle	Schofield	Korekawa	Korekawa	Hertz	Souletie	Luzzati	Fischer	Schmatz
Leroux	Villain	Pawley	Livage	Levelut	Zittartz	North	Higgins	Windsor
Sandars		Will	Milledge	Mitchell		Parello	Leadbetter	
Smith			Pawley	Powles		Sturmann	Monnerie	
			Rees	Ruppersberg		Witz	Ottewil	
			von Schnering				Renouprez	
							Rivail	
							Schelten	
							Stiller	
							Thomas	
							Waddington	
							Wegner	
							Weiss	

internal organisation of the institut laue-langevin at 1.12.77

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J. White - Director
J. Joffrin - Co-Director
T. Springer - Co-Director

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T. von Egidy
B. Jacrot
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MANAGEMENT BOARD

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T. Springer
J. White

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J. Loveluck

COLLEGE 3 : FUNDAMENTAL AND NUCLEAR PHYSICS
G. Siegert

COLLEGE 4 : EXCITATIONS
W. Stirling

COLLEGE 5 : STRUCTURES
F. Tasset

COLLEGE 6 : LIQUIDS, GASES AND AMORPHOUS MATERIALS
J. Copley

COLLEGE 7 : IMPERFECTIONS
A. Murani

COLLEGE 8 : STRUCTURAL BIOLOGY
P. Timmins

COLLEGE 9 : CHEMISTRY
S. Howells

INSTRUMENT GROUPS

3 AXIS SPECTROMETERS
(B. Dorner · C. Escribe)

INSTRUMENTS FOR FUNDAMENTAL AND NUCLEAR PHYSICS
(T. v. Egidy · G. Siegert)

DIFFRACTOMETERS
(J. Brown · K. Ziebeck)

DIFFUSE SCATTERING AND TIME OF FLIGHT SPECTROMETERS
(B. Jacrot · A. Heidemann/ R. Scherm)

MONOCHROMATORS
(A. Freund)

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M. Jacquemain

REACTOR OPERATION AND INSTRUMENT SUPPORT DEPARTMENT
Y. Droulers

COMPUTING AND ELECTRONICS DEPARTMENT
D. Rimmer

ADMINISTRATION
A. Plattenteich

SCIENTIFIC SECRETARIAT AND LIBRARY

B. Maier

PROJECT OFFICE

J. Faudou

The institut max von laue·paul langevin

The Institut Max von Laue - Paul Langevin (ILL) at Grenoble was formally founded in January 1967, with the signature of an intergovernmental convention between France and the Federal Republic of Germany. The aim was to provide the scientific comunity of the affiliated countries with a unique neutron beam facility applicable in fields such as the physics of condensed matter, chemistry, biology, nuclear physics and materials sciences. The construction of the Institut and its high flux reactor was undertaken as a joint French-German project, with a total capital investment of 335 million FF. The reactor went critical in August 1971 and reached its full power of 57 MW for first time in December 1971. The year 1972 saw the start-up of the cold and hot sources, the first instruments and the beginning of the experimental programme. On January 1, 1973, the United Kingdom joined the Institut as a third equal partner, contributing its share to the total capital investment. The corresponding intergovernmental convention was formally signed in July 1974 by the pertinent ministers from the three affiliated countries.

The ILL is a non-trading company under French civil law. The three countries are represented by the following Associates :

— Kernforschungszentrum Karlsruhe GmbH, Germany (formerly GfK)
— Centre National de la Recherche Scientifique, France
— Commissariat à l'Energie Atomique, France
— Science Research Council, United Kingdom.

These Associates are represented on a Steering Committee, which establishes the general rules of the management of the ILL. The Institut is headed by a Director and two Assistant Directors, all with a five year tenure, the former to be nominated alternately by the German and the British Associate, the other two by the remaining Associates. A Scientific Council, nominated by the Associates, advises the Directors on the scientific programme and on practical aspects relating to its operation.

The scientific user's community of the ILL is represented in 8 Subcommittees of the Scientific Council, which meet twice a year to select those research proposals which are to be carried out at the neutron beam facilities of the ILL. A further Subcommittee of the Scientific Council deals with questions of instrumentation, serving as a discussion platform between the ILL and its external users.

The purpose of the ILL thus differs fundamentally from most other research institutes. It is a central facility created so that chemistry, physics, biology and metallurgy specialists from laboratories in the partner countries can use the unique power of neutron techniques to broaden the attack on their problems. Designing and operating instruments and helping the visiting users to carry out their experiments is thus the principal task of the Institute's own scientists. The experimental use of the instruments by ILL staff is subject to the same approval system as their use by external teams.

EVENTS IN 1977

A limited open day for families and friends of ILL staff was held on Saturday 14 May. In the photograph above the Reactor Control Room is being explained to a group of visitors accompanied by Dr. J. White, the Director.

On Thursday 7 July the ILL was visited by Sir Fred Stewart, the Chairman of the Advisory Council for the Research Councils in the United Kingdom. The picture below shows (from left to right) Mr. N.T. Hardyman and Mr. W.O. Ulrich of the Department of Education and Science, Sir Fred Stewart, Professor J.L. Jinks of Birmingham University and members of ILL staff.

introduction

During 1977, a review of the programme and potentialities of the Institut was begun. This was prompted by the growing awareness of a need for some changes in the style of our user oriented programme, by the acute limitation of money for investment arising from uncertainty in the extent of currency inflation, and by the major work of the year, undertaken in close collaboration with the Scientific Council, of defining the longterm scientific prospects for the Institut and a renewal programme, second souffle, for maintaining its scientific potential.

The Institut Laue-Langevin exists to provide scientists in the three member countries with intense neutron beams and with special high resolution neutron beam instruments which would be otherwise unavailable for studies in physics, chemistry and biology. This service aspect of the ILL's programme has grown steadily since the first operation of the reactor in 1972, showing only now a tendency to saturate (Figure 1) as the number of beam holes is saturated by instruments, and possibly also in response to the new policies of giving fewer and longer time allocations for experiments since October 1976. In 1977 this programme attracted 1069 visitors from 165 different laboratories or universities in 23 countries. It is a tribute to Professor Mössbauer, who left the Institut in

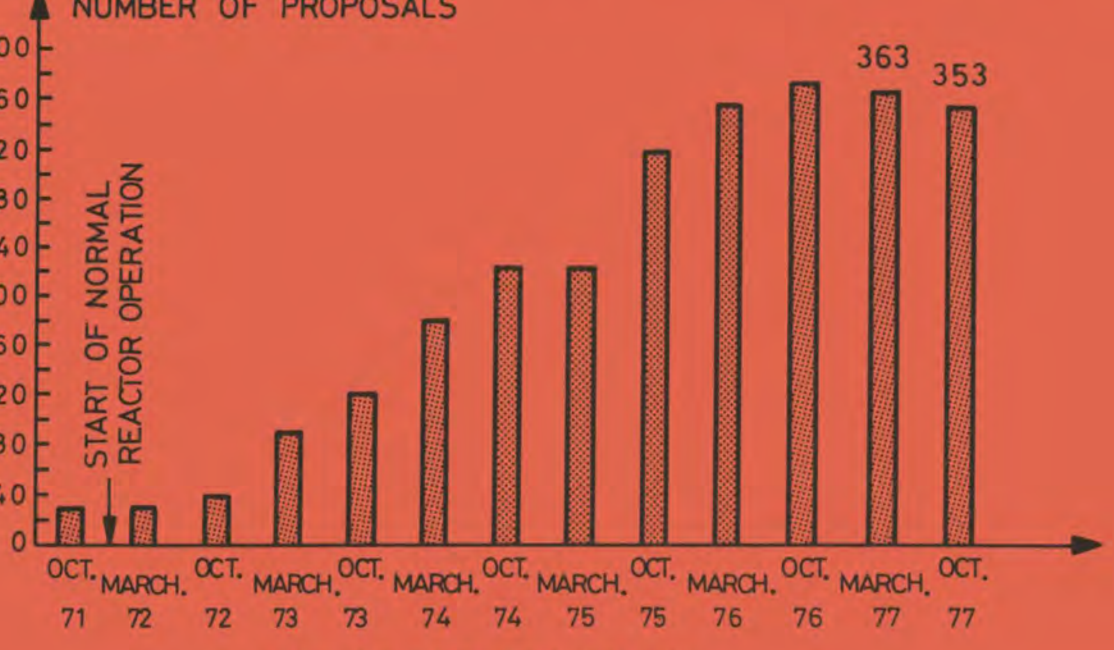


Figure 1. - Development of the number of experimental proposals submitted to the Scientific Council.

February 1977, and to the ILL staff, that such a diverse and healthy programme has been established. An analysis of the programme by subject area is given in the Table.

EXPERIMENTAL PROGRAMME - JANUARY 1st TO DECEMBER 31st 1977

MAJOR AREAS OF SCIENTIFIC INTEREST	BIOLOGY	CHEMISTRY	CRYSTAL STRUCTURE	MAGNETIC STRUCTURE	LIQUIDS AND AMORPHOUS	DIFFUSE SCATTERING	PHONONS	MAGNETIC EXCITATIONS	PHASE TRANSITIONS	NUCLEAR PHYSICS	SCIENTIFIC TEST AND FEASIBILITY EXPERIMENTS	TOTAL
INSTRUMENT/ DAYS	242	408	676	617	523	493	354	230	502	827	356	5 228
NUMBER OF EXPERIMENTS	59	83	70	72	63	78	33	26	55	68	104	711
NUMBER OF INSTRUMENTS INVOLVED	6	8	11	10	14	14	6	5	13	6	18	30
MONOCHROMATOR AND INSTRUMENT DEVELOPMENT EXPERIMENTS (INCL. D13)							INSTRUMENT/DAYS NUMBER OF EXPERIMENTS					549 165

The statistics of growth in the programme of measurements hide the important fact that most experiments performed during the last two to three years have been limited by the amount of time available to do them. In the first phase of the exploitation of the ILL instruments, the response of the Scientific Council's sub-committees to the great overdemand for instrument time was to give many promising proposals a chance to establish themselves by some neutron measurements, followed later on by continuation studies. This policy has not only allowed a number of clear successes to be achieved, such as the establishment of the new upper limit on the electric dipole moment of the neutron, the dynamics of some pseudo one-dimensional metals and the structure and dynamics of polymers and biological macromolecular assemblies, but it has also allowed a basis of choice to be laid down, upon which the scientific policy of the ILL for the next few years can operate.

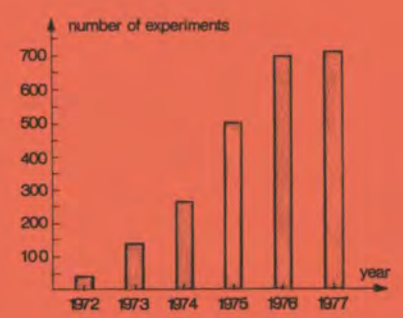


Fig. 2 a) - Development of the number of experiments carried out.

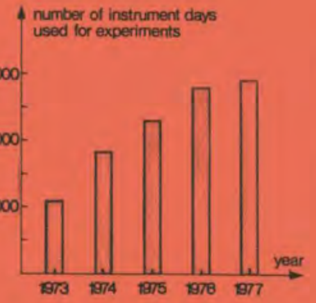


Fig. 2 b) - Development of the number of instrument days.

Fig. 2 c) - Development of the number of days per experiment carried out.

The number of experiments done at the ILL, and the number of instrument days used for these experiments during 1977, are compared in Figures 2a, b and c, which also illustrate the tendency since 1975 for the number of days per experiment to drop from about 9 to about 7.5. Figures for earlier years are nearer to 14 days per experiment, but some of this time must be accounted for by the greater instrument failures in that period. Our intention since 1977 has been to reverse somewhat this trend and find a new balance between short-term measurements and longer term experiments in the programme. Arrangements of the schedule, and new types of technical support, will be implemented towards these ends. This must be done while recognizing the need for the users of the ILL to continue their active and diverse programmes and recognizing that there will always be the need for relatively short-term measurements using the unique instruments of the ILL, as part of wider studies made using other techniques in the home laboratories. We do not expect a drastic reduction in the number of experiments performed in the Institut in the coming years. Technical improvements like multidetectors will give increased efficiency for some instruments and better data reduction could reduce turnround times. The sub-committees of the Scientific Council have selected some experiments and areas of study for special emphasis during 1977 and the effects of this policy will be reviewed in about one year.

In order to facilitate the work of the Scientific Council and its sub-committees, some changes in structure were made. The Crystallography Sub-committee has been divided into two, with emphasis on crystal physics and magnetism, and on chemical crystal structure determination, respectively. The Physical Chemistry Sub-committee has been invested with two sub-committees, whose specific charge is to consider proposals in Polymer Science and in Surface Chemistry and Colloid Science, respectively.

The ILL also exists to develop new techniques in neutron physics leading to new types of neutron instruments. After the initial large investment in this area, beginning in 1968 and ending in about 1974, the investment for new instrument construction has been sufficient to build between two and three new instruments per year. The investment per annum, in constant (1977) francs, is shown in Figure 3. The result of the initial spike of investment was that most instruments were fully operational and scheduled for routine operation in 1975. Most of the electronics and other components were by that time many years old, at least in conception, and so it is not surprising that during 1977 progressively greater problems were encountered with a number of instruments. An investment rate equivalent to the building of about two instruments a year constitutes chronic under-investment for a collection of approximately 30 instruments, exploited so intensively and for short experiments, as they are at the ILL. 1977 also corresponded to a critical year because

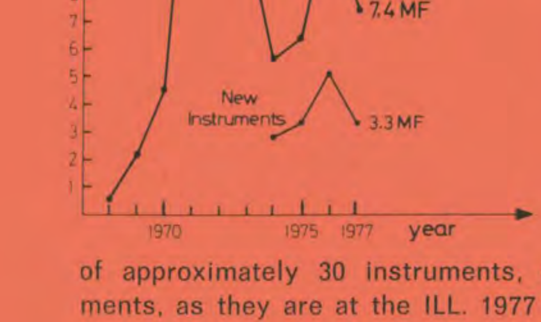


Fig. 3 - Instrument investment per year (value of money in 1977 units).

of uncertain currency inflation. The instrument investment budget came under acute pressure.

The Institut's response to these constraints was to give priority to investment in the existing instruments, keeping them in as good a state of operation as possible, and to investment for developing new underlying techniques for future new instruments (multidetectors and ultra high vacuum evaporation techniques for producing polarizing mirrors). Lower priority was given to new instrument construction so that no new instruments were started in 1977, and the polarized proton filter (D9) was shut down, even though it had worked at polarizations up to 83 %. There were also some further delays in the construction programme for the IN12 cold neutron three-axis spectrometer and the interferometer (D 18).

The third reason for the existence of the ILL is to promote work-shops and other meetings for the discussion of new neutron techniques and the application of neutron methods in hitherto untouched areas of science. During 1977 the activity of the Institut in this area was increased by holding workshops on " Neutron Diffraction and Biological Structure " (co-sponsored by the European Molecular Biology Organisation), " Monochromators and Neutron Optics ", determination of " Magnetic Structures and Spin Densities ", and on " Neutron Properties and Fundamental Physics Experiments with Neutrons ". These workshops stimulated lively discussions and were well attended in all cases, even though only limited support could be given to some participants by the Institut.

As mentioned above, the work of the instrument groups, re-organised in 1976 under the leadership of the Senior Scientists, was reinforced by making appropriate budgetary provisions. This policy will be continued in 1978 to ensure correct functioning of the instruments. Only small changes were made in the general organisation of the Institut, but one important landmark was the signature by the Director and representatives of the Unions in the ILL of a " Convention d'Entreprise " (Works Agreement) covering all aspects of work at the ILL. The final achievement of this document, after many years of work, is a credit to those members of staff who have worked on it so painstakingly, and Mr. A. Plattenteich who, as Head of Administration, saw it through to its completion.

The reactor again functioned well during 1977, operating for a total of approximately 97.4 % of the total time. During the year there was considerable uncertainty as to whether the reactor could be operated continuously due to the restrictions in the United States on the importation of spent fuel elements for reprocessing and subsequent re-export of the highly enriched uranium. Fortunately, some of these restrictions were lifted in time to avoid the interruption of operation. For this we have to thank many for their speedy consideration of our case, and their help. During the year there were no radioactivity incidents, nor did any of the staff receive more than the permitted radiation dose.

An innovation in connection with the tenth anniversary of the foundation of the Institut and the fifth anniversary of the first operation of the reactor was the day of information for the International Press, held in April 1977, and the open day at the Institut for members of the Institut and members of the public, held in May 1977. Both events were widely appreciated and it is hoped to repeat them at regular intervals as part of the duty of the Institut to the neighbourhood and the member countries.

The system 1070, PDP-10 central computer at the Institut is now working at near to full capacity, but a proposed increase in the processor could not be accomodated in the budget of 1977. The question of the replacement of the central computer is becoming more urgent and the most likely date for replacement looks to be 1980. This problem is being discussed within the context of the renewal programme to ensure integration of the proposals for the central computer with those of the hierarchy of computers suggested there for interactive data reduction. Irrespective of the decisions taken for the second souffle, the replacement must be made and the first meetings to this end have been held.

Both the PDP 1134 front end computers and the 1155 central concentrator for the NICOLE replacement were delivered in 1977 and the process of changing instruments over from the old NICOLE to the new system has started. The work is expected to be finished in autumn 1978. The concentrator is, meanwhile, being used for the development of data reduction programs, which will become available to the instruments as they are connected to it. During 1977 the Institut introduced a second line of process computers, based on the SEMS (France) SOLAR series, by the purchase of two computers intended for IN12 and D1B. It is expected these will be operating in mid-1978. The CARINE system, though operating with relatively few break-downs when not disturbed, is still the cause of great delays in the instrument operation. The progressive separation of instruments from CARINE is a matter of priority in the next few years to speed up data collection.

Long-Term Prospects for the Institut and Renewal Programme

When the Institut Laue-Langevin was established by charter on the 19 January 1967, and when this charter was amended for the accession of the British partner on the 1 January 1973, it was foressen that the earliest date on which any one of the partners could withdraw from the Asosciation would be 1 January 1982, after having given written advice of this at least two years before. In order to determine their attitude to the long-term continuation of the Institut, in view of its success, the Associates requested studies to show :

1) for how long the reactor could be expected to perform adequately and what major investments would be required to ensure its satisfactory operation.
2) what are the long-term prospects for good science using neutron beams such as those provided by the reactor ; and
3) what needs to be done in the way of a renewal programme to maintain the potential for good science using the reactor.

The first of these problems was studied in detail by an external commission of experts, in conjunction with an in-house working group, which produced its report in March 1977. The burden of this report was to suggest that the reactor would have a likely life-time of 10-15 years after the date of 1982, without significant rebuilding. The second part of the report was produced in close collaboration with the Scientific Council of the Institut. Each sub-committee undertook to prepare a future prospects report for its own area and these were finally collated and edited in the Institut for submission to the Scientific Council in March

1977. At the same time an outline of the likely needs for re-investment based upon the deficiencies in investment over the past few years, and the areas of greatest weakness in the instrument sector, were prepared, and these three documents formed the basis of the draft report on the future prospect submitted to the Steering Committee of the Institut in May 1977.

As a result of this submission, the Institut was asked to further define the requirements of a renewal programme, second souffle, and during the summer of 1977 many working groups were active on this, defining new instruments, new sources, and new types of neutron technology. A final document "Report on Long-Term Prospects for the Institut Max von Laue - Paul Langevin, Grenoble, France" was submitted to the Steering Committee of the Institut on 2 December 1977.

In general terms, the renewal programme amounts to a replacement of many instruments based on outmoded technology, and whose function overlaps extensively with instruments at medium flux reactor stations or pulse sources in the three countries. The programme foresees a net small increase (of the order of 5-10 %) in the number of staff and in the net operating costs of the Institut, as a result of a few supplementary instruments. Some general principles foreseen for the implementation of the renewal programme are :

1) No compromises would be made in the neutron intensities delivered to new instruments constructed. In general we would prefer to see one very high flux instrument rather than two instruments of rather lower flux sharing a beam, though this may reduce somewhat the range of instruments available.
2) Efforts will be made to allow the experimenter to interact more strongly with his experiment, while it is in progress, by on-line data reduction. This will allow chance observations during an experiment to be followed up in the same run, even under conditions of a service-oriented institute, while making data collection more efficient in the more straightforward experiments.
3) Complementarity will be systematically developed between the instruments and sources available at the Institut and those available or becoming available at the medium flux stations in the three countries and at the pulse source foreseen in the United Kingdom. A strong possibility is the construction of a new cold neutron source at the ILL and of a highly optimised ultra cold neutron source for fundamental and solid state physics experiments.

The report which follows gives more details of the instrument programme and of scientific work carried out at the ILL during 1977, as well as further details of technical developments and administrative activities. A second volume of this report contains reports of individual experiments carried out during the year.

J.W. WHITE
Grenoble - 16 January 1978

instrumentation

introduction

An integrated programme of improvement to the existing instruments, and of new instrument construction, was carried out in 1977. Under the financial constraints, a high priority was given to finishing instruments in the course of construction and both the ultra cold neutron source, PN5, and the spin echo spectrometer, IN11, came into operation, the first for a number of scheduled special beam experiments and the second for a series of proving experiments being done in collaboration with external groups. This series of proving tests should take about nine months and should show the best methods of operating the spin echo spectrometer. No new instrument construction was started, since, as mentioned in the Director's Report, priority was given to the development of underlying techniques and to finishing new instrument projects in hand. Even so, the completion of D18 (the interferometer) and IN12 (the cold neutron three-axis machine) will be delayed until 1978. In the case of IN12, some advantage was taken of the delay to implement a new system of three-axis drive mechanics and of interfacing electronics which may serve as a standard for future three-axis machines. The IN12 instrument will be the first three-axis machine to use the new range of Solar computers. A major technical investment was the establishment of a commission to determine and specify a modern system of mechanics, motors, electronics and computer interface suitable for controlling all shaft movements. A uniform system for both three-axis instruments and diffractometers is to be sought as a first objective, but uniformity between these different types of machines will not finally be a constraint. The commission will report early in 1978. The evolution in the number of scheduled instruments at the ILL is shown in Figure 4.

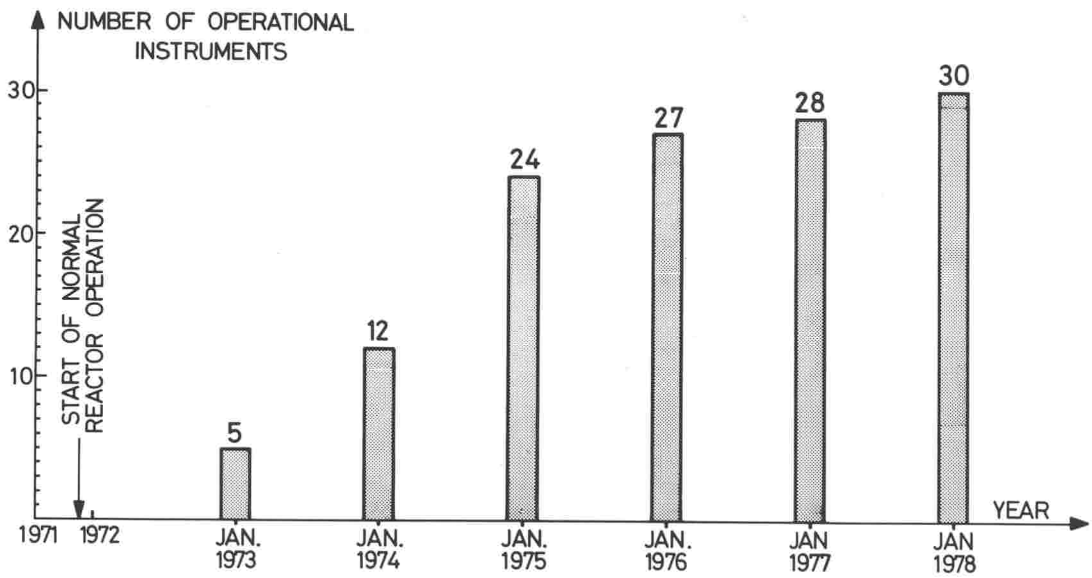
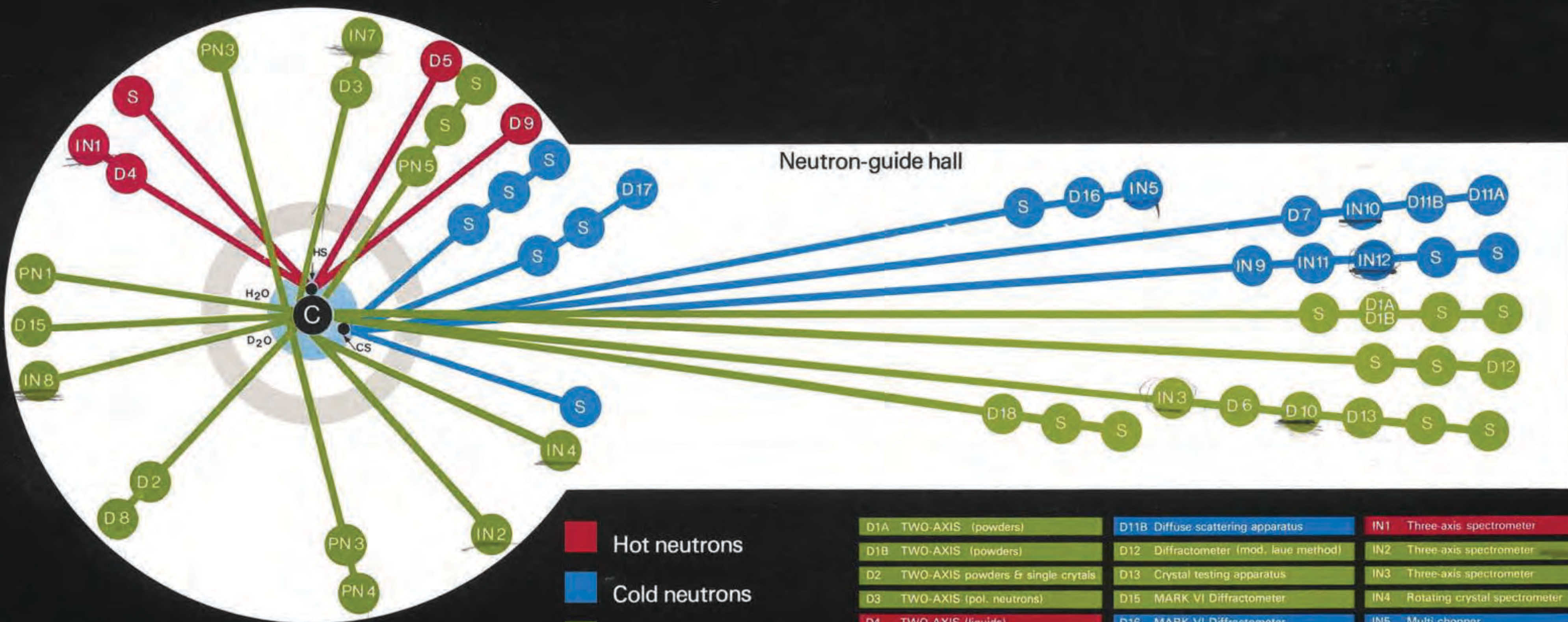


Figure 4. - Development of the number of operational instruments.

beam tube arrangement and instruments at the H.F.R. of the I.L.L.



Hot neutrons

Cold neutrons

Thermal neutrons

C Reactor core

HS Hot source

CS Cold source

D1A	TWO-AXIS (powders)	D11B	Diffuse scattering apparatus	IN1	Three-axis spectrometer
D1B	TWO-AXIS (powders)	D12	Diffractometer (mod. laue method)	IN2	Three-axis spectrometer
D2	TWO-AXIS powders & single crytals	D13	Crystal testing apparatus	IN3	Three-axis spectrometer
D3	TWO-AXIS (pol. neutrons)	D15	MARK VI Diffractometer	IN4	Rotating crystal spectrometer
D4	TWO-AXIS (liquids)	D16	MARK VI Diffractometer	IN5	Multi chopper
D5	THREE-AXIS (pol. neutrons)	D17	Small angle scattering apparatus	IN7	Statistical chopper
D6	Hedgehog diffractometer	D18	Neutron interferometer	IN8	Three-axis spectrometer
D7	Diffuse scattering apparatus	PN1	Fission product spectrometer	IN9	TOF polarisation spectrometer
D8	Four circle diffractometer	PN2	Conversion electron spectrometer	IN10	Backscattering spectrometer
D9	Four circle diffractometer	PN3	Gamma ray spectrometer	IN11	Spin-echo spectrometer
D10	Three-axis el.scattering	PN4	Anti compton spectrometer	IN12	Three-axis spectrometer
D11A	Small angle scattering apparatus	PN5	Ultra cold neutron source		

D Diffractometer

IN Spectrometer for Inelastic Neutron Scattering

PN Nuclear Physics Instrument

S Special Beam Instrument

A detailed report on the work of each instrument group is given below. The investments made for the groups have, in all cases, led to significant improvement in instrument performance ; for example, on Lohengrin, reduction of background by a factor of 10, improvement by a factor of 10 in the timing of the spectrometer, and a purer mass spectrum with, nevertheless, an improvement of 10 % in intensity. On the GAMS, PN3, the new target changing device has allowed the manipulation of radio-active and actinide targets, and the graphic display system now allows any distortions in the sample to be immediately detected. This has considerable value from the point of view of the safety of the installation.

In the Three-Axis Group, considerable improvements to goniometers on all machines have been made, as well as to the drive systems. The Rutherford Laboratory collimators have been introduced widely and standardisation between spectrometers is proceeding.

In the Diffraction Group, considerable relief was given to CARINE, and hence other instruments using this computer, by the installation of D8 on a dedicated PDP-11 computer. The problems of data transfer are now engaging full attention. General improvements to monochromators, cryostats, and to the stability of the diffractometers has led to increased performance and, for D3, the cryoflipper installed during the year now has an efficiency which is independent of the neutron wavelength and the sample magnetic field. The signal to noise ratio of the film detection system of D12 has ben considerably improved by the addition of a system of oscillating slit collimators between the sample and the film. Only neutrons which come from the direction of the specimen or close to it ($\pm$ 0.5 cm) are recorded on the film. The background due to the cryostat walls is thus eliminated, and long exposures are possible (see figures i and ii).

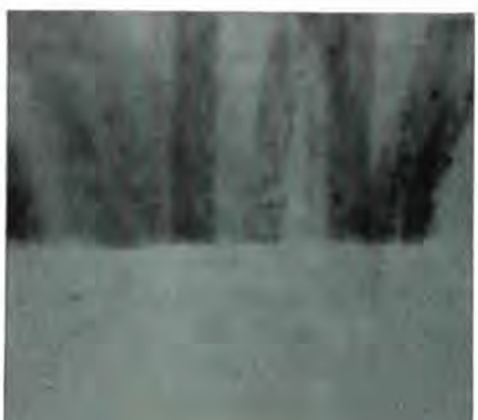
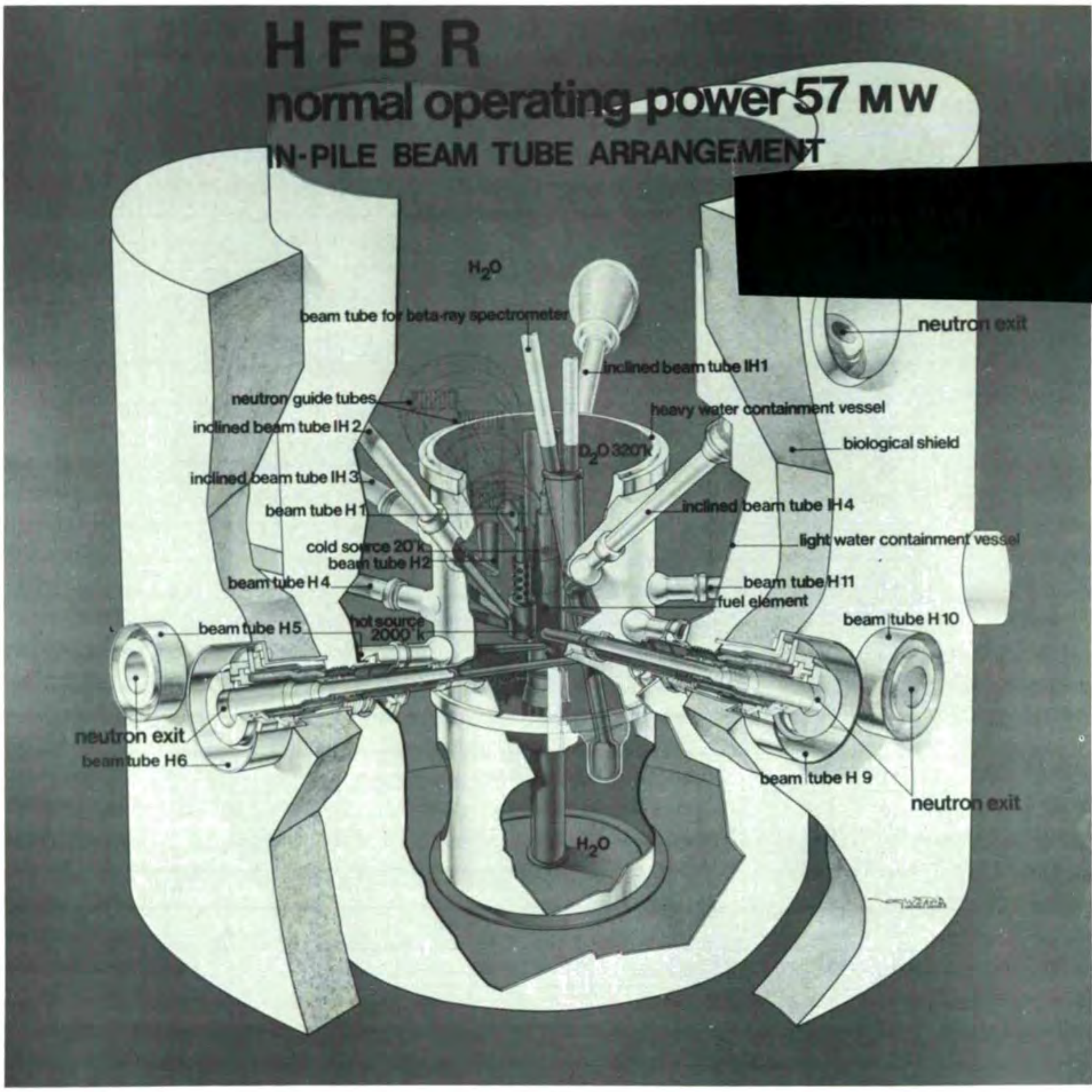


Fig. i. - The background signal (upper half of the figure) received from an aluminium cylinder around the sample position on D12.

Fig. ii. - A 6° oscillation photograph of $DyMnO_4$ on D12 at 20K (exposure time 30 minutes).

For the Diffuse Scattering and Time-of-Flight Group, important investments were made to improve the operation of the small angle cameras D11 and D17 and, in particular, the transfer of IN5 to the ARC system of guaranteed supply has eliminated the effect of thunder-storms during the summer.

The area of special beam instruments at the ILL continues to be supported strongly, although the demands for servicing on the equipment brought to the Institut from other laboratories, and for general support, are sometimes beyond those which can be made available. Requests for greater standardisation of this equipment with that already at the ILL have been made. The policy with respect to special beam instruments is to give as much support as possible while maintaining a first priority for the scheduled programme. A review of the whole range of special beam instruments at the ILL will be conducted at the Scientific Council in March 1978 in order to decide the priorities for future support. It will be a matter of policy to give strong support during an initial period to chosen experiments, which must have a well-defined life-time when proposed. After the initial period, support from outside the Institut will be a necessary condition for continuation.



A cutaway view of the reactor and some of the associated beam tubes

INSTRUMENT OPERATING STATISTIC

THE REACTOR HAS OPERATED FOR 257 DAYS DURING THE YEA

(7.3 DAYS WERE RECUPERATED BY

[redacted]	otal operating time (days)	Loss of beam time (days)	Coll. 3	Coll. 4	Coll. 5	Coll. 6	Coll. 7	Coll. 8	Coll. 9
IN1	225.3	31.7		90.2		16.3	22.0		77.0
IN2	226.7	30.3		192.8		9.0	7.7		
IN3	216.9	40.1		180.2		3.0			
IN4	226.0	31.0		28.8		30.1	39.2		94.4
IN5	219.3	37.7			2.8	88.7	37.6	27.2	54.0
IN7	50.0	207.0					50.0		
IN8	192.6	64.4		144.5		5.3	18.2		
IN10	239.4	17.6		10.5		34.8	50.9	16.0	109.2
IN11									
D1A	232.8	24.2			173.0	9.0	6.0		9.1
D1B	250.3	6.7			136.4	33.6	10.7		7.5
D2	233.8	23.2			130.8	51.8		5.3	
D3	218.2	38.8			176.2				
D4	234.1	22.9				170.3			
D5	231.7	25.3			171.7	31.5	14.6		
D7	178.2	78.8				2.8	158.8		
D8	220.7	36.3			166.1			41.0	
D9	231.3	25.7			204.1		5.5		
D10	232.1	24.9			144.3		62.4		
D11	231.5	25.5			7.9	5.9	51.8	68.4	40.7
D12	218.0	39.0		22.0	93.0				7.0
D13	114.0								
D15	207.2	49.8			205.7				
D16	226.4	30.6			51.3			112.1	
D17	62.5					3.0	2.0	16.6	18.9
PN1	218.0	39.0	162.0						
PN2	224.0	33.0	186.0						
PN3 (G1)	210.5	46.5	186.8						
PN3 (G2/3)	221.3	35.7	212.9						
PN4	52.4		52.4						
PN5									
PN6	27.0		27.0						

JANUARY TO DECEMBER 1977)

4.3 DAYS WERE AFFECTED BY UNSCHEDULED SHUT-DOWNS

XTENDING THE OPERATING CYCLE)

ternal test, feasibility, d instrument nprovement xperiments	Comments
19.8	
17.2	
33.7	
33.5	
9.0	
	Instrument modification completed June 1977, commissioning experiments in progress
14.6	Loss of beam time includes 20 days for electronic modification
18.0	
	Continuation of instrument tests and scientific feasibility experiments
35.7	
62.1	
45.9	
42.0	
63.8	Test period includes 35.0 days for multidetector installation and test
13.9	
16.6	Loss of beam time includes changing instrument mode to polarised neutrons
13.6	
21.7	
25.4	
56.8	Test time includes 43.0 days for D11B commissioning
96.0	Test period includes instrument modification and improvements
114.0	42 short term experiments recorded (XTAL alignment, mosaic control, topography, membranes etc.)
1.5	
63.0	Test period includes 15·6 days for instrument alignment and modifications
22.0	Commissioning experiments completed. Full scheduling commenced 22nd July, 1977
58.0	
38.0	
23.7	Operational time includes decay measurements during shutdown period.
8.4	Loss of beam time includes sole use of PN4.
	Use restricted by experimental requirement and positioning of PN3 (G1)
	Commissioning experiments continued
	Operational ILL instrument from November 1, 1977

TABLE II - PROJECTS IN PROGRESS (1977)

IN5 B	A high intensity time-of-flight spectrometer in the λ-range 4.1 to 5.5 Å. It will have three double focusing monochromator crystals Si (III) 20 cm high ; a Fermichopper ; 2 metre flight path ; 4 m2 detector area. The guide beam hole on H15 was cut during the October shut-down to provide space for the monochromator assembly. The instrument layout is in progress and a comparative study of detectors is underway.
IN 12	High resolution triple axis spectometer on a cold neutron guide tube. During 1977 the monochromator shielding and sample table were completed. The analyser-detector unit is under construction. Tests have shown that the new drive modules are capable of speeds considerably in excess of those of the traditional "Tanzboden" units. IN12 will be controlled by a SOLAR 16/40 computer via a microcomputer for step-motor control. The SOLAR will be delivered in January 1978. First tests of the complete instrument should be possible by late summer of 1978.
D18 B	Polarised neutron version of the neutron interferometer. There has not been any progress made with this instrument due to lack of funds.
D19	In 1977 a few delays in the realization of D19 have occured due to the lack of means (technical and manpower). Nevertheless construction of the D19 multidetector will be finished in 1978, and it will then be tested with its own computer, which has been ordered this year. A smaller prototype 2 dimensional detector, already under test, is expected to be of value to replace standard diffractometer counters.

TABLE III - PROJECTS UNDER DEFINITION

IN10 B	The scientific and technical definition of this instrument, a backscattering spectrometer, is complete. It will operate with cold neutrons having a wavelength near 6 Å and an energy range up to 1 meV. Further progress is dependant upon the budget.
IN13	This is a backscattering spectrometer on a thermal guide. It will operate at 2.2 Å with Q-values up to 6 $Å^{-1}$ and an energy range from —300μev to + 500μev by means of a temperature-scan (0 to 500°C) together with a 2θμ-scan (160 to 178°) of the monochromator. The project is now completed, and construction will start in 1978 subject to manpower and budgetary constraints. According to an ideal time schedule, it would be operational during 1980.

TABLE IV - SPECIAL PROJECTS

Optimised Shaft Control	A working group has been set up to study in depth the problems of automatic shaft control, that is, the moving time of shafts and the position of angles, as part of the long term plans for improving the performance of triple-axis spectrometers and diffractometers. The working group will report during 1978.
Monochromators	During 1977 the success rate of Ge and Si crystal production has been improved, the anisotropic mosaic spread being controlled during production. Tests of the efficiency of Si crystals for cold neutrons are in progress. Ge crystals have been produced to assemble vertical focusing monochromators ; this technique has been successful on D10, giving a gain in intensity without subsequent loss in resolution. The joint project by the MPI Stuttgart and I.L.L. to develop and produce good quality Beryllium crystals continues with good results. Tests are being carried out at I.L.L. for optimisation of the growth parameters. A feasibility study of pyrolytic graphite monochromators with variable lattice spacing has been undertaken.
Evaporator	A new type of neutron polariser, the super-mirror, was developed in 1976. The super-mirrors consist of a large number (50 or more) of thin layers vacuum deposited on a glass substrate. In 1977 they were tested in practice, serving as polariser and analyser on the IN 11 spectrometer. For their further development an ultra high vacuum evaporator is being installed on a waste neutron beam, which will permit on-line monitoring of the neutron reflectivity of the super-mirror that is being deposited. The evaporator will be put into full, automatic operation in 1978, and its size will be sufficient for a small scale production of polariser systems.

TABLE V
SPECIAL INSTRUMENTS AND SPECIAL BEAM EXPERIMENTS CARRIED OUT OR IN PREPARATION IN 1977

EXPERIMENT No.	TITLE
07-04-002A	In beam NMR spectrometer
03-03-073 03-03-074 03-03-075	(n, α) (n, p) and (n, f) reactions on several heavy isotopes
07-03-045 05-16-94	Neutron topography
05-01-100 5-15-81 5-16-93A	High precision lattice parameters in KDP and TGS near T_c
03-03-007	Neutron storage ring using ultra-cold neutrons
03-03-008	Neutron bottle using ultra-cold neutrons
03-03-011	Protein contents in seeds
03-04-001	Concentration profiles by (n, α) and (n, p)
03-03-018R	ga/gv from free β-decay
03-03-038	Neutron half life
03-03-076	^{231}Pa, ^{230}Th (n, f)
03-03-077	^{235}U (n, f)
03-03-056	1 and 2-photon decay in n + He^3
03-03-058	Gamma directional distribution from oriented nuclei
03-03-059	$\gamma-\gamma$ directional correlation after neutron capture
03-05-001	Neutrino cross section
03-05-002	PNC effects in polarized neutron optics
5-16-51 5-17-104 5-17-105	Laue diffraction on αFe_2O_3, CoU_2, NiO, CoO
03-05-003	Spin rotation

instruments which became operational in 1977

NEUTRON SPIN-ECHO SPECTROMETER IN11

The neutron spin-echo (NSE) principle is utilised to determine the time Fourier transform, $\overline{S}(\underline{Q},t)$, of the scattering function $S(\underline{Q},\omega)$ at a given momentum transfer $\underline{Q}$. The NSE method compares the incident velocity of each individual neutron with its scattered velocity, so that resolution and beam monochromatization are basically independent. The spectrometer, which is designed specifically for high-resolution quasielastic spectrometry, is shown schematically in fig. 5.

For each neutron, the wavelenght change $\Delta\lambda$ during scattering is encoded as a phase shift $\Delta\phi$ in precessing polarisation, and it is the x-component of this precessing polarisation which is measured in the experiment, namely $P_x \alpha \cos(\Delta\phi)$

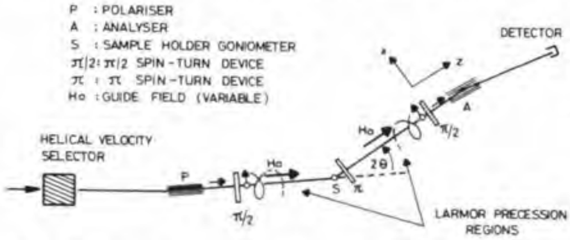


Fig. 5. - Schematic view of the spin-echo spectrometer IN11. s

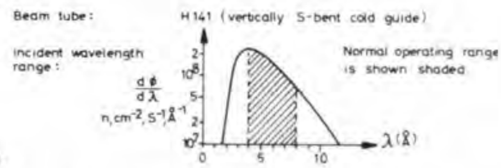


Fig. 6. - Incident wavelength range of IN11.

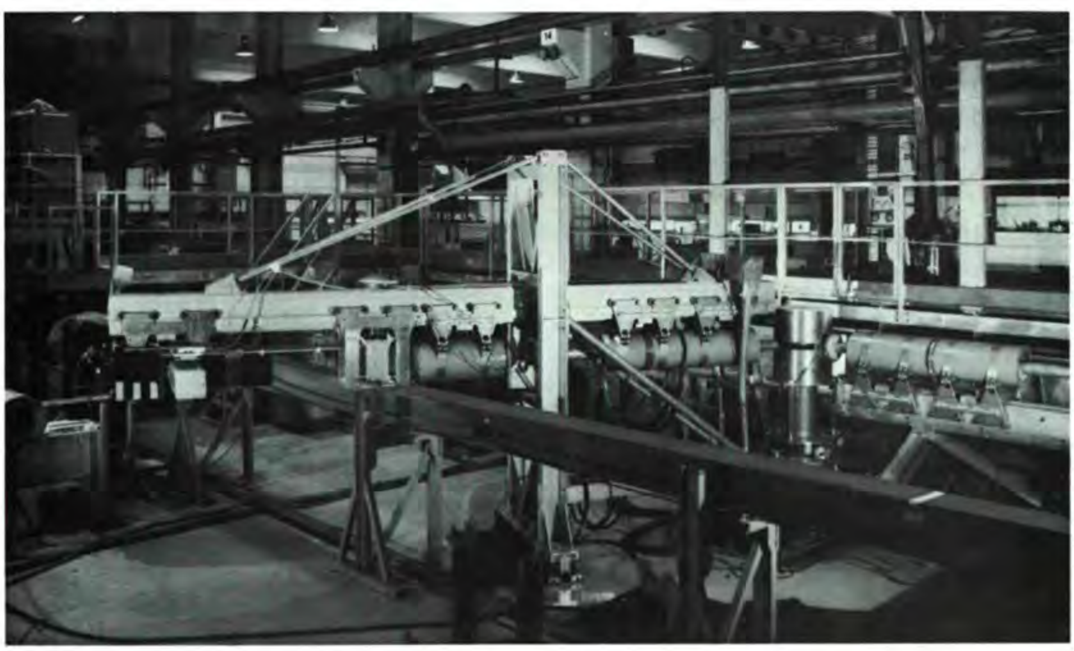
Within the quasielastic approximation one has $\Delta\lambda \ll \lambda_o$, so that ω is proportional to $\Delta\lambda$, and the measured quantity is $P_x = \int S(\underline{Q},\omega) \cos(\omega t)\, d\omega = \overline{S}(\underline{Q},t)$. The Fourier variable t depends on the number of precessions in the magnetic field H_o , the field length d, and the incident wavelength λ_o . For d(cm), H_o (oersted) and λ_o (Å), $t = 2|\gamma|\mu_N\ m^2 H_o\ d\ \lambda^3/h^3$, where h is Planck's constant, m is the neutron mass, μ_N the nuclear magneton and $\gamma = -1.913$. Hence for fixed geometry, t = constant H_o , and the experiment consists of measuring P_x as a function of H_o .

Since this measurement gives the Fourier transform of the scattering function, the definition of the instrumental resolution needs some clarification. In particular, the Fourier transformation makes deconvolution procedures unnecessary, the latter being replaced by a simple normalisation of the polarisation against a calibrated scattering sample.

We therefore define the resolution in terms of a particular spectral shape. For example, if $S(\underline{Q},\omega)$ is Lorentzian with width parameter γ, the NSE spectrum will be the exponential function $P_x = \exp(-\gamma\ 1t1)$. The resolution of the instrument can then be defined as the full-width at half maximum of the Lorentzian line for which P_x has dropped, say, 5 % at the maximum attainable value of the Fourier parameter (i.e. $\exp(-2\ \gamma\ t_{max}) \doteq 0.95$). The percentage drop of 5 % is arbitrarily chosen as an easily measurable change in the polarisation.

Instrument details

Beam tube	:	H14 (vertically S-bent cold guide)
Incident wavelength range	:	see fig. 6
Monochromotization	:	$\pm$ 20 % ($\pm$ 10 %, variable is under construction)
Polariser, Analyser	:	Neutron optical types, $P_o > 97$ %. Both supermirror and Soller guide systems are available.
Peak intensity at the sample	:	1.5 x 10^7n. $cm^{-2}.s^{-1}$ (area 30 x 30 mm^2)
Scattered beam	:	accepted solid angle 15' x 15' to 1° x 1°
Momentum transfer range	:	$1.0° \leqslant 2\theta \leqslant 140°$ at 4Å, 4 x $10^{-2} < Q < 3.0$ Å^{-1} at 8Å, 2 x $10^{-2} < Q < 1.5$ Å^{-1}
Precession field length	:	67, 133 or 200 cm
Precession field strength	:	$0 < H_o < 1500$ œ
Spectral resolution (energy transfer needed to give 5 % change in P_x, see text)	:	at 4Å, 6 x $10^{-8} < \lvert\hbar\omega\rvert$ eV at 8 , 6 x $10^{-9} < \lvert\hbar\omega\rvert$ eV
Detector	:	5 cm ^{3}He



The IN11 spin-echo spectrometer operating at 80° scattering angle. The incident beam is raised by a vertically S-bent guide to allow clearance of the D11 collimation system.

ultra cold and very cold neutron source PN5

1. Description of the Source :

The source of Ultra Cold Neutrons (UCN $3 < v_n < 6$ m/s) and of Very Cold Neutrons (VCN $6 < v_n < 100$ m/s) which has been installed at the High Flux Reactor, is essentially a neutron guide. It fetches the neutrons inside the reactor and guides them by total reflection to the experiments. It includes :

— an in-pile guide which is an internally polished stainless steel tube of 6.7 cm internal diameter. Inside the reactor the entrance window is a thin Zircalloy dome (< 0.6 cm) connected to the tube by a diffusion weld (Fig. 7). Outside the reactor

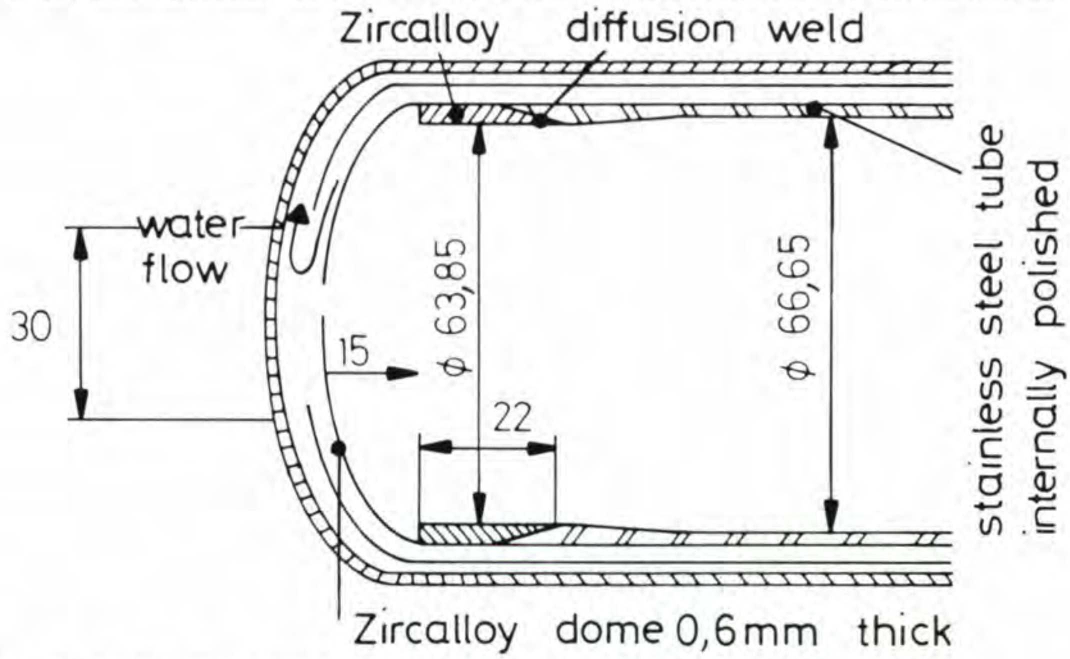


Fig. 7. - Sketch of the converter of the ultra-cold neutron source PN5.

the exit window is a sheet of aluminium 100 µm thick. The nuclear hat (< 5 KW total ; 2.5 watt/g maximum) is removed by flowing H_2O (300 g/s) which acts also as converter. The tube is installed inside the inclined beam tube IH3, thus with the exit 3 m above the entrance.

— an out-of-pile guide which is a square (7 x 7 cm^2) curved tube (R = 9.82 m), made of nickel-coated, borated glass plates. The glass elements are inside a stainless steel vacuum container, with an entrance window of 200 µm of aluminium. The set is placed inside a removable beam catcher made of iron and paraffin.

— a "distribution box" which contains movable sections of guides which could divert the beam in three different direction 40° left, straight on, and 40° right. The curved guides (R = 0.5 m) are made of thin nickel-coated glass plates fixed in grooves inside nickel coated plastic plates with spacing of 2-3 cm. The layout of the instrument is shown in Fig. 8.

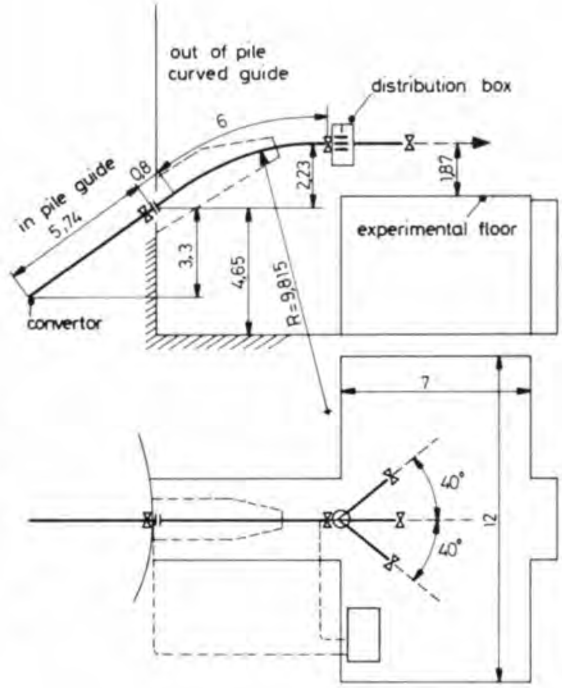
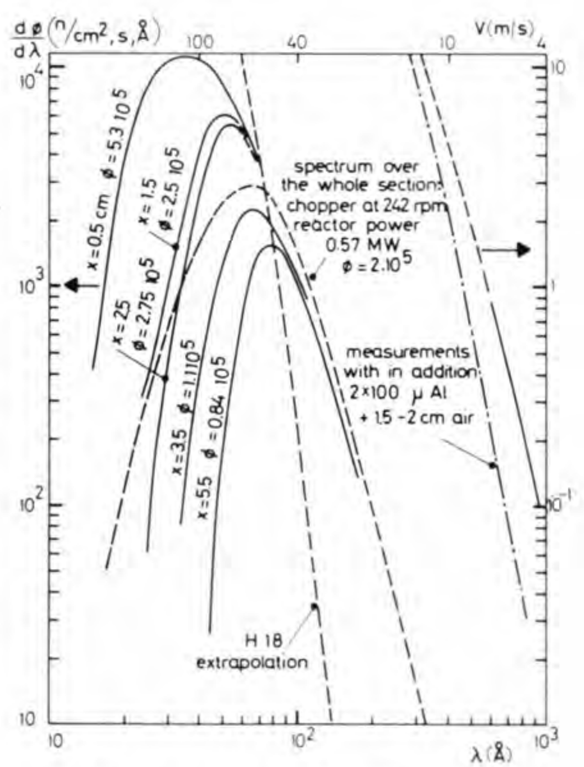


Fig. 8. - Lay-out of the ultra-cold neutron source PN5.

2. Neutron Spectra

Preliminary measurements have been made by a time-of-flight method. Fig. 9 gives VCN spectra, either the mean spectrum over the whole section at the exit of the main curved guide, or detailed spectra for various values of abscissa x from the top of the section (x = 0.5 — 1.5 — 2.5 — 3.5 — 5.5 cm). The total flux varies from 5.3 x 10^5 m/cm²/s at the top, to 0.84 x 10^5 at the bottom of the guide section with a mean value of 2 x 10^5.



Fg. 9. - The very cold neutron spectra of PN5.

Fig. 10 gives UCN spectra taken with and without collimator, which are respectively lower and upper limits of the actual spectrum. The total number of detected UCN with velocities below 6.7 m/s (thus which can be stored in bottles made of nickel or beryllium) is about 50 m/cm2/s with collimator and 150 m/cm2/s without collimator and the actual value is estimated to be 90 (at full reactor power).

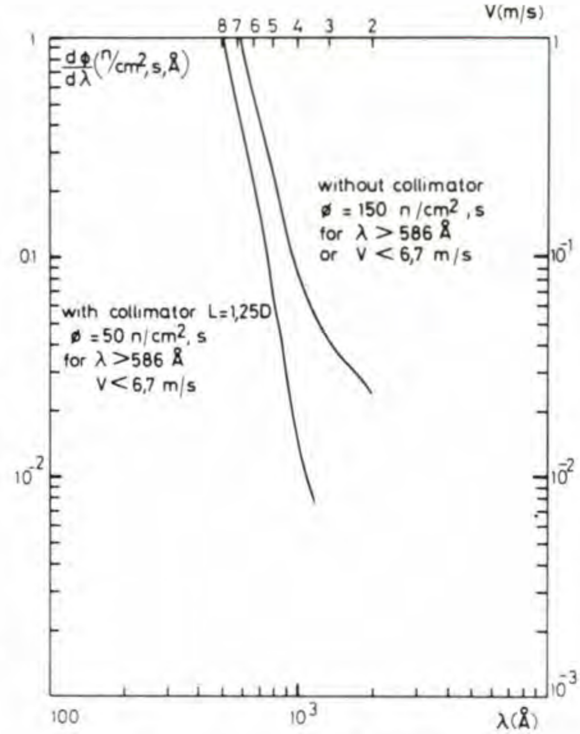


Fig. 10. - The ultra-cold neutron spectra of PN5.

instrument group
"fundamental and nuclear physics"

PN1	:	Fission Product Spectrometer (LOHENGRIN) on beam tube H9
PN2	:	Beta Spectrometer (BILL) on the vertical beam tube V3
PN3	:	Three Curved Crystal Gamma Spectrometers (GAMS 1, 2, 3) on the through going beam tube H6/H7
PN4	:	Ge Anti-Compton and Pair Spectrometers on the through going beam tube H7
PN5	:	Ultra-Cold Neutron Source on the inclined beam tube IH3
PN6	:	On - Line Mass Separator for Thermally Ionized Fission Products (OSTIS) on neutron guide H23L
PN7	:	Cold Polarized Neutron Beam on neutron guide H14L
H18	:	Cold neutron guide : Determination of the neutron half-life (S37)
H22	:	Thermal neutron guide : Neutron induced particle emission (S10), γ-γ angular correlation (S31), γ-ray directional distribution from oriented nuclei (S34) and one and two photon decay after neutron absorption in ^{3}He (S39)
H25	:	Thermal neutron guide : Concentration profiles by neutron-induced particle emission (S30)
IH1	:	Very intense neutron beam tube : Neutron-induced fission (S16, S38)
—		Neutrino cros-sections and neutrino-oscillations (S40, no neutron beam position requested).

PNI - FISSION PRODUCT SPECTROMETER LOHENGRIN

(H. Schrader)

During 1977 the mass separator was operational for 215 days (80 % of the reactor time). The beam time has been used for 14 experiments in collaboration with external research groups for 148 days (55 %) and for several test runs during 67 days (25 %). Within the test runs the development of the fission product (f.p.) back-ground from sputtered uranium onto the beam tube and the technique of covered targets have been studied in order to understand and to reduce the sputtering effect. From March to October 1977 the background decreased from 6 f.p./(s-cm parabola length) to 0.75 f.p./(s-cm) (0.4 %) because only very thin targets of 40 $\mu g/cm^2$ UO_2 or targets covered with a 450 $\mu g/cm^2$ Ni foil were used. The Ni foil produced an energy shift for heavy and light fission products of about 15 %. Ni covered targets are now available with a maximum intensity of 1.5 x 10^4 f.p/s at 72 cm beam exit length (210 f.p./(s-cm)) with a mass resolution of $A/\Delta A$ = 800 (fwhm) and for the most abundant masses, kinetic energies and ionic charges.

The experiments were mainly devoted to the investigation of fission yields. Different methods of γ-intensity ratios in the mass chain were applied. The yield of fission product isomers as a function of their kinetic energy has been studied by a group from the University of Mainz (A = 132-136) and by a CENG/KFA Jülich collaboration (^{131}Sn, ^{132}Te). A time of flight system for fission products with an absorber technique has been tested successfully by a group from CEN Saclay obtaining a nuclear charge resolution of $Z/\Delta Z = 40$ (A = 91, E = 88 MeV) in an argon gas absorber. The energy straggling in He, Ar, N_2 has been studied as well. In nuclear spectroscopy of neutron rich fission products the Q_β -values of ^{85}Se, $^{88,90}Br$, $^{144,145}Ba$, $^{144-147}La$, ^{147}Ce, ^{148}Pr have been measured.

PN2 - BETA SPECTROMETER BILL

(K. Schreckenbach)

In 1977 the beta spectrometer BILL was working continuously about 80 % of the time. 13 targets have been measured for nuclear and atomic physics.

It could be shown that the sensitivity of a measurement can be improved considerably by repetitive scanning over a part of the spectrum. 20 scans over one line group (corresponding to a variation of 5 % of the magnetic field) during two days caused no deterioration of the resolution in the sum spectrum.

The programs for the instrument control were modified and are written now in FORTRAN. Together with a faster terminal (LA36) which was also installed this year, BILL can now be operated in a more convenient and flexible way. Also the reliability has been increased further.

PN3 - CURVED CRYSTAL GAMMA SPECTROMETERS (GAMS 1 AND GAMS 2/3)

(H.G. Börner, W.F. Davidson)

During 1977 the curved crystal spectrometers GAMS 1 and GAMS 2/3 were running for 85 % of the time. Test experiments and minor breakdowns summed up to the remaining 15 %. The γ-rays following neutron capture in 12 different targets were studied.

A modification of the target changing facility including the installation of a glove box, and a shielding against fast neutrons allows for the introduction of radioactive and especially actinide targets. In addition the adjustment of the target position can be made by remote control. The actual state of a running experiment on GAMS 1 can now be controlled via telephone which transmits the angle of diffraction and the counting rates. GAMS 2/3 has had a polarized laser installed to increase the precision of angle measurements.

PN4 - GE PAIR AND ANTI-COMPTON SPECTROMETERS

(D. Warner)

The Ge pair-spectrometer was fully operational throughout 1977. High energy spectra of γ-rays following thermal neutron capture in 7 different targets were obtained. Modifications made to the shielding of the GAMS 1 detector with which the beam is shared lead to a 50 % increase in available measuring time. In addition, the time resolution and efficiency has been improved by the installation of constant fraction timing.

The Ge detector for the anti-Compton spectrometer was delivered and measurements performed on two targets. Unfortunately, the detector became unstable at its nominal operating voltage, and had to be returned under guarantee. The repair has now been completed and the detector is again operating satisfactorily.

PN5 - ULTRA-COLD NEUTRON SOURCE

(P. Ageron)

The Ultra-Cold Neutron source became operational in April 1977. Flux measurements for ultra-cold neutrons (UCN) and very cold neutrons (VCN) have been made. The UCN flux (neutrons with velocities below 6,2 m/sec) is 250 n/cm^2sec and the total flux is 2×10^5 n/cm^2sec with a velocity distribution peaking at 60 m/sec.

Two experiments are currently underway to store these neutrons either in a neutron bottle or in a magnetic torus. The first experiment searches for an electric dipole moment of the neutron. In the second experiment neutrons (velocities between 10 and 20 m/sec) have been stored for the first time in a toroidal magnetic sextapole field (0.5 m radius, 3T max field strength, 1T/cm field gradient). Stored neutrons could still be detected after two periods of the neutron half-life.

PN6 - ON-LINE MASS-SEPARATOR OSTIS FOR THERMALLY IONIZED FISSION PRODUCTS

(K.D. Wünsch)

After a modification made in November 1976 which increased the intensity by a factor of six, OSTIS now produces a point source of up to 5×10^6 mass separated rubidium or caesium fission products per second in front of the detectors. The high demand for this instrument continued in 1977. OSTIS was operational 80 % of the time and 16 different experiments were carried out including two ion-source tests.

A special experiment including ^3He-detectors as well as a small ion source and a fast switching system for the acceleration voltage (20 kV) and for the quadrupoles was set up to investigate the Rb-Cs coincidences. Measurements were performed to determine Q_β - values, P_n - values, half-lives and fission yields. Delayed neutron, gamma and conversion-electron spectroscopy were continued.

Plans exist to upgrade OSTIS further by increasing the high voltage to 40 kV and to change the ion source design. A first indirect heated ion-source is being developed at the University of Giessen to work at higher temperature and to ionize also the rare earth elements.

PN7 - POLARIZED NEUTRON BEAM

(W. Mampe and B. Vignon)

The on-line isotope separator OSTIS.

The present experiments on this beam are intended to look for angular asymmetry in the electromagnetic decay of nuclei which are oriented by the capture of polarized cold neutrons. In this way violation of parity and time reversal invariance can be measured.

According to the experimental requirements two very large liquid scintillators (500 l each) or two large NaI crystals or 6 NaI detectors can be mounted (ISN Grenoble). A high precision electronic system is available which has very small systematic drifts (3 parts in 10^6 due to temperature stabilisation and effective shielding against magnetic stray fields). Two long term experiments have been carried out in 1977. It is planned to install a new neutron polariser with increased performance in the beginning of 1978.

The neutron beams H18, H22, H25 and IH1 were used continuously and successfully throughout 1977 for nuclear spectroscopy, fission research and fundamental physics experiments. A cooperation between ISN and ILL Grenoble, TU Munich and Caltec Pasadena started with the construction of the detector for the neutrino experiment. The scientific results obtained with the instruments are reported in the section of college 3 (fundamental and nuclear physics) in this volume.

Co-ordinator : G. SIEGERT

instrument group "three-axis spectrometers"

IN1	:	on the hot source (beam tube H8)
IN2	:	on the thermal beam tube H13
IN3	:	on guide tube H24
IN8	:	on the thermal beam tube H10
IN12	:	under construction on cold guide H14.

During the year 1977 the instruments IN2 and new IN3 have operated in a reasonably reliable manner. Unfortunately the performance of IN1 and IN8 has been marred by frequent breakdowns. No major modification of the existing instruments was undertaken. The Carine system continues to give problems and leads to considerable loss of time ; its replacemnt should give significant improvement.

IN1 - HOT SOURCE 3-AXIS

(J.R.D. Copley and J. Tomkinson)

The instrument has operated moderately well during the past twelve months, although there have been several serious breakdowns. Any breakdown which entails entry to the casemate (shared with D4) can mean considerable delay before the necessary repairs are made. Once again the motor which rotates the monochromator drum, and its associated electronics, have had to be completely replaced. Improvements include the addition of a second monitor (betwen sample and analyser), partial motorisation of the overhead crane, and installation of shielding curtains between IN1 and D4. Further-more, improvements to the beryllium filter analysing system, in particular construction of a new multiwire detector, are under way.

As soon as possible, a decision has to be taken regarding the replacement of IN1 with a completely redesigned hot source three-axis instrument.

IN2 - THERMAL BEAM 3-AXIS WITH A DOUBLE MONOCHROMATOR

(B. Dorner, W.J. Fitzgerald and C. Joffrin)

IN2 has been in regular use for the last year and has been working satisfactorily apart from minor electronic and Carine problems.

Most experiments have used pyrolitic graphite as monochromator and analyser crystals and a fixed incident energy of 3.14 THz. Many experiments have studied low-frequency excitations associated with structural and magnetic phase transitions. During the past six months two new "Rutherford collimators » using stretched mylar have been installed ; one between the sample and analyser and the other between the analyser and detector. This has increased the measured flux by a factor of $\sim$ 1.5.

Further use of these collimators is envisaged for the future and the gain in flux is significant.

IN3 - FOCUSING TRIPLE-AXIS SPECTROMETER ON THE GUIDE TUBE H24
(R. Scherm and V. Wagner)

IN3 operated routinely throughout 1977 without any major breakdown problems. It has often been used with the Cu 111 monochromator, in the energy range 4 to 9 THz, thus filling the range between IN2 and IN8. The reproducible crystal mountings installed in 1976 have proved extremely useful, permitting the exchange of monochromators or analysers during the course of an experiment. A new, stronger sample table has been installed allowing the use of heavy cryostats.

Except for the steady complaints about the slowness and frequent breakdowns of the Carine computer and electronics, the instrument is, in general, operating very satisfactorily.

IN8 - THERMAL BEAM 3-AXIS
(R. Currat, C. Escribe and R. Pynn)

As in 1976, IN8 has been in great demand all year because of its high flux and low background. Variable vertically bent monochromators of pyrolytic graphite and germanium 111 are now available. The flux gain as measured on a small sample, is a factor of 2.5 for all the attainable incident wavelengths from 1.5 to 4 Å.

The improvement to the monochromator drum drive unit and goniometer table permits a higher speed during positioning. The sample table now has independent rotations. The new beam stop permits one to work very near to the direction of the incident beam which can be very useful for magnetic excitations. The use of two Rutherford collimators is envisaged in the near future, the first between monochromator and sample and the second between sample and analyser.

IN12 - 3-AXIS SPECTROMETER (COLD NEUTRONS)
(W. Stirling)

Considerable progress has been made with the construction of this instrument. The monochromator protection of vertically displaced lead and polythene blocks has been completed and the automatic control system is almost ready. The sample table has been completed and tests have demonstrated that the new drive modules can move large masses much faster than with previous mechanical systems at ILL. Initial tests of the neutron beam with a curved pyrolytic graphite monochromator have shown that, if the full vertical height of the H14 beam is used, fluxes in excess of 10^7 n cm^{-2} s^{-1} will be available at the sample position. A SOLAR 16/40 computer is to be delivered early in 1978 and will be connected to IN12 via a microcomputer which controls the stepmotors. First tests of the complete instrument should take place sometime in the summer of 1978. The new mechanical and electronic systems of IN12, if successful, may be implemented on future triple-axis spectrometers.

Co-ordinator : C. Escribe

instrument group
"time of flight"

IN4	:	Rotating crystal spectrometer on thermal tube H12	fully operational
IN5	:	Multichopper spectrometer on cold guide H16	
IN7	:	Double monochromator and Fermichopper on thermal tube H15	
IN11	:	Spin echo spectrometer on cold guide H14 (full operation envisaged end of 1978)	
IN5B	:	New time of flight instrument (design study started in 1977)	

IN4 - TIME OF FLIGHT SPECTROMETER

(J.B. Suck, P. Poncet, R. Richardson)

28 experiments were performed on IN4 in 1977. This year much effort was put into building a high temperature ($\geqslant$ 2000 K) furnace for IN4 which is difficult due to the horizontal sample geometry in the spectrometer. This furnace is therefore still not completed. To facilitate the control of the cryostat, an automatic He-backflow regulation was added to the cryostat system. The results of the measurements of absolute intensities and the energy resolution for elastic scattered neutrons for all three monochromator systems (graphite, Cu, Fermi chopper) are now available (internal scientific report 77SU17T). We are still looking for a good solution to reduce the background from windows and gas inside the spectrometer. Hopefully, this will be found next year. 6 new detector boxes were installed in autumn 1977, enlarging the intensity, and the momentum transfers measurable at the same time by nearly 20 %.

IN5 - MULTICHOPPER SPECTROMETER

(A.J. Dianoux, F. Douchin)

The instrument was operational throughout the year, performing 44 experiments. 7 of them were disturbed by chopper breakdown, with a mean loss of 3 days each time, mainly due to running in. In the present state of the machine this duty ratio can only be improved by grouping the experiments in long periods using the same chopper speed, i.e. 10 000 or 15 000 r.p.m. The temperature control system of the chopper bearings has been equipped with a zero degree reference, improving safety and accuracy. The problem of power failures (thunderstorms) is now completely solved by the connection of IN5 to the ARC system. The link neutron guide between the choppers has been equipped with glass windows allowing optical control of the stability of the guide supports.

The new series of 400 ^3He detectors is under delivery with very long delays due to electronic noise problems (microphonics). Only 100 new detectors are now available. Their background contribution is twice as high as that of the first 400 detectors (10 c/det/h). The connection systems between detectors and "time-of-flight" coding unit has been considerably improved. The dispatching of the spectra allows every kind of grouping.

A new 400° C furnace is available, allowing the use of 3 samples simultaneously, with an automatic changer, good gradient, and thin windows in the beam. The former IN5 Helium cryostat has been eliminated and is to be replaced in 1978. A special closed circuit refrigerating machine is under study. The replacement of the "NICOLE" computer system and the completion of the detectors extension will take place in 1978. Mounting of a multidetector is being studied. It would fill a gap in the small Q range of the instrument.

IN7 - DOUBLE MONOCHROMATOR AND FERMICHOPPER

(A. Murani)

The rebuilding of the time-of-flight spectrometer IN7 was completed in April 1977. It now consists of graphite double monochromators and the beam is pulsed by a Fermi chopper. A counter bank of 36 He^3 counters at a flight path of 2m from the sample covers the small angle range of between — 10° and + 25° about the beam centre thus providing an ideal arrangement for small angle and magnetic scattering work. The first tests carried out proved quite satisfactory; the spectrometer's performance, in terms of intensity at the sample and the overall energy resolution, being comparable to that of IN4 (despite the shorter flight path for IN7). A few scheduled experiments have been performed during the period June to August. However, due to the breakdown of the trigger unit, the spectrometer has been out of action during the 5th cycle and is not yet repaired. Servicing the electronics of the instrument is a major problem for ILL staff because of the non-standard electronic units and lack of complete and adequate circuit diagrams. It is clearly necessary to replace the instrument electronics by ILL standard units for more efficient use of the spectrometer and in order to avoid similar wasteful breakdowns in the future.

IN11 - SPIN ECHO SPECTROMETER

(J. Hayter and F. Mezei)

Spectrometer construction was essentially completed by summer, and since then IN11 has been undergoing scientific evaluation tests. Both Soller guide and supermirror polariser/analyser combinations have been used; the final installation will be a focusing supermirror system with longitudinal magnetization. Unlike the Soller guides, this has a wavelength-dependent polarization, but gives an intensity gain of a factor of 5 when optimised for the particular wavelength in use.

Scientific evaluation have been successfully undertaken in four main areas :

- coherent nuclear inelastic scattering ($SrTi0_3$)
- incoherent inelastic scattering including spin-flip processes (V_2H_20)

— magnetic field compensation for the interaction between the two arms of the spectrometer

— asymmetric Fourier scans to improve momentum as well as energy resolution (see figure 11).

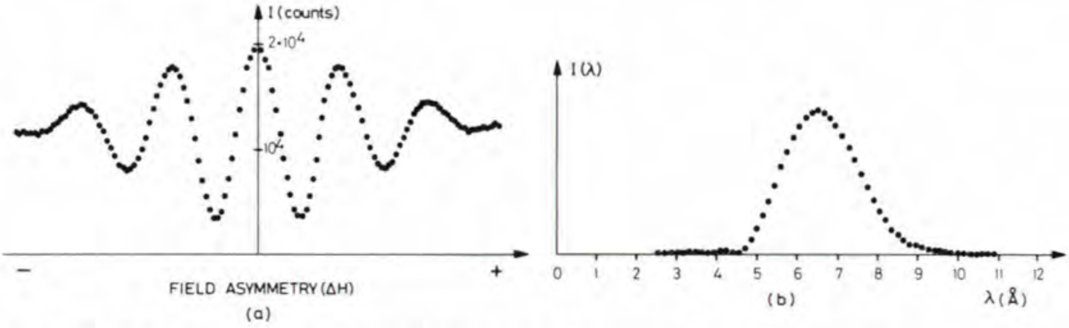


Fig. 11 - Fourier neutron spin-echo scan of the velocity selector spectrum
a) Intensity vs. Δ H, the magnetic asymmetry between the two arms
b) Fourier transform of measured data showing the beam spectrum

Several external experiments were discussed for tentative scheduling at the October meeting of the Scientific Council.

IN5B

The concept of **IN5B** a new time-of-flight instrument in the **λ**-range 4.1 to 5.5 Å (3 double curved Si monochromators in a 20 cm high guide, Fermichopper, 2 m flight path) has been started. The guide H15 was cut in October 1977 to accomodate the monochromator.

IN9

Work and development of the polarized proton filter has been stopped after having achieved the following performances : The 7 mm thick LMN crystal filter at 6.0 K can polarize a white beam of 3 x 3 cm. The filter transmits 28 % of an unpolarized **λ** = 5 Å beam yielding 83 % polarization with ± 0.5 % stability over several runs of 10 days each.

Co-ordinator : R. SCHERM.

instrument group "diffuse scattering"

On the cold guide H15 :
D7 : Diffuse scattering spectrometer
D11 : Small angle and diffuse scattering spectrometer
IN10 : Backscattering spectrometer
On the cold guide H16 :
D16 : Four circle Mk 6 diffractometer
On the cold guide H17 :
D17 : Low-q, high resolution spectrometer
On the thermal guide H24 :
IN13 : New backscattering spectrometer for short wavelengths (design study started in 1977)

D7 - DIFFUSE SCATTERING SPECTROMETER
(W. Just, K. Ibel, A. Murani)

D7 was functioning with unpolarized neutrons from January 1977 to October 1977. The last reactor cycle of 1977 was reserved for experiments with polarized neutrons using a Heusler alloy-Cu_2AlMn crystal as polarizer, a Mezei coil as neutron spin flip device and the dynamical flipping mode as an option for the measurement of the spin dependent part of a "time of flight" spectrum as in previous years.

During the routine operation with unpolarized neutrons the main deficiencies of the instrument appeared to be :

— difficulties with alignment of the incoming beam after wavelength changes (measures were taken during the October shutdown to counter this problem).
— for scans of the diffuse scattering pattern in the reciprocal space of a single crystal the present detector support necessitates several distinct angular displacements in order to cover smoothly the angular range.
— magnetic work suffers seriously from high background due to the tail cryostat of D7.

Preparatory work for the change-over from NICOLE to a PDP11 system was effected and first tests of real data and control link were performed.

D11 - SMALL ANGLE AND DIFFUSE SCATTERING SPECTROMETER
(G. Goeltz, J. Haas)

Since April 1977, D11A and D11B have been considered as one instrument named D11.

In 1977 the incoming neutron guide was lengthened ; the diaphragms in the collimator flight-path were aligned with a laser beam ; the selector is now mounted on flat polished iron pieces allowing a more precise alignment. For transmission measurements the positions of monitor, counter and attenuator have been exchanged. On the IN12 side new protection walls have reduced the background for diffuse scattering and for the next positions of the multidetector (2m, 5m and 10m).

During the long reactor stop in October the arrangement of the electronics in the control cabin was modified. Now the experiments can be controlled by the new PDP11/40 computer, beginning with the reactor cycle in November 1977. But the software still needs improving. New " time-of-flight " electronics for the multidetector are available (this also exists for diffuse scattering, but has not yet been tested). A new chopper with a disk turning in vaccum will be installed before the end of the year.

D16 - FOUR CIRCLE MK6 DIFFRACTOMETER
(G. Zaccai, S. Wilson)

It is the only diffractometer on a cold source guide at the Institute and it is continually being improved to cope with the increasing and varied demands which are made upon it. During the October shut-down, the rails on which it was mounted have been replaced by a Tanzboden element and air-pads. A change in wavelength is now much smoother and does not entail major realignment. Early in 1978, the monochromator shielding will be replaced. Different monochromators are under consideration, especially crystals with large spacing, which could reflect beams of wavelength greater than 6 Å .

Apart from experiments on biological samples and clays, D16 was used, in this past year, to study adsorption on surfaces, and chemical kinetics with a small one-dimensional multidetector mounted on the counter arm. Expansion of the computer system to use the extra memory is continuing satisfactorily.

D17 - LOW-q, HIGH RESOLUTION SPECTROMETER
(M. Roth, P. Timmins)

D17 is a 2-axis spectrometer, with multidetector, for scattering experiments in the scattering vector range 5×10^{-3} Å^{-1} to 1.0 Å^{-1}, requiring high resolution. It is thus designed for studying high order diffraction peaks of large periodical structures. It can also be operated as a classical small angle scattering spectrometer.

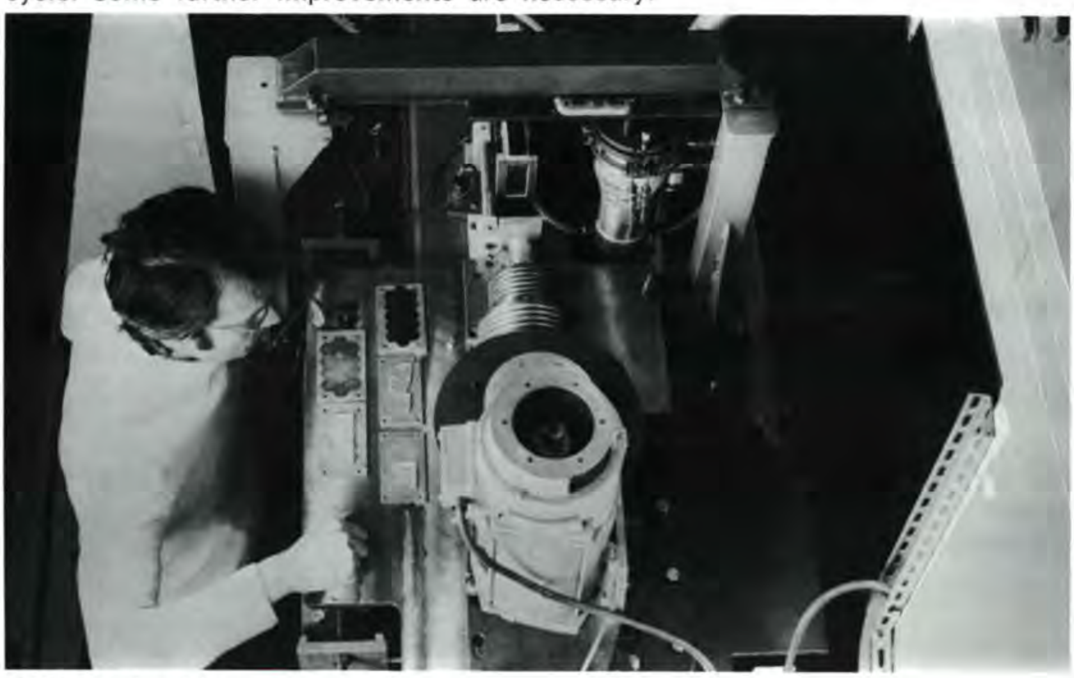
The first measurements with this spectrometer were made in September 1976. The main effort in 1977 has been to bring this apparatus into an easy and reliable state of use. This point seems now to have been reached. In addition a new velocity selector giving à FWHM wavelength distribution of 5 % with a high luminosity is now available (it supplements the first existing one with 10 % $\Delta\lambda/\lambda$). This new selector can be used for neutrons with $\gamma > 10$ Å . An effort has been put into the development of some new ancillary equipment, mainly the adaption of an Eulerian cradle for crystallographic experiments (at present only the movement is monitored by the computer), and the construction of a sample changer in vacuum for measurements on samples in controlled temperature conditions near room temperature. This also permits reduced background by removal of the quartz window from the collimator exit and detector entrance.

D17 is equipped with a PDP11-40 computer for controlling experiments and collecting data. Some data reduction, treatment and display are possible on measured spectra. The computer is programmed in FORTRAN. A program is now available making easy the preparation of any series of experiments via a simple dialogue with the computer. The programs for data treatment allow the making of background corrections, transmission determinations, multidetector cell efficiency corrections, and data regrouping as a function of the scattering vector. A program for crystallographic experiments with the Eulerian cradle (crystal orientation determination and positioning) is under development.

IN10 - BACKSCATTERING SPECTROMETER
(A. Heidmann, S. Howells)

The backscattering spectrometer IN10 was working with hardly any instrument breakdown (loss of beam time 1 %) in the period from January to October 1977. During the reactor shut-down in October 1977 a number of improvements have been made. A new support for the neutron guide between the graphite crystal and the sample was installed. The result was a 15 % increase in intensity at the sample. The time needed for a change in wavelength was reduced from half a day to half an hour. Further improvements to the machine : a more precise system to guide the analysers, and a rigid connection between the branching-off guide and the analyser are necessary and planned for the next year. The " fast and transparent " Doppler drive has been under development for one and a half years. No great progress has been made until now due to a lack of manpower and money.

The standard DEC software RT11 (Fortran language) was adapted to IN10 within 3 months and has been running quite well since the beginning of the last reactor cycle. Some further improvements are necessary.



IN10 Doppler drive.

IN13 - BACKSCATTERING SPECTROMETER FOR SHORT WAVELENGTHS
(design study started 1977)
(J.-L. Buevoz, A. Heidemann)

The project of the high resolution backscattering inelastic spectrometer IN13 is nearly completed. The mechanical solutions have been chosen with the aim of having a very versatile and automated instrument. A decision will be taken at the end of 1977 concerning the choice of the computer. The drawing of the different mechanical parts (special guide and its support, helium box, xy table for deflector movement) will begin soon in order to be able to cut the existing guide at the D6 position and install the monochromator part during the shut-down of October 1978, the analyser area being installed later. The work on electronics and programs will start as soon as the decision on the choice of the computer has been taken.

Co-ordinator : A. HEIDEMANN

instrument group "diffraction instruments"

D1A	:	High resolution powder diffractometer on thermal guide H22
D1B	:	Multidetector on thermal guide H22
D2	:	High flux 2-axis diffractometer on thermal beam H11
D3	:	Two-axis polarized neutron diffractometer with lifting counter on thermal beam H5
D4	:	Liquids diffractometer on hot beam H8
D5	:	Three-axis polarization analysis spectrometer on hot beam H4
D8	:	High flux four circle diffractometer on thermal beam H11
D9	:	Four circle diffractometer on hot beam H3
D10A/B	:	Four circle three-axis diffractometer on thermal guide H24
D12	:	Neutron cameras on thermal guide H23
D15	:	Four circle Mk6 diffractometer on inclined thermal beam IH4
D18	:	Neutron interferometer on neutron guide H25
D19	:	2D multidetector to be installed for tests on thermal guide H24
LI4/5/7	:	X-ray laboratories
S20	:	Neutron diffraction topography
S21	:	High resolution double crystal spectrometer

Amongst these instruments all except D12, D18 and D19 have been fully scheduled throughout the year. Developments within the group have been directed towards improvement in the efficiency of use of the available neutrons and in increasing the range of possible sample environments under which diffraction experiments can be done. Durnig the year experiments under stress, either uniaxial or isotropic have been carried out on D1A, D15, D3 and D5. D12 has undergone considerable modification to enable Weissenberg photographs to be obtained at near helium temperatures. The use of low temperatures available from single stage cryorefrigerators installed at D8 and D9 has continued to increase in spite of some technical problems. Temperatures down to 8-10 K should shortly be available on D15 and using a two stage refrigerator and a new helium transfer cryostat on D10 should attain temperatures in the band helium range ; both of these retaining the flexibility of 4-circle geometry.

To increase the efficiency in the use of the neutron beams improvements continue to be made by increased use of focusing monochromators. Development of multidetector systems for which D19 is the prototype is being actively pursued and in such systems promise significant improvement in data collection rates in the future. High priority within the group is now given to replacement of CARINE by faster and more up to date diffractometer control systems. The prototype PDP11 system on D8 should undertake its first experiment before the end of the year and 1978 will see the development of a system on D1B aimed particularly at "real time" experiments.

D1A - HIGH RESOLUTION POWDER DIFFRACTOMETER
(A.W. Hewat)

The focusing monochromator (Freund, Hewat & Hustache, Nucl. Instr. & Methods 1978), which was installed late in 1976, has made a big difference to the intensity. For some problems, the flux is now even greater than available on D2, whilst the high resolution is not reduced. A range of wavelengths from 1.1 Å to 5.7 Å can be rapidly selected by simple rotation of the focusing monochromator. Since this rotation is now encoded, the wavelength can be reset to a precision of $\Delta\lambda/\lambda = 10^{-4}$, so that calibration of each change is no longer necessary. The new monochromator is particularly useful for work with very small samples, such as those used for high pressure experiments. For this type of work, a new single crystal sapphire pressure cell has been developed under a contract with the CNRS Grenoble Laboratory of Professor Bloch. With this cell, which at present will go to 10 kbar and a temperature of 5 K, most of the background features of polycrystalline cells are suppressed. Development will continue in 1978 when Dr. C. Vettier becomes co-responsible.

Other improvements were the commissioning of a much more reliable and flexible ILL cryostat, and a small crane for easier mounting of heavy equipment. The data reduction package on the DEC-10 computer has been further improved, but the Carine control computer is increasingly showing signs of its considerable age. As well, without any technical assistance on D1A, more complex experiments and further improvements have become impossible. In fact, without more emphasis on the user program, it will be increasingly difficult to satisfy the high demand on D1A time (38 proposals in 1977).

D1B - TWO AXIS DIFFRACTOMETER WITH MULTIDETECTOR
(J.L. Buevoz (until 31-12-77), G. Bomchil (from 1-6-77), P. Convert)

D1B has operated efficiently all the year, enabling experiments to be performed covering a wide field of structure analysis. A second monochromator (Ge 311) is

D1B in its new position.

now available with a wavelength of 1.3 Å, but with a reduction in flux by a factor of 4. During the October shut-down the geometrical setting of D1B has been modified. The distance monochromator-sample is now 3 m instead of 4.3 m which provides a flux increase of 50 %. In addition the take-off angle has been increased to 44° such that the graphite wavelength is now 2.5 Å. This reduces the background by a factor of 4, for adsorption studies on graphite and eliminates the multiple scattering associated with Bragg reflections for d = 1.23 Å.

A 15 cm high focusing Ge (311) monochromator for 2.5 Å neutrons has been ordered for delivery in mid 1978. The new monochromator will increase the flux by a factor of 4 and alleviate the $\lambda/3$ contamination. The most important innovation concerning D1B is that a Solar 16.40 computer has been ordered. This will be a dedicated computer for data acquisition and instrument control permitting 800 data to be stored on disc and fast preliminary evaluation and comparison of data. The new computer will be operational in 1979 thus relieving the current limitations of the Carine system especially for kinetic studies.

D2 - HIGH FLUX TWO AXIS DIFFRACTOMETER
(K.R.A. Ziebeck (up to 1-11-77) and C. Marti (from 1-11-77))

D2 continued to function satisfactorily throughout the year and maintained a heavy demand. The commissioning of D15 relieved most of the single crystal experiments except those concerned with critical scattering. An increasing proportion of the experiments were concerned with surface studies or liquids. The choice of D2 for liquid studies has been its high flux and improved resolution at small Q. In order to further optimise these experiments a small linear detector is envisaged for 1978. For magnetic scattering experiments, a horizontal field, 5T, superconducting magnet is expected to arrive early in 1978.

D3 - TWO AXIS POLARISED NEUTRON DIFFRACTOMETER
(F. Tasset and P.J. Brown)

The high demand for D3 was maintained throughout 1977 and the diffractometer continued to operate efficiently. Several programs have been written for the PDP11 which enable visitors to align their crystals more easily and without a detailed knowledge of the diffraction geometry. The programs on the DEC10 for analysing the D3 data, have been continuously up-dated as further improvements were made to the measurement technique. It is now a simple matter for a visitor to process his data and obtain a form factor before he leaves the Institute (see fig. 12). In

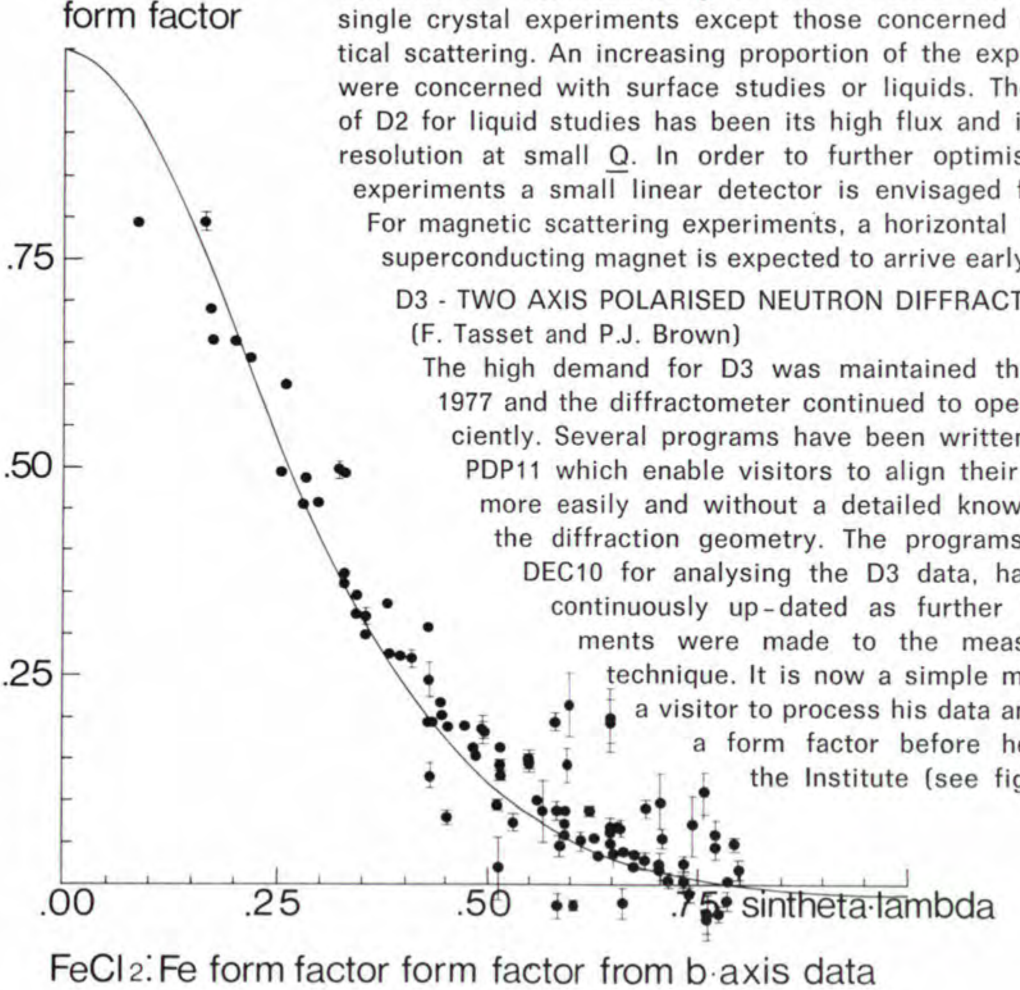


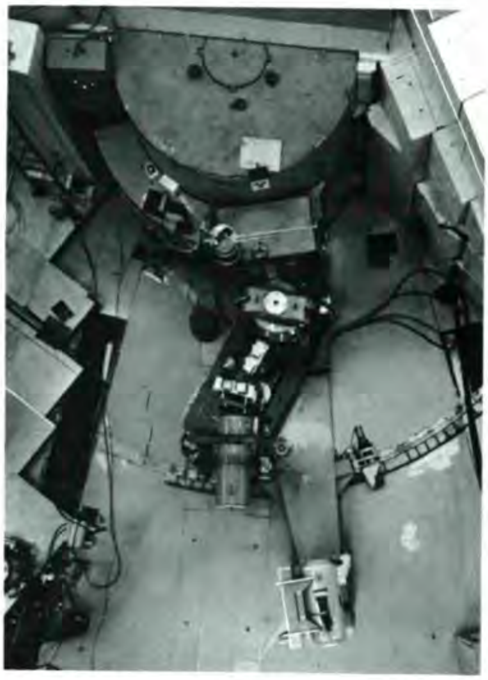
Fig. 12. - Form factor data obtained on D3.

addition a completely new flipper has been developed and incorporated into D3. The new flipper makes use of the Meissner Effect in a superconducting Nb foil and the Majorama technique of flipping. The flipper which operates at 4.2 K provides a stable highly efficient flipping ratio which is wavelength and field independent.

D4 - TWO AXIS LIQUIDS DIFFRACTOMETER ON THE HOT SOURCE
(P. Chieux)

Throughout 1977 D4 continued to operate efficiently. Improvements to the detector shielding and that of the environment of D4 have minimised the background. The introduction of a multidetector has significantly increased the effective neutron flux and has enabled statistics of < 1 % to be obtained in a reasonable measuring time. Data collection is facilitated by two Texas Silent terminals, the cassettes being processed on the DEC10 computer. It is hoped in 1978 to have a direct link to the DEC10 via a concentrator.

D5 - THREE AXIS POLARISATION ANALYSIS SPECTROMETER
(J. Schweizer, D. Givord and K.R.A. Ziebeck from 1-11-77)



D5 seen from above in the " W " configuration.

A wide variety of experiments were performed during 1977 which made full use of unique features of D5. The diversity ranged from liquids and amorphous magnets to highly absorbent rare earth compounds. The latter measurements on Sm and Gd compounds were possible because of the short wavelength provided by D5 and the reduction in the neutron absorption cross section with wavelength. Several inelastic experiments have used polarised neutrons to distinguish between magnetic and lattice vibrations. The introduction of boron coated Soller slits enabled measurements to be made on powder samples. The new electromagnet, with which the field may be easily switched from the vertical to the horizontal direction, has greatly facilitated the polarisation analysis experiments. To improve these measurements still further, a new shielding for the analyser is currently being developed.

D8 - HIGH FLUX FOUR CIRCLE DIFFRACTOMETER
(S. Mason and C. Riekel)

D8 is now controlled by a PDP11/40 system including disc, Dectapes and Tektronix display. The control system will remain similar to those on D9 and D10 but many new features will added. During 1978 we expect to test on D8 a linear detector (length one metre) which has a degree of vertical resolution and is suitable for both single crystal and powder studies. The Displex 100 temperature refrigerator ($T > 45$ K) works well, especially since the addition of flexible transfer lines. Motor driven variable apertures for the α_2 collimation (between monochromator and sample will soon be installed).

D9 - FOUR CIRCLE DIFFRACTOMETER WITH SHORT WAVELENGTHS
(M.S. Lehmann and G. Bentley)

During the year D9 has been in routine operation and only minor modifications were carried out. The vacuum tube, connecting the monochromator housing to the exit at the reactor face, was replaced owing to radiation damage to the joints. A gas flow furnace constructed at the CNRS Grenoble has been tested and found to work successfully. Plans are in progress to construct a similar furnace, for temperatures up to 800°C, which will be available to ILL users. A new detector arm and shielding have been constructed and will be installed early in 1978. The new detector will move more rapidly thus reducing the setting time. During 1977 D9, which was constructed for single crystal diffractometry, was used briefly as a powder diffractometer. This type of experiment is not foreseen as a routine use of D9, since neither detector banks nor adequate Soller collimator are readily available.

D10 A/B - HIGH RESOLUTION FOUR CIRCLE THREE AXIS SPECTROMETER
(C. Zeyen and A. Filhol)

Throughout 1977 D10 continued to operate efficiently, with a high flux provided by the vertically focusing copper monochromator. A new detector shielding has become operational this year. The increased signal to background ratio has been especially useful for measurements of very weak scattering. For structural studies the influence of the high flux has been reduced by the Carine computer system, which is now far too slow for the diffractometer.

More than one half the experiments in 1977 used the three axis mode of operation and it is envisaged that this tendency will increase. Many different types of sample environment are now possible on the D10 cradle, these include high and low temperatures, high pressures and uniaxial stress, as well as magnetic fields.

D12 - NEUTRON CAMERA
(A. Wright)

During 1977 the low temperature Weisenberg arrangement was essentially rebuilt. The rotation table has been changed and a more substantial goniometer incorporated. The wall thickness of the cryostat tails was reduced to minimise the background scattering. In addition to new layer line screens a major innovation was the dévelopment of a novel set of collimators. The collimators, which are essentially two concentric cylinders with radial apertures, oscillate about the film axis and permit only those neutrons diffracted by the specimen to impinge on the film. These improvements have enabled the magnetic super lattice of materials with complicated magnetic structures and small moments to be recorded.

D15 - FOUR CIRCLE DIFFRACTOMETER ON AN INCLINED BEAM
(M. Thomas)

The lifting counter is now controlled automatically within the Andromache crystallographic package of the PDP8. This enables crystals to be measured, in normal beam geometry, even if the zone axis is inclined by $\sim$ 4° to the vertical. Therefore large ancillary equipment, for example superconducting magnets, can now be mounted on the diffractometer. The improvement has also optimised the measuring technique since it is now possible to automatically measure reflections in different layers. The working area around D15 has been increased by extension of the platform thus enabling the spectrometer to be operated in comfort. In mid 1978 D15 will equipped with a two stage refrigerator mounted on the mark VI Eulerian cradle enabling measurements to be made in equi-inclination geometry, over the temperature range 10-300 K.

D18 - NEUTRON INTERFEROMETER
(W. Bauspiess, Schindler and M. Schlenker (since October 1977))

In April 1977 the diffractometer bench for D18, manufactured at the Inst. of Physics Univ. Dortmund, arrived at the ILL and was installed in the D18 B position so that the mechanics could be tested. To demonstrate the high angular resolution of the interferometer axis, rocking curves of two Bragg reflections have been measured which show oscillatory structures in the range of 0.1 sec. of arc. In August an insulating room was constructed to contain the whole D18 area. This improved the thermal stability of the instrument by a factor of at least 4. The relative position of the monochromator and interferometer crystals do not now change measurably over a period of 12 hours even if the feed back control is switched off.

L14/5/7
(Y. Glaize and P.J. Brown)

Owing to insufficient technical support there has been no further developments to these facilities over the past year.

S20 - NEUTRON DIFFRACTION TOPOGRAPHY
(M. Schlenker)

A special instrument, S20, is dedicated to neutron diffraction topography, an observation technique akin to X-ray topography which produces images of single crystals using Bragg diffracted neutrons. The original capabilities of neutron topography are related with the low absorption of neutrons by most materials and with the direct interaction of neutrons with the distribution of magnetic moments.

This instrument, operated by a group from the Laboratoire Louis-Néel of the CNRS Grenoble, was used in investigations of growth defects in crystals containing heavy elements, hence too absorbing for X-ray topography to be feasible, and in studies of ferromagnetic and antiferromagnetic domain structures ; in the latter case, neutron topography is particularly valuable because it is the only direct method of observation available.

S21 - HIGH RESOLUTION DOUBLE CRYSTAL SPECTROMETER
(C. Zeyen)

S21 is situated on the thermal guide tube H24 and uses the waste beam of D10. Two nearly perfect crystals are arranged in the parallel focusing geometry. Extremely narrow reflection profiles (a few seconds of arc depending on the crystal quality) are obtained by either rotating the second crystal (ω-scan) or by varying the temperature of the first crystal (temperature-scan).

Both crystals are mounted into cryostats guaranteeing very good temperature homogeneities. Temperature is controlled and measured with a precision better than 10^{-3} Kelvin. Thus very small lattice distortions acompagnying structural phase transitions, lattice parameter changes induced by defects or impurities can be measured with a resolution of up to 10^{-6} depending on the crystal quality.

Given the extreme temperature resolution this spectrometer is particularly suited for the measurement of critical exponents, scaling functions and the study of multicritical points in order to check the predictions of renormalization-group-theory. The instrument can also be used for certain small-angle scattering experiments by placing the sample between the two parallel crystals. The spectrometer and the temperature regulation are computer controlled.

Operated in collaboration with Dr. H. Meister (Euratom, Ispra) the machine is also mainly financed by this organization. This year it has started to be scheduled for outside users.

Co-ordinator : K. ZIEBECK

instrument group "monochromators"

D13A	:	Neutron double-crystal diffractometer on thermal guide H24
D13B	:	High precision neutron double-crystal diffractometer on guide tube H24
D13C	:	Neutron single crystal orientation unit on H23
LI 2A	:	X-ray double crystal diffractometer
LI 2B	:	X-ray single crystal orientation unit
LI 3	:	Gamma-ray diffractometer

Laboratory for single crystal orientation and preparation

1. - INSTRUMENT DEVELOPMENT

D13A has carried out its routine work as usual without major modifications, i.e. check of monochromator crystal efficiency and special experiments on samples before being studied on neutron spectrometers. The installation of D13B between D13A and S21 on H24 has been achieved and first experiments of its performance with neutrons will be started soon.

D13C has been installed, too, on the thermal guide H23. Six nearly perfect Ge crystals with different orientations mounted on a drum can be used alternatively as monochromators and provide a 6 cm high monochromatic neutron beam without second order contamination. This beam height, which is not available on D13A, permits a much more rapid alignment of vertically and/or horizontally focusing multi-crystal monochromators than on D14A. At present minor parts of the construction are being finalised and first experiments are foreseen for January 1978.

On the γ-diffractometer L13 the support of the deformation device at high temperatures was modified. It has thus become possible to control the maximum mosaic spread used mostly in the horizontal direction of hot-pressed Ge and Si monochromator crystals during the anisotropic deformation process instead of the minimum mosaic spread.

2. - DEVELOPMENT OF MONOCHROMATOR MATERIALS

The success rate at the production of Ge and Si monochromator crystals has been improved, especially at low deformations where the mosaic structure was still somewhat non-uniform, by varying the rate of applied stress during the hardening process. Si crystals in particular now present a very homogeneous dislocation distribution. These crystals deform in a more uniform way because of their homogeneous defect structure before deformation. Tests of their efficiency for cold neutrons are in progress in order to replace pyrolytic graphite.

Several beryllium single crystals have been grown in the Max-Planck-Institut für Metallforschung, Stuttgart, Germany, and tested at the ILL for optimization of the growth parameters. With increasing amounts of impurities the mosaic spread became less uniform whereas small amounts of Cu seemed to homogenize the mosaic structure. The thick bars have also been studied by neutron topography for selecting large nearly perfect subgrains for subsequent in-beam plastic deformation. The α-β transformation is being investigated with the aim of improving the subgrain structure by a special cooling procedure. Finally, a feasibility study of pyrolytic graphite monochromators with variable lattice spacing has been undertaken.

3. - COMPOSITE SYSTEMS AND BENT CRYSTALS

A series of tests for curving thin plates of Si and Ge perfect crystals by a chemical procedure aiming at higher curvatures than achieved up to now has been carried out. Based on positive results a set of 15 crystals is being treated for the construction of a composite focusing monochromator. Germanium crystals with anisotropic mosaic spread have been produced in order to assemble a 16 x 9 cm^2 vertically focusing monochromator for IN8 allowing the variation of the radius of curvature during the experiment. The vertical mosaic spread of the (III)-oriented plates is 5 minutes whereas the horizontal one is about 30 minutes.

Based on the first successful application of the vertical focusing technique for neutron diffraction experiments at D10 another diffraction instrument (D1A) has been equipped with a composite system of 28 Ge crystals 14 x 5 cm^2 in dimension. Here the anisotropic mosaic spread (4 minutes vertical, 18 minutes horizontal) is of great advantage for focusing efficiently. The gain in intensity without subsequent loss in resolution was such that the intensity at D1A is now comparable to the intensity at D2 which is installed on a beam tube close to the reactor.

The development of large, vertically focusing monochromators with anisotropic mosaic spread has completely changed the philosophy of neutron guide tube exploitation, especially for thermal guide tubes. But vertical focusing will also lead to a large gain in intensity for slow neutrons. A 21 x 15 cm^2 horizontally and vertically focusing Si monochromator is under construction for IN5B.

4. - DIFFRACTION STUDIES OF IMPERFECT CRYSTALS

The dislocation structure of Cu single crystal which have been deformed under different conditions is being studied in more detail combining electron microscopy, γ-ray and neutron diffraction and topography in order to understand better the diffraction properties of monochromator crystals with isotropic and anisotropic mosaic structure. This work is carried out in collaboration with Oxford University. As a first result, the total attenuation coefficient μ has been determined as a function of neutron wavelength and of mosaic spread. Whereas the dependence of μ on the mosaic spread is negligibly small, its wavelength dependence came out to be a strong one in the thermal region.

The experimental data obtained with Cu and Si could be fitted rather well, by a formula describing the combined processes of inelastic scattering, capture and multiple scattering in a first approximation. Fig. 13 represents the results for several neutron monochromator materials at room temperature. More detailed and temperature dependent investigations are in progress.

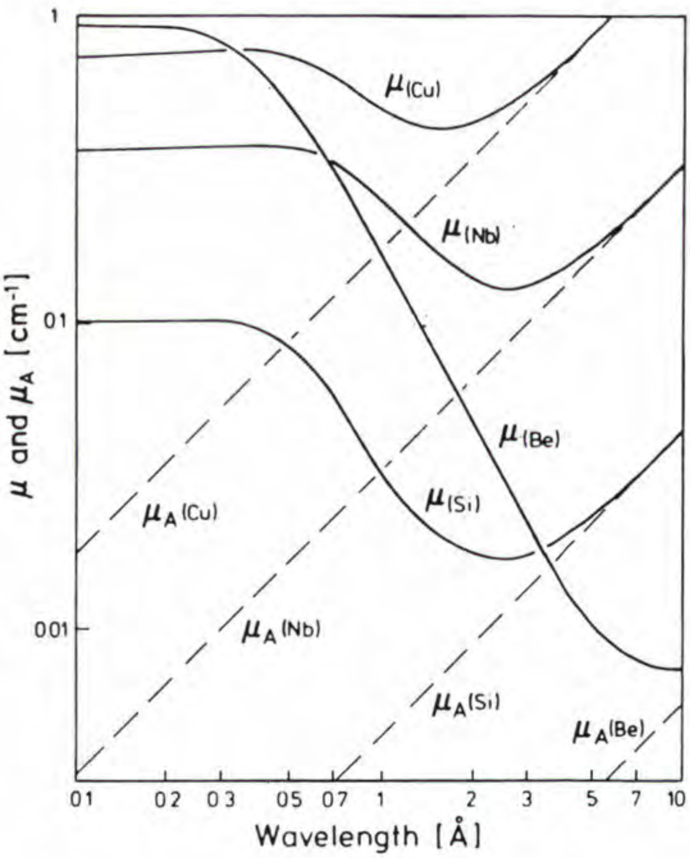


Fig. 13. - Linear coefficients of nuclear absorption (μ_A) and total attenuation (μ) as a function of neutron wavelength for different monochromator materials.

Neutron diffraction patterns of nearly perfect Si and Ge crystals have been studied in the asymmetrical Laue case. The observation of a very high peak reflectivity of 80 % compared to 50 % in the symmetrical case was theoretically explained using a relatively simple model and dynamical theory.

Co-ordinator : A. FREUND

colleges

introduction

All the internal scientific activity of the Institut is grouped into "colleges" with particular scientific interests.

The following is the current list of colleges :

College 2	:	Theory
College 3	:	Fundamental and Nuclear Physics
College 4	:	Excitations
College 5	:	Structures
College 6	:	Liquids, gases and amorphous materials
College 7	:	imperfections
College 8	:	Structural biology
College 9	:	Chemistry

Each College corresponds to a Subcommittee of the Scientific Council of the ILL, which advises the directors on the scientific programme. New research proposals submitted to the ILL will first be examined by the Colleges with respect to their technical feasibility and then be presented to the Council. A further task of the College is to contribute to a smooth carrying-out of the experiments by appointing local contacts and by advising the instrument responsible as well as the Scientific Secretary on the time schedules for the various instruments.

Experimenters have come to I.L.L. from these research centres or universities

college 2
"theory"

MEMBERS OF THE COLLEGE :

Brack M.
Burkhardt T.W.
Derrida B.
Fogedby H.
Haldane F.D.M.
Hinkelman H.J.
Iche G. (CNRS)
Johnston R.
Loveluck J.M.
Lovesey S.W.
Nozières P.
Schuck P.
Sherrington D.
Southern B.
Theumann A.
Young P.

VISITING SCIENTISTS :

Barber M.	(New South Wales)
Béal-Monod M.T.	(Orsay)
Castaing	(ENS, PARIS)
Eisenriegler E.	(KFA, Jülich)
Fischer K.	(Jülich)
Ford G.W.	(Univ. of Michigan)
Gautier F.	(Strasbourg)
Jennings B.	(Stony Brook)
Lavis D.A.	(London)
Leggett A.	(Sussex)
Lindgard P.A.	(Risø)
Menyhard N.	(Budapest)
Schofield P.	(Harwell)
Thouless D.	(Birmingham)
Toulouse G.	(ENS. PARIS)
Wallace D.	(Southampton)
Zawadowski A.	(Budapest)

(This list does not includes short visits of a few days)

The Theory College has continued to concentrate its effort in the field of condensed matter physics, but there are now two members of the group working in nuclear theory.

SCIENTIFIC TRENDS AND HIGHLIGHTS IN 1977

The year has seen a continuing effort in several already established fields (e.g. phase transitions and critical phenomena, spin glasses, static and dynamic properties of one-dimensional magnets), together with ventures into some new areas, such as the study of mixed valence systems (Haldane, Sherrington) and both the magnetic ordering and lattice dynamics of quantum crystals (Béal-Monod, Castaing, Nozières). These new interests partly reflect changes in college membership, and are partly the result of a development of existing interests. The effort in nuclear physics has now been increased by the addition of a second nuclear theorist (Brack), and, supported by a number of visitors in this field, a successful interaction with both ILL experimentalists and nuclear theorists at the Institut des Sciences Nucléaires has developed.

A striking feature of recent developments in theoretical physics is that many of the concepts and techniques are applied to a wide variety of apparently rather different problems. While this provides an underlying unification of different branches of theoretical physics, it also frustrates a description of the activities of the theory group in terms of traditional subject classifications. For example, within the group, real space renormalization group methods have been applied to a number of different problems : in the field of spin glasses, to compare the effects of dilution (percolation) and the competition between ferro- and antiferromagnetism (" frustration ") by Southern and Young, to discuss the surface critical behaviour of the Ising model (Burkhardt, Eisenriegler) and to calculate the surface free energy of Ising-type models (Burkhardt, Southern). The renormalization group approach has also been applied to study non-critical effects, such as the theory of bifurcations (Derrida), the description of long time - long wavelength correlations in Heisenberg paramagnets (Fogedby and Young) and in a study of the temperature dependence of the spin wave stiffness for a model ferromagnet (Lovesey), while other aspects of the dynamical behaviour of liquids (Lovesey) Heisenberg paramagnets in the hydrodynamic regime (Fogedby and Young) and one-dimensional magnets (Loveluck and Lovesey) are related by a description in terms of a generalized Langevin equation and the idea of mode-coupling. Other aspects of scaling theory have found applications in the Kondo problem (Haldane, Nozières) and in a study of the asymmetric Anderson model (Haldane), which was shown to exhibit universal behaviour, with two interesting limiting cases - the " mixed valence " and " Kondo " limits.

Furthermore, apparently unifying themes sometimes cover a diversity which is only resolved by consideration of the methodology rather than the system studied. For example, the heading of one-dimensional magnets covers work on the 1D XY model (Fogedby), using field-theoretic techniques previously applied to a model of a 1D electron gas, and, a completely different aspect, development of a stochastic equation to study the spin dynamics of a 1D Heisenberg magnet (Loveluck and Lovesey) which is based on mode-coupling theory. Similarly, some aspects of mixed valence systems were elucidated by the scaling approach to the asymmetric Anderson model, mentioned above, but other aspects, such as the role of electron-lattice coupling, have been investigated by a completely different approach by Sherrington. The apparently unifying theme of ^3He also embraces such diverse aspects as the study of two dimensional itinerant spin systems (Béal-Monod), as a model of helium films, the spin ordering of both 3D and 2D **solid** ^3He (Béal-Monod), which has possible connections with spin glass ordering, and the lattice dynamics (vacancy dynamics, melting mechanism, etc.) of solid ^3He (Castaing, Nozières).

Besides the renormalisation group approach to spin glasses, mentioned above, further work on disordered systems has included consideration of some exactly soluble models of quenched disordered systems (Sherrington), a 1D spin glass model incorporating some essential features of previous studies in a more transparent context (Theumann), and some preliminary work on excitations in disordered magnetic systems (Sherrington). A study of surface effects in the order-disorder transition of binary alloys was also completed by A. Theumann.

In the field of nuclear physics, work continued on semiclassical theories of nuclear matter (Brack, Schuck), with the inclusion of the effect of correlations, while work on the time-dependent Hartree-Fock method for the description of nuclear fission and fusion (Schuck) has also been extended to the theory of fission-fragment mass distributions (Brack), which is directly relevant to ILL experiments. Much of this work was done in collaboration with B. Jennings and P. Ring both of whom visited the ILL for over a month.

VISITORS, SEMINARS, WORKSHOPS AND CONFERENCES

As in previous years, the group has greatly benefited from visiting scientists, listed above, partly through direct interaction with the research programme of the group, but also by the influx of new ideas and themes which such visits provide. Many of these visitors have been extremely valuable in keeping the group in touch with recent developments in rapidly evolving fields, such as the renormalisation group approach to critical phenomena (visitors in this field included Barber, Toulouse, Wallace and Zawadowski) and the study of spin glasses (Fischer, Thouless). The group also profited from the sabbatical year of Prof. G.W. Ford, in particular from a number of seminars on topics with the general themes of non-linear perturbations and stochastic differential equations, with applications for example to rotational Brownian motion.

The Theory College has participated in the seminars on theoretical physics, organised by P. Nozières, which provide a valuable contact with other theoreticians in the Grenoble area. The seminar continues to be a very successful forum, and this year almost forty talks were given, covering both topics in which the ILL Theory Group has active research interests, as well as other topics which are currently attracting attention in theoretical physics, for example, superfluid ^3He and both surface magnetic and chemisorptive properties of transition metals.

A 3-day workshop on " Recent Developments of Semiclassical Approaches in Nuclear Physics " was held in November, organised by M. Brack and P. Schuck. The programme included invited speakers from Saclay (A. Votros, B. Grammaticos), Orsay (O. Bohigas, J. Treiner, H. Krivine), Stony Brook, New York (B. Jennings), Berkeley, California (B. Myers) and ISN Grenoble (M. Bouyssy), as well as the ILL organisers.

The active participation of nuclear physicists from the Grenoble area ensured a very lively and successful meeting and provided an excellent forum for the exchange of ideas.

Secretary : J. M. LOVELUCK

college 3
"fundamental and nuclear physics"

INTERNAL AND EXTERNAL MEMBERS OF THE COLLEGE

Avenier M.	
Almeida J.	
Asghar M.	
Barreau G.	
Bauspiess W.	
Blachot J.	(CENG)
Blakeway S.	
Bocquet J.-P.	(CENG)
Börner H.	(Jülich)
Brack M.	
Braumandl F.	
Byrne J.	(Sussex)
Cavaignac J.-F.	(ISN)
Charvet J.-L.	(ISN)
Crançon J.	(CENG)
Davidson W.F.	
Decker R.	(Giessen)
Do Huu Phuoc	(Lyon)
Von Egidy T.	
Emsallem A.	(Lyon)
Greene G.	(Harvard)
Guet C.	
Hamilton D.W.	(Sussex)
Hawerkamp K.	
Hungerford P.	
Jeuch P.	
Jung G.	
Kaiser W.	
Koglin E.	
Larysz J.R.	
Mampe W.	
Monnand E.	(CENG)
Nifenecker H.	(CENG)
Perrin P.E.J.	(CENG)
Rehfield D.	(Giessen)
Ristori C.	(CENG)
Schrader H.	
Schreckenbach K.	
Schussler F.	(CENG)
Schuck P.	
Siegert G.	
Smith K.	(Sussex)
Trinks U.	(Bonn)
Vignon B.	(ISN)
Warner D.	
White D.	(Oregon)
Wünsch K.D.	(Giessen)

VISITING SCIENTISTS

Armbruster P.	(GSI Darmstadt)
Bauchiat C.	(Paris)
Boehm F.	(Pasadena)
Chery R.	(Lyon)
Crawford G.I.	(Glasgow)
Dakowski M.	(Saclay)
Denschlag H.O.	(Mainz)
D'Hondt P.	(Gent)
Engler G.	(Soveq)
Finch E.	(Dublin)
Forte M.	(Ispra)
Golub R.	(Sussex)
Greif J.	(Giessen)
Hagberg E.	(CERN Geneva)
Hoff R.W.	(Livermore)
Jonson B.	(CERN Geneva)
Kienle P.	(Munich)
Kobisk E.	(Oak Ridge)
Kratz K.L.	(Mainz)
Leroux B.	(Bordeaux)
Miller P.	(Oak Ridge)
Mössbauer R.	(Munich)
Moreh R.	(Beer Sheva)
Münnich F.	(Braunschweig)
Müller K.	(Munich)
Paul W.	(Bonn)
Pendlebury J.	(Sussex)
Ramsay N.	(Harvard)
Rauch H.	(Vienna)
Reines F.W.	(California)
Robson J.	(McGill)
Signarbieux C.	(Saclay)
Suffert M.	(Strasbourg)
Van Assche P.	(Mol)
Wilson R.	(Harvard)
Wagemans C.	(Mol)
Weirauch W.	(Braunschweig)
Wollnik H.	(Giessen)

GENERAL SUMMARY

Experiments have been performed in the following fields of nuclear and fundamental physics.

1) The fission process was studied with the mass spectrometer for fission products LOHENGRIN (PN1), with the on-line mass separator OSTIS (PN6) and at the intense neutron beam IH1.

2) Detailed and high precision investigations of the nuclear structure are performed at the beta spectrometer BILL (PN2), at the crystal spectrometers for gamma rays GAMS1 and 2/3 (PN3), at the pair and anti-Compton spectrometers (PN4) and at the thermal neutron beam H22. Nuclear spectroscopy measurements on fission products were carried out at LOHENGRIN and OSTIS. Neutron induced particle emission ((n, α) and (n, p)) is investigated at the thermal neutron guide H22.

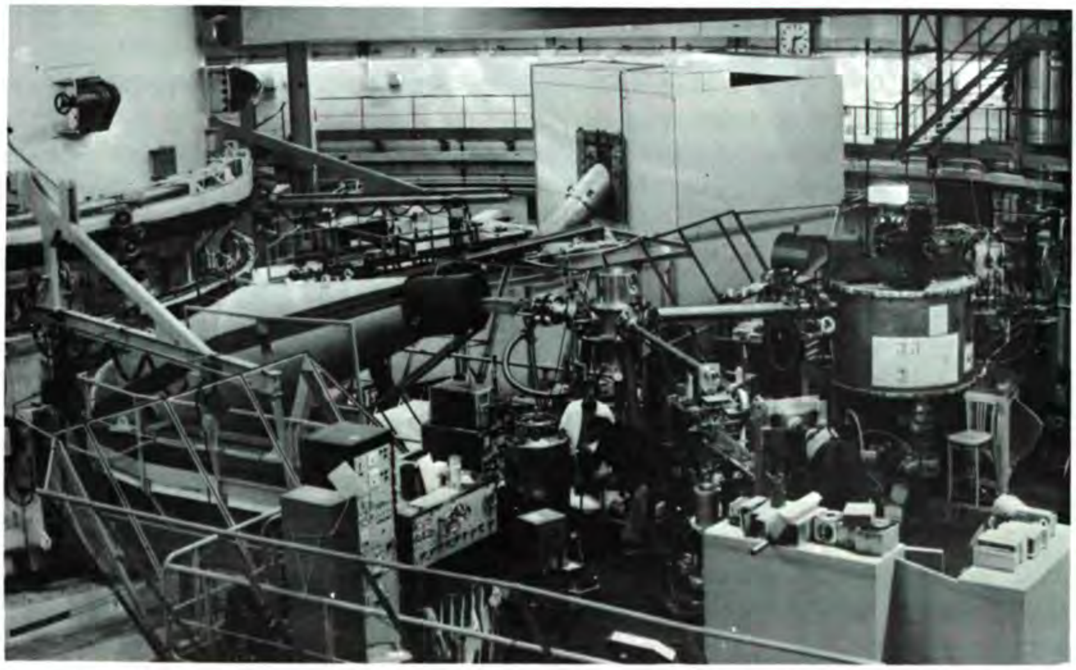
3) The fundamental physics programme comprises measurements of the neutrino cross-sections and the search for neutrino oscillations, the half-life of the neutron, the magnetic moment of the neutron and the search for the electric dipole moment of the neutron. Ultra-cold neutrons and cold neutrons were applied. A search for parity violation in hadronic interaction and tests of time reversal invariance are carried out at the polarized cold neutron beam (PN7).

4) Nuclear methods are applied to atomic physics at BILL and GAMS and to solid state physics at the thermal neutron guide H25.

Altogether 103 experiments have been performed. They are given in detail in 79 accepted proposals which were selected from 113 proposals submitted in 1977.

SCIENTIFIC TRENDS

A programme was started in 1976 to use the anti-neutrino flux of the reactor to determine cross-sections for neutrino induced reactions (inverse β -decay) and to search for neutrino oscillations. New experiments have been devoted to the



Ultra-cold neutron source with (from left to right) its shielding, guide, distribution box (above the two people), to which 2 experiments are connected. The upper guide leads to the magnetic storage ring for ultra-cold neutrons located in the cylindrical container on the right of the picture.

half-life and to the electric dipole moment of the neutron. It was possible for the first time to store neutrons in a magnetic field for more than 20 min. The search for parity violation in hadronic processes will continue with special emphasis to establish not only lower limits but definite values in simple nuclear systems.
The main research activity with the beta spectrometer BILL and the gamma spectrometer GAMS is devoted to nuclear spectroscopy in the actinide region in order to establish new nuclear structures. In addition, this high precision nuclear spectroscopy is aiming at the detailed study of levels at higher excitation energies. In nuclear fission experiments were started to investigate yields of mass and nuclear charge in the fission valley and in the heavy fission product group and to look for isomer formation.

EXPERIMENTS CARRIED OUT IN 1977

1) **Nuclear fission experiments performed with the mass separators for fission products LOHENGRIN and OSTIS and with special experimental arrangements.**

a) **LOHENGRIN :**

The yield of spin isomers in fission was studied as a function of kinetic energy of the fission products. This permits a correlation to be established between the spin and the excitation energy of the fission fragments. Isomers in the μsec region are measured on-line, isomers with half-lives above 0.1 sec are transported with a tape to the measuring position. This tape transport facility was used also to measure the nuclear charge distribution of fission products with the radiochemical method in the light wing of the heavy group. By comparing γ-ray spectra taken at Lohengrin and at Ostis the nuclear charge distribution could be deduced in the heavy wing of the heavy group. To cover the heavy group completely, the development of nuclear charge and mass sensitive detectors was continued. Promising results have been obtained from a gaseous absorber and from a silicon Δ-E-detector each followed by a time-of-flight system. The application of the collision-induced X-ray emission was followed further on and the emitted β -particles (indicating a change of nuclear charge) were counted in a surface barrier detector to test this method. The programme to investigate the response function of surface barrier detectors was continued with measurements of the plasma delay time.

b) **OSTIS :**

The yield of Rb and Cs isotopes from fission was measured with a standard Ostis source containing about 2 g of ^{235}U. The necessary corrections for the delay time in this ion source have been applied. In addition a very small ion source containing only 2 mg of ^{235}U was developed. It could be shown that the delay times are in the range of 5 to 15 msec which is much less than the shortest half lives. Therefore no corrections are necessary and the yields can be measured directly.

c) **SPECIAL EXPERIMENTS :**

Detector arrangements have been used to measure special modes of neutron induced fission of ^{235}U like α-particle accompanied fission, fission and simultaneous emission of two alpha particles and fission at very low excitation energy i.e. without neutron emission.

2) **Nuclear Spectroscopy**

High precision nuclear spectroscopy on nuclei excited by neutron capture was performed by the beta-spectrometer BILL, the gamma spectrometers GAMS, the anti-Compton and pair spectrometers and by special experiments at neutron beams. Nuclear spectroscopy on fission products was done at LOHENGRIN and OSTIS.

a) **Beta spectrometer BILL** : Energies and spins of levels have been determined with the (n, e) reaction for ^{109}Pd, ^{152,154}Eu, ^{155}Gd, ^{168}Er, ^{174}Yb, ^{199}Pt and ^{235}U. The neutron binding energies of ^{114}Cd, ^{165}Dy, ^{168}Er and ^{200}Hg were measured with an error of about 10^{-5} ($\triangleq$ 100 eV).
A direct measurement of M1 admixtures in the stop-over transitions in a γ-vibrational band (^{168}Er) was performed for the first time. The admixtures were measured from three such transitions via the L subshell ratios of the conversion electron lines. A M1 admixture is in contradiction to the model of a superfluid nuclear matter.
In ^{235}U many β -, γ- and octapole vibrational bands have been identified for the first time via the multipolarities of the transitions. Strong E0 components were found in the transitions from the β -vibrations.
The continuous β -spectrum from fission products produced by ^{235}U (n, f) was measured. The result will be used to calculate the anti-neutrino spectrum from fission products and from the reactor.

b) **Gamma spectrometers GAMS and pair and anti-Compton spectrometers :**

Level schemes in the isotopes ^{109}Pd, ^{138}Ba, ^{145}Sm, ^{153,155}Gd, ^{168}Er, ^{194}Os, ^{200}Hg, ^{227}Ra, ^{231}Th, ^{235}U and ^{250}Bk were deduced with the help of precise gamma spectra of these nuclei. In ^{145}Sm a correlation between primary gamma intensities from (n, γ) and (d, p) strengths was established, indicating direct capture mechanism. In the case of ^{155}Gd and ^{168}Er extensive γ-data have been taken to explore the region of highly excited intrinsic states. ^{194}Os was measured for the first time by exploiting to the full the combination of the high neutron flux plus the sensitivity of the γ-spectrometers. The prolate-oblate shape transition of the Os isotopes was followed up to ^{194}Os which becomes a truly oblate rotor. From a measurement made in 1976 together with Ge (Li) data from Brookhaven, a succession of nuclear levels could be established in ^{196}Pt, which was predicted recently by the interacting boson approximation with the symmetry subgroup 0(6). The level structure of ^{196}Pt is believed to be the first example of this symmetry. The (n, γ)-spectrum of ^{227}Ra has been measured for the first time. This is one of the few nuclei accessible by (n, γ) techniques in the transitional region between ^{209}Bi and ^{230}Th and unusual vibrational states are expected.

c) **LOHENGRIN :**

The program to determine Q_β values in the range of low yield fission products was continued successfully. The decay of spin isomers of fission products was examined.

d) **OSTIS :**

On Rb and Cs fission products available at Ostis a wide variety of nuclear spectroscopic measurements have been carried out. Half-life determinations were made and the new isotope ^{147}Cs was identified. Gamma- and conversion electron spectroscopy was performed to deduce energies and spins of nuclear levels of very neutron rich nuclei. High precision measurements of Q_β-values have been made with an intrinsic Ge-detector with errors between 5 and 50 keV.
Energy spectra of delayed neutrons have been taken by measuring the time of

flight of the neutrons and by using ^{3}He spectrometers. These energy spectra show pronounced structure.

e) Special experiments : A facility was developed to measure γ-γ angular correlations after neutron capture. First measurements were performed on $^{161,163}Dy$ targets. A dilution refrigerator was operated at a temperature of 30 mK. It can be used now to measure on-line directional distributions of γ-rays from oriented nuclei.

An experiment especially designed to measure the cross-section for one and two photon decay after neutron absorption in ^{3}He was carried out.

3) **Beam Experiments Using Nuclear Reactions**

a) **Charged particle emission after neutron capture :**

The (n, α), (n, γα), (n, p) and (n, γp)-reactions were performed with S (natural sulphur), ^{40}K, Zn, $^{152,155,157}Gd$, ^{209}Bi, and ^{235}U targets. In addition, the radioactive target nuclei ^{37}Ar, ^{76}Br, ^{109}Cd (produced by the ISOLDE facility at CERN, Geneva) and ^{93}Mo (produced at the Lyon cyclotron) were used. After preliminary data evaluation the cross-section in the ^{235}U (n, α) ^{232}Th reaction seems to be much smaller than reported in the literature. The total (n, α) + (n, p) cross-section for ^{37}Ar is 2040 $\pm$ 200 b. This is the highest cross-section after ^{10}B (n, α) and ^{3}He (n, p).

b) **Scattering length :**

With the neutron interferometer D18 the scattering lengths of H, ^{2}H, ^{3}He, N, O, Ne, Ar, Kr and Xe have been measured. The data set is currently analyzed.

4) **Nuclear methods applied to atomic physics and to solid state physics.**

a) **Atomic physics** : the energy shift between the Kα, X-ray of Hg (Z = 80) and its hypersatellite line (relative intensity 10^{-5}) emitted by a doubly K-ionized atom has been determined in the ^{199}Au decay as 1145 $\pm$ 12 eV by means of the curved crystal gamma spectrometer GAMS1. There remains an unexplained discrepancy of 39 eV with theoretical calculations (J.P. Desclaux, CENG).

b) **Solid State physics :**

The concentration profiles of implanted Boron (standard doping material for p-type semiconductors) can be deduced from the energy loss of α-particles emitted after neutron capture in ^{10}B. The following problems connected with semiconductor technology were investigated :

— Range distribution and diffusion of ^{10}B implanted in SiO_2. It was found that the mean projected range is 10 to 20 % higher whereas the straggling is 10 % lower than predicted by theory. The diffusion coefficient is much lower than expected. The diffusion of ^{10}B in Si was measured separately for comparison with the known diffusion of ^{11}B in Si to get the mass dependence of the diffusion coefficient.

— The concentration profiles at Si/SiO_2 boundaries (which are used in microelectronic devices) were measured as a function of oxidizing conditions, inert annealing, temperature and crystal orientation to deduce the segregation coefficient (the concentration of ^{10}B in SiO_2 compared to that in Si). First results indicate that the segregation depends on the time of oxidation and whether dry or wet oxidation was used.

5) **Fundamental Physics**

a) **Neutrino physics :**

To measure cross-sections for anti-neutrino induced reactions, and later to look for neutrino oscillations, detector prototypes were constructed (ISN, Grenoble) and background measurements were made. The detector will be installed in the basement of the reactor where the background from the reactor is very low and the cosmic rays are shielded by the concrete and water of the reactor.

b) **Properties of the neutron :**

The experiment to measure the magnetic moment of the neutron was completed. The precision has been improved by a factor of 100. The ratio of the magnetic moment of the neutron to that of the proton is now

$$\mu_n/\mu_p = -0.68497945\ (17).$$

An experiment was set up and is progressing well, which stores the protons from the neutron decay by a combination of electric and magnetic fields in order to determine the half-life of the neutron.

c) **Parity violation :**

The programme to search for parity violation in hadronic processes has been continued. Nuclei are oriented by capture of polarized neutrons. A large asymmetry effect of $(4.4 \pm 0{,}6)\ 10^{-4}$ i.e. parity violation was found in the reaction ^{117}Sn (n, γ) ^{118}Sn. A similar investigation for the reaction ^{35}Cl (n, γ) ^{36}Cl is currently under way.

More information on these experiments can be found in the Annexe to this Annual Report (separate volume).

SEMINARS, WORKSHOPS AND CONFERENCES

In 1977 the fundamental and nuclear physics college organised 31 seminars, dealing with nuclear structure, fission, heavy ion collisions, atomic and fundamental physics and the application of nuclear methods to solid state physics. Visiting scientists (S. Balestrini, R. Casten, H.G. Clerc, M. Dazowski, G. Engler, A. Gizon, W.D. Hamilton, R.W. Hoff, J. Lieder, B. Leroux, R. Moreh, P. Quentin, F. Reines, E. Roeckl, D. White, H. Wollnik) contributed with 16 seminars. 15 talks were given by physicists from Grenoble (H.G. Börner, M. Brack, F. Braumandl, W.F. Davidson, R. Decker, J.P. Desclaux, A. Gizon, C. Guet, K. Hawerkamp, P. Jeuch, W. Mampe, E. Monnand, K. Schreckenbach, F. Schussler, K.D. Wünsch).

Four workshops have been organized by the ILL in this college in 1977. The first was held 19 Jan. on " Future Fission Research at the ILL ". The need for a fission product separator for coincidences betwen fission products and α-particles, neutrons and γ-rays at an external neutrons beam was pointed out in this workshop. On 17 June a workshop on Neutron Optics and Ultra-Cold Neutrons was organized. Ten participants came from outside and about 25 ILL physicists participated.

In cooperation with CEN-Grenoble a meeting devoted to " Nuclear Fission " was held on 29th and 30th Sept. About 50 physicists attended, roughly one half of them being from the ILL.

A workshop on " Fundamental Physics Experiments with Reactor Neutrons and Neutrinos " was organized by the ILL on 10 and 11 Oct. The workshop was attended by 37 participants from outside Grenoble and by about 40 physicists from the ILL, ISN and CENG. Theory and experiments of properties of the neutron, of parity violation and time reversal invariance and of neutrino physics were discussed. Special emphasis was put on future experiments to be performed at the ILL.

Secretary : G. SIEGERT

college 4
"excitations"

MEMBERS OF THE COLLEGE

I - **EXPERIMENTALISTS, ILL**

Copley J.R.D.
Currat R.
Dorner B.
Escribe C.
Fitzgerald W.
Ghosh R.
Jenkin G.
Joffrin C. (L.L.B. Saclay)
Lechner R.E.
Lefebvre J.
Pynn R.
Scherm R.
Stirling W.G.
Suck J.B.
Wagner V.
Ziebeck K.R.A.

II - **THEORETICIANS AND EXTERNAL**

Castets A. (CNRS)
Coey M. (CNRS)
Fogedby H.C.
Loveluck J.
Lovesey S.
Rossat-Mignod M. (CENG)
Southern B.
Villain J. (CENG)

GENERAL SUMMARY

As its name suggests, the work of College 4 is concerned with studies of the elementary excitations of solids and with their interactions. The principal subject subdivisions, as used by the ILL for administrative purposes, are :

- 04-01 : Lattice dynamics (essentially phonon dispersion curves and phonon-phonon interactions)
- 04-02 : Dynamics of structural phase transitions and electron - phonon effects
- 04-03 : Magnetic excitations and magnon-phonon effects
- 04-04 : Dynamics of magnetic critical scattering.

The College has approximately 25 members of whom 14 are engaged actively in experimental work at ILL, the others being external members or theoreticians. As in the past, most of the experimental work has been performed using triple-axis crystal spectrometers (IN1, IN2, IN3, IN8) but some experiments use diffractometers (D5, D10, D12) and time-of-flight and high-resolution instruments (IN4, IN5, IN10). In the last year the triple-axis instruments have operated adequately, in general, but all continue to suffer from unacceptable time losses due to a combination of the Carine computer, a d.c. motor positioning system and somewhat outdated electronics. It is hoped that improvements to be implemented on the cold-neutron spectrometer IN12 will provide the basis for a new control system. IN12 has a step-motor " central-drive " system and is to be connected to a dedicated SOLAR 16/40 computer.

In Table 1 are given the totals of experimental periods, listed by instrument, for the period October 1976 to October 1977. The distribution of experiments is very similar to that for 1975-1976. At the meetings of March and October of 1977, the members of Subcommittee 4 considered a total of 96 proposals of which 62 were allocated beam time (not including short test experiments). Table 2

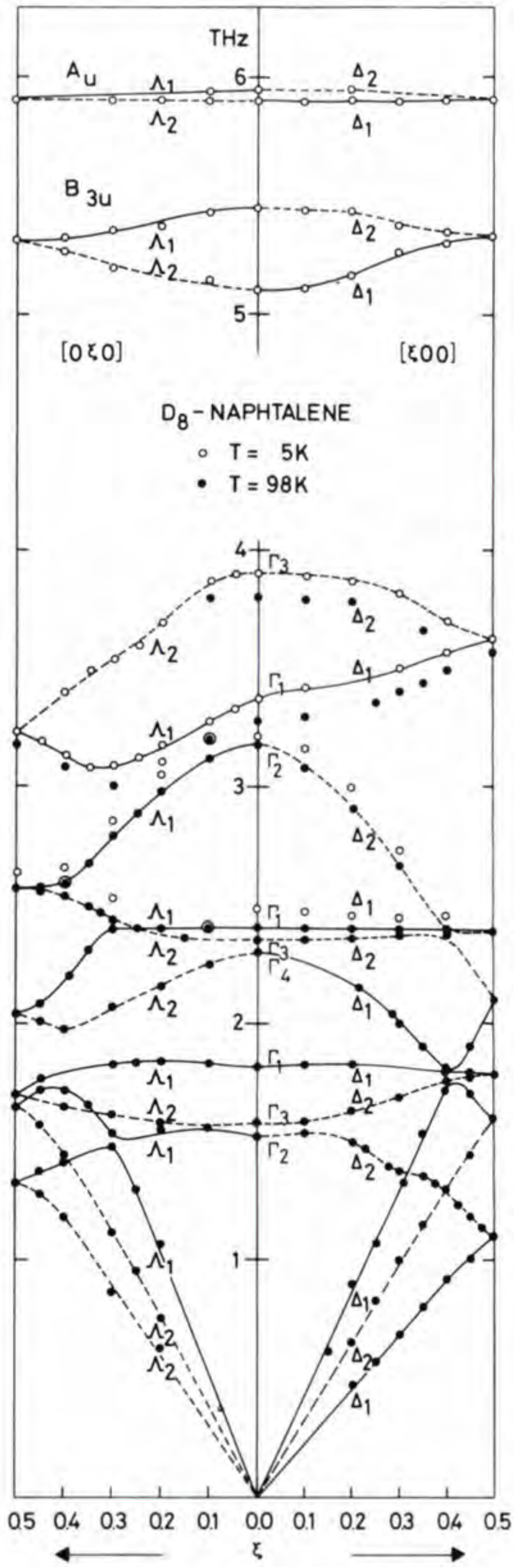


Fig. 14. - Experimental dispersion curves of deuterated naphthalene (IN3). (the lines are guides for the eye)

lists these proposals by category ; for comparison the figures for 1976 are also given. Overall there is little obvious change from 1976 to 1977 except that the total number of "phonon " proposals decreased somewhat with a corresponding increase in the "phase transition" category.

At the March meeting the problem of the performance of ILL triple-axis spectrometers was raised. Although general satisfaction was expressed, it was stated that there was obviously room for improvement, particularly in shaft-positioning and computer control. Since that time an expert committee within the Institut has been studying the former of these problems. It is to be hoped that considerable improvements will result from this study. It was noted at the October meeting that there continues to be a lively interest in phonon dispersion curve measurements, particularly for molecular crystals.

SCIENTIFIC TRENDS AND HIGHLIGHTS IN 1977

In the field of molecular crystal dynamics, it is interesting to note the success of an experiment on IN3 to measure in detail the dispersion curves of deuterated naphthalene [1]. Figure 14 presents the dispersion curves for two reciprocal space directions, principally at 98K but with some 5K data. These results are considerably more complete than previous measurements. The data is to be compared in detail with sophisticated model calculations and future work on naphthalene will be concerned with the temperature and pressure dependence of the phonon frequencies and widths. For this programme, workers from Russia, Poland, West Germany, Britain and the ILL are collaborating.

Another unusual dispersion curve measurements is that on β -Gallium [2]. Since the β -phase is metastable, the crystal was grown in situ on a motorised 4-circle goniometer **inside** the cryostat ; particular care was necessary to maintain accurately the sample temperature and to protect the crystal against mechanical shocks. Rather complete dispersion curve data were obtained on IN2 for frequencies below 2.5 THz.

There continues to be current interest in the lattice dynamics and phase transitions of perovskites represented by experiments on $NaNbO_3$ [3], KTN [4] and $KTaO_3$ [5]. The latest IN10 measurement of the "central peak" width in SrTiO [6] shows that no line broadening is observed within an experimental upper limit of 0.05 μeV over a temperature range of more than 10° above and below T_c.

Lead phosphate, $Pb_3(PO_4)_2$, has a rhombohedral high temperature phase and exhibits a ferroelastic phase transition at 180°C to a monoclinic structure. Soft modes have been observed [7] at both fundamental Bragg peaks and at superlattice positions. A precise study of the linewidth of the latter soft mode is soon to be performed. Another ferroelastic material under study is Sb_5O_7I[8], which exhibits strongly temperature-dependent quasielastic scattering at the superlattice positions.

Turning to materials where electron band effects play an important role, we should mention the elegant experiments on lead tin selenide, $Pb_{1-x}Sn_xSe$ [9]. Using a horizontally curved analyser on IN3, the low frequency [001] modes were studied as a function of temperature and concentration. A clear dip was found at 40K, for a tin concentration of 20 % in both the frequency and the linewidth of the zone-centre transverse optic mode of lowest frequency. This effect has been related to the band inversion which occurs at that temperature.

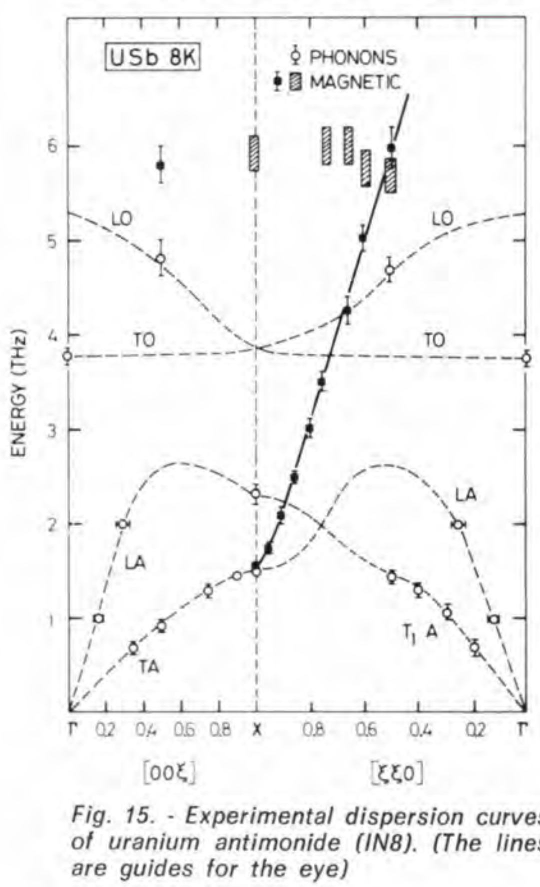


Fig. 15. - Experimental dispersion curves of uranium antimonide (IN8). (The lines are guides for the eye)

As in previous years, magnetic inelastic scattering continues to provide new and exciting information. For the first time, a spin-wave excitation has been observed in a metallic actinide compound, USb [10]. The dispersion curves, both phonon and spin-wave, are shown in Figure 15. As well as the spin-wave excitation, which **decreases** in frequency with decreasing temperature an exciton or crystal-field transition has been observed at about 6 THz. Further work is necessary to determine the polarization of these magnetic excitations.

In recent years there has been a considerable interest in the behaviour of magnetic excitations in systems of low dimensionality. Although the one-dimensional Heisenberg antiferromagnet TMMC ($(CD_3)_4NMnCl_3$) has been studied in depth by neutron methods, it is only recently that the effect of impurities on the ordering has been considered. In TMMC containing paramagnetic copper [11], it is found that the spin-waves develop a large width at wavevectors smaller than that corresponding to the Cu-Cu distance. There is also some evidence which suggests that in this case the spin-wave dispersion curve does not go smoothly to zero frequency, but rather develops an energy gap at zero wavevector.

The first measurements on a dilute two-dimensional ferromagnet, $K_2Cu_{1-x}Zn_xF_4$, have recently been performed [12]. Both the frequency and linewidth of the magnetic excitations are affected by the presence of the non-magnetic impurity. Excellent agreement was obtained between the experimental results and the predictions of a continued fraction calculation for low concentrations, while at higher impurity concentrations the calculation slightly underestimates the excitation frequencies.

Many neutron measurements have been made on the itinerant antiferromagnet chromium, usually alloyed with a transition metal. A recent IN8 experiment has studied the magnetic excitations as a function of temperature in **pure** chromium [13]. In a series of constant energy scans through the satellite positions, the magnetic inelastic intensity was found to increase with temperature up to a maximum at ~ 331 K, some 20 K above the Néel temperature. Moreover a discontinuous change in the intensity was observed at 301 K, consistent with a first order introduction of a band gap.

The latest in a series of experiments on ordered ferromagnetic Pd_3Fe concerns the behaviour of the [111] direction spin-waves as the temperature is raised through the Curie point ($T_c \sim 500$ K) [14]. The spin-waves exhibit a large softening and damping, but, in contrast to the situation in iron and nickel, no well-defined spin-waves were observed above T_c in the paramagnetic phase.

Of necessity, the above account constitutes a subjective, but reasonably representative selection from the large number of College 4 experiments performed at ILL during the last year. It is to be hoped that it indicates the type of "excitation" research at present being undertaken at the Institut.

WORKSHOPS, CONFERENCES AND SEMINARS

As usual, many of the Tuesday and Thursday seminars treated the physics of condensed matter. In addition, during 1977 the 3-axis group met regularly each Wednesday for informal seminars and discussions.

Secretary : W. STIRLING

EXPERIMENTS CITED ABOVE

[1]	Naphthalene $C_{10}D_8$	:	Bokhenkov, Dorner, Kalus, Mackenzie, Natkaniec, Pawley, Schmelzer
[2]	β -Ga	:	Bosio, Cortes, Copley, Teuchert
[3]	$NaNbO_3$	:	Denoyer, Lambert, Currat, C. Joffrin
[4]	$KTaNbO_3$ KTN	:	Cowdille, J. Joffrin, Ziolkiewicz, Currat
[5]	$KTaO_3$	:	Perry, Buhay, Currat
[6]	$SrTiO_3$	:	Heidemann, Hayter, Axe, Mezei
[7]	$Pb_3(PO_4)_2$	:	C. Joffrin, Currat
[8]	Sb_5O_7I	:	Prettl, Wagner
[9]	PbSnSe	:	Vodopyanov, Scherm
[10]	USb	:	Lander, Stirling
[11]	TMMC	:	Renard, Boucher, Fitzgerald
[12]	K_2CuZnF_4	:	Wagner, Krey
[13]	Cr	:	Booth, Ziebeck, Escribe
[14]	Pd_3Fe	:	Cowley, Hilton, Stirling

TABLE VI

Instruments used for experiments in the College " excitations " (October 1976 - October 1977)

Instrument :	IN1	IN2	IN3	IN4	IN8	IN10	D5	D12
Number of experimental periods :	8	20	18	1	15	3	1	1

TABLE VII

Number of proposals submitted to the meeting of the Subcommittee "Excitations" in 1977.

Category	March 1977		October 1977		1976	
	Submitted	Accepted	Submitted	Accepted	Submitted	Accepted
04 - 01	14	11	23	12	48	32
04 - 02	13	9	15	10	19	15
04 - 03	13	9	14	9	31	20
04 - 04	2	1	2	1	—	—
Totals	42	30	54	32	98	57

college 5
"structures"

MEMBERS OF THE COLLEGE

Aldebert P.	
Bartunik H.D.	
Bauspiess W.	Dortmund
Bentley G.A.	
Bomchil G.	
Brown P.J.	
Buevoz J.L.	
Burger N.	
Cheel V.	Oxford
Convert P.	
Croset B.	
Feld R.	
Filhol A.	CNRS Bordeaux
Fitzgerald W.	
Freund A.	
Gardner P.	
Givord D.	
Graeff W.	Dortmund
Gregory A.	
Hermann-Ronzaud D.	
Hewat A.W.	
Jenkin G.	
Lehmann M.S.	
Leslie M.	Oxford
Marti C.	
Mason S.A.	
Overs T.	
Riekel C.	
Savariault J.M.	Toulouse
Schlenker J.	
Schweizer J.	CENG DRF/DN
Soubeyroux J.L.	Bordeaux
Tasset F.	
Thomas M.	
Timmins P.	
Trost W.	
Vettier C.	
Wilson S.A.	
Wolfers P.	CNRS Grenoble
Wright A.	
Zeyen C.	
Ziebeck K.	

VISITING SCIENTISTS

Costa M.	Coimbra, Portugal
Eiriksson V.R.	Iceland
Lander G.	Argonne, USA
Olovsson G.	Uppsala,Sweden
Olovsson I.	Uppsala,Sweden

GENERAL SUMMARY

During 1977 the range of instruments used by members of the college has remained unchanged, though most of them have undergone some improvements as outlined in the section of the report devoted to diffraction group instruments. The college has made a major effort during the year to improve both the ease of use and the documentation of programs associated with crystallographic computing. There now exist new documents describing the college 5 data reduction system, the Cambridge crystallography subroutine library, and a set of routine programs for 4-circle diffractometers. Programs from other centres which have been adapted to run on either the DEC10 or the CDC system are : the constrained refinement program ORION of Andre, Foure and Reaud and the multipole refinement program MAUDY from Buffalo. A start has been made on a new program to determine conditions for multiple Bragg scattering from single crystals taking the diffractometer resolution into account.

Interest within the college in the determination of electron densities by comparative X-ray and neutron diffraction studies remains high. Investigations have been carried out on pyridine n-oxide trichloracetic acid, pyridine n-oxide cobalt 2-perchlorate and para-nitro pyridine n-oxide. These are aimed at following the charge density around NO_2 groups as a function of chemical environment. A rather simpler system currently being studied by the same methods is hydrogen peroxide (H_2O_2). Within this general area of interest some members of the college are taking part in the International Union of Crystallography project to assess reproducibility in the determination of charge densities. The compound being studied by the participants is oxalic acid. At ILL a set of integrated intensities has been collected on D8 at 0.84 Å and on D15 at 1.16 Å, both at 100 K. Comparison of the two data sets pin-points problems due to multiple scattering in the aligned zone-axis normal beam geometry used on D15.

In the attempt to increase the spatial resolution of diffraction studies, data collected with high momentum transfer at short wavelengths is becoming more and more important. In such measurements a proper subtraction of thermal diffuse

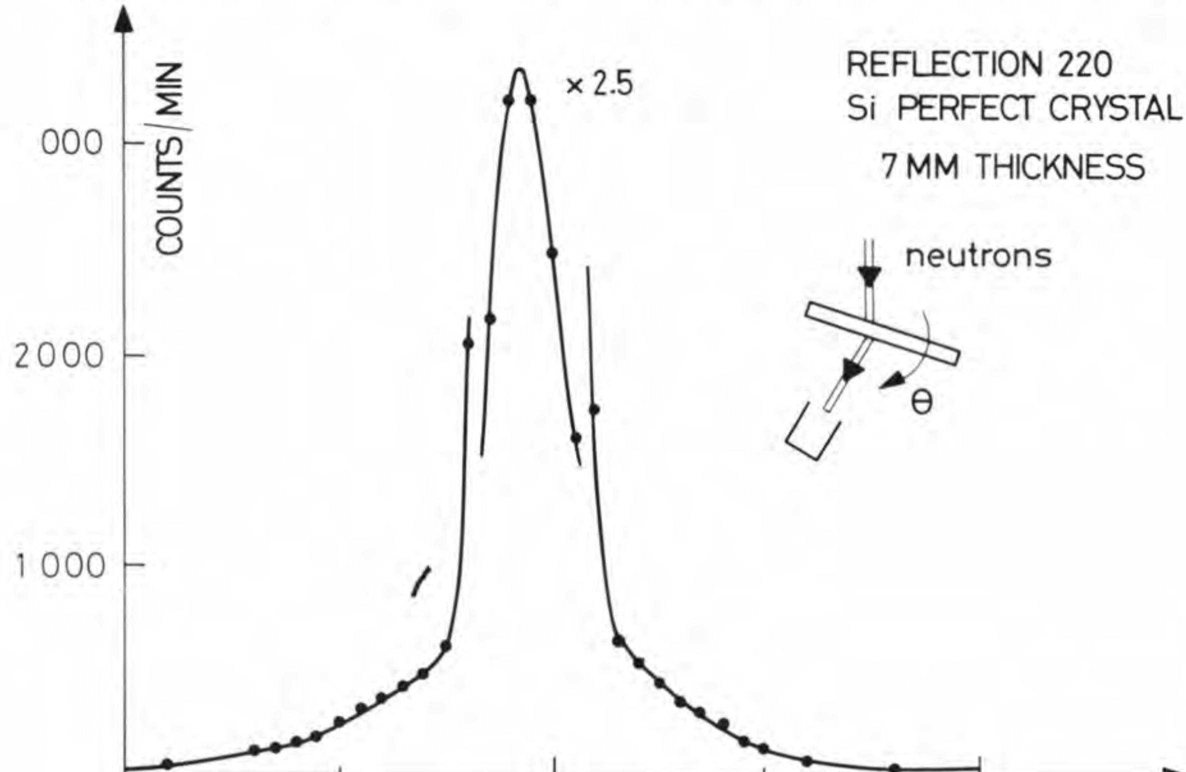


Fig. 16. - Rocking curve for the reflection 220 from a plate of perfect Si crystal in Laue Geometry (λ = 0.60 Å). The intensity of the elastic scattering from a perfect crystal is independent of crystal thickness (if the crystal is sufficiently thick), whereas the thermal diffuse scattering is proportional to the amount of material in the beam, so in principle the thermal diffuse scattering can be obtained from rocking curves of two crystals with different thickness by subtraction.
The reflection 220 is near the focusing position and the thermal diffuse scattering is clearly visible as tails on the elastic peak. *(Graf, Schneider, Lehmann and Freund)*

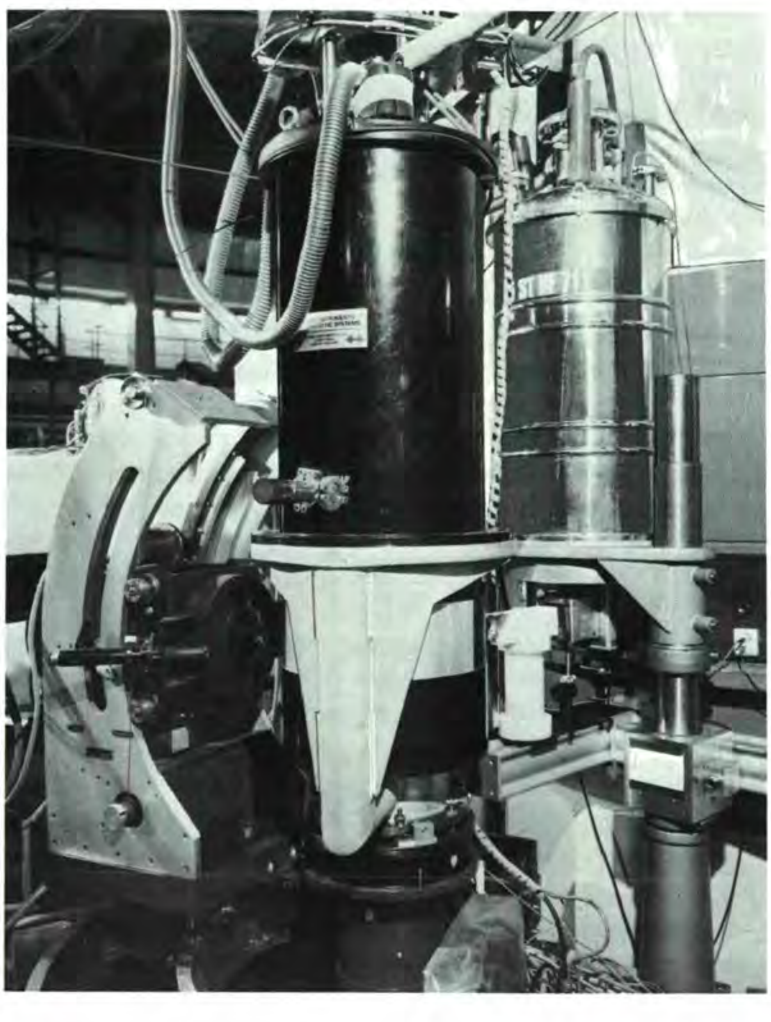
scattering (T.D.S.) is essential if the thermal parameters obtained are to have any physical meaning. Efforts are now being directed to ways of improving the TDS correction. A recent study of a perfect silicon crystal on D9 at 0.6 Å enables the evolution of the TDS as a function of $\sin\theta/\lambda$ to be seen very clearly (Figure 16).

In the field of protein crystallography measurements on a single crystal of triclinic lysozyme begun in 1976, were completed to d-spacings below 1.5 Å during 1977. Least-squares programs, for the refinement of individual atomic parameters for all atoms, are being implemented. These programs make extensive use of a fast Fourier algorithm.

Studies of polycrystalline materials also continue to develop strongly. The availability of a new high temperature furnace has enabled the ceramics La_2O_3 and Nd_2O_3 to be investigated up to 2200°C on D1B. Three different phase regions have been identified and the structures of the three phases elucidated. Several hydrogen bonded systems have been studied using high resolution powder diffraction on D1A. For example, new measurements on DADP have more clearly revealed the mechanism of the anti-ferroelectric transition from the behaviour of the anisotropic thermal ellipsoids in both phases. High pressure measurements on KDP and DKDP have shown how the hydrogen bonded PO_4 groups rotate with pressure in these ferroelectric materials. Both phases of deuterated resorcinol and acetanilide have been refined with up to 130 structural parameters, and with sufficient detail to reveal molecular librations. The refinement of five phases of ND_4NO_3 represents the most complete structural study yet made of the series of transitions in this rather difficult material. Other problems still under attack include the phases of solid methanol and the transition in n-methyl acetamide. Recent successful studies of phase transitions in inorganic materials are illustrated by Pb_3O_4, $CsPbCl_3$, $Na_2K_{1-x}O_3$ and K_2SnCl_6.

A significant part of the scientific effort of the college is in the field of magnetic materials. D1B continues to be widely used for magnetic structure determination in cases where only polycrystalline material is available. The very high sensitivity obtainable with the D1B multidetector is illustrated by the determination of the magnetic structure of $CeAL_2$. In this compound it was possible to measure the very small magnetic peaks associated with the magnetism of cerium in a complex spiral structure. The study of the complex antiferromagnetic structure of VI_2 using the low temperature Weissenberg camera D12b demonstrates the unique possibility offered by the photographic technique for the rapid and unambiguous determination of magnetic propagation vectors. This magnetic structure determination forms part of a larger programme aimed at a fuller understanding of magnetic interactions in layered transition metal halides. Work done up to the present has included studies of the magnetisation densities in $CoCl_2$, $FeCl_2$ and $CrCl_3$ in their field induced ferromagnetic phases. It is hoped that such systematic studies of chemically similar and isomorphous materials will lead to a better appreciation of the forces involved in inter and intralayer interactions in these compounds.

The programme of work on rare earth transition metal alloys has been continued in 1977. A polarised neutron study of $TbCo_2$ has been carried out which enables the temperature dependence of the susceptibility of cobalt to be determined above and below the ordering temperature ; this dependence resembles more closely a Curie-Weiss susceptibility than that expected for the previously accepted model of internal field metamagnetism. The study of the Laves phase alloy $HoFe_2$ has allowed the holmium ground state, in the presence of both crystal field effects and holmium-iron interactions, to be determined. In this alloy strong reflections with large polarisation ratios are observed which suggests that it may be possible to develop new and better polarising monochromators using them. In the Pauli paramagnet YNi_5 the polarisation of the 3-d band induced by a 48 Kœ applied field has been observed. It is found that the induced moment is very different on the two distinct crystallographic sites. In $TbNi_5$ the rare earth interactions polarize the 3-d band and it is hoped to compare the spatial distribution of the polarisation in this case with that of YNi_5. The diminution of the absorption cross-sections of Sm and Gd at short wavelengths has enabled magnetic scattering in $SmCo_5$ and GdMg to be studied using neutrons of wavelength <0.5 Å available at D5 by virtue of the hot source. In $SmCo_5$ the samarium wave function has been determined and shows an important admixture of terms coming from the first excited $|J = 1/2>$ multiplet. In $GdCo_5$ the observation of a canted magnetic moment on S-state ions in a cubic field implies the existence of higher order exchange interactions as well as the Heisenberg coupling.



New cryoflipper and superconducting magnet on D3.

Polarisation analysis has been used as a supplementary technique in magnetic structure determination and gives evidence for a canted structure in Mn_4N. In NiS_2 the superstructure lines have been shown, by this technique, to have both nuclear and magnetic contributions.

A study of the polarisation of the conduction electrons in the metallic phase of VO_2 under 48 Kœ applied field has been made, taking advantage of the high sensitivity of the polarised neutron technique. The corresponding magnetisation density is significantly non-spherical in character. If this density is interpreted as corresponding to the charge density of conduction electrons then it shows that there are electrons at the Fermi-surface in all three sub-bands of the vanadium T_{2g} manifold in disagreement with recent band models.

SEMINARS, WORKSHOPS and CONFERENCES

There was a workshop called :

" Workshop on Magnetic Structures and Spin Densities " on Oct. 10th and 11th, 1977

The workshop had the following main topics

(a) Methods of magnetic structure determination

(b) New techniques in magnetic structure determination

(c) Magnetisation densities

(d) Magnetisation and the chemical bond

Under each topic two or three invited speakers were asked to give a review of the state of the art in their particular areas of interest. The rest of the sessions were left open for informal presentations and discussion. Under topic (a) particular attention was given to the ambiguities that can be inherent in magnetic structure determinations. In topic (b) information on a wide variety of new techniques was presented : these included the photographic Laue technique for study of magnetic domains, magnetic topography, polarisation analysis and classical photographic techniques applied to magnetic structures. Session (c) was devoted to the study of magnetisation densities in rare earth and actinide compounds ; considerable interest was shown in new techniques for obtaining the groundstate wave functions of rare earth metals from polarised neutron measurements. The final session was devoted to the kinds of investigations aimed at measuring delocalisation of magnetisation density brought about by chemical bonding ; topics discussed varied from very simple systems such as transition metal halides, through garnets to much more complicated chemical problems such as manganese pthalocyanine and Cobalt II porphyrin. Taken as a whole the workshop provided a welcome forum in which ideas on the current status and future prospects for studies of elastic magnetic scattering were exchanged.

J. BROWN

college 6
"liquids, gases and amorphous materials"

MEMBERS OF THE COLLEGE :

Besnard M.	
Blétry J.	(Univ. of Grenoble)
Chieux P.	
Copley J.R.D.	
Cyrot F.	(CNRS)
Desre P.	(Univ. of Grenoble)
Dianoux A.J.	
Dupuy J.	(Univ. of Lyon)
Heidemann A.	
Hilton P.	(Univ. of Edinburgh)
Howells W.S.	
Jal J.F.	
Klein M.	
Lechner R.E.	
Lovesey S.W.	
Poncet P.F.J.	
Pynn R.	
Ranninger J.	(CNRS)
Richardson R.	
Scherm R.	
Stirling W.G.	
Suck J.B.	
Thorel P.	(CNRS)
Volino F.	(CNRS)
Wright A.F.	

GENERAL SUMMARY

The emphasis within this college is on neutron diffraction and neutron inelastic scattering experiments on various types of liquid and liquid crystal. Relatively little work has been performed on gases and amorphous materials. Of the keywords listed in the keyword list for College 6 (see end of the annual report), all but 6 - 06 (molten salts) were represented in proposals submitted this year. Proposals in categories 6 - 03, 6 - 04 and 6 - 07 have up to now been structure studies, whereas the liquid crystal experiments (6 - 09) have been investigations of dynamical processes. Proposals in the remaining categories include both structure and dynamics experiments.

Of the diffraction instruments, D4 is exclusively used by College 6, and a large fraction of D2 time goes to the college. The machines D1B, D5, D7, D11 and D17 are also used. On the inelastic side the triple-axis machines IN1, IN2, IN3 and IN8 are employed occasionally, IN4 is used to a limited extent, but the main demand falls upon the high resolution spectrometers IN5 and IN10.

In the 12 months ending December 1977, 63 experiments from College 6 were carried out.

In March 1977, 32 proposals were submitted, of which 28 were accepted ; 22 of them were given reduced time. The corresponding figures for October were 30, 25 and 9. This change reflects the fact that in October several instruments were either undersubscribed, or only slightly oversubscribed.

SCIENTIFIC TRENDS AND HIGHLIGHTS IN 1977

We shall briefly review some of the work that has been carried out during the past year.

Quantum Liquids

There is a continuing programme of research into the properties of liquid helium, and in particular ^3He and ^3He-^4He mixtures. This year, a technically demanding experiment has been performed to study the pressure dependence (from 0 to 20 bars) of the scattering from ^3He at 0.7 K. The low frequency spin density scattering at wavevectors of order 1 Å $^{-1}$, becomes stronger with increasing pressure, whereas the higher frequency mass density fluctuations decrease in intensity. At about 2 Å $^{-1}$ the frequency at the peak decreases dramatically with increasing pressure. Attempts to explain this behaviour in terms of a pressure-dependent effective mass indicate that the mass changes more with pressure than is expected on the basis of macroscopic measurements.

Monatomic Liquids, Binary Liquids and Molecular Liquids

The neutron diffraction studies of liquid rubidium at low densities have recently been extended to temperatures as high as 1970 K and densities down to 0.6 g/cm^3, i.e. 40 % of the density of normal liquid rubidium at 312 K. A preliminary analysis of these measurements indicates that in the density range 1.2 to 0.6 g/cm^3 the nearest neighbour distance only increases by a few per cent, but the number of nearest neighbours decreases by roughly a factor of two. This work is to be continued next year.

Inelastic scattering measurements on rubidium and aluminium were performed this year, using both triple-axis instruments and the time-of-flight spectrometer IN4. The IN4 results for liquid aluminium at two temperatures are fairly extensive, and a preliminary aanlysis shows that there may be collective excitations at $Q \approx 1.5$ Å $^{-1}$. An experiment to examine the pressure dependence of both the self and distinct parts of $S(Q,\omega)$, for liquid argon, is being undertaken on IN4 at the time of writing.

In the field of binary alloys, there has been an active programme of research, making extensive use of both isotopic substitution and concentration variation techniques. Work on Cu-Sb alloys has been completed, and the Li-Na system has been investigated close to the critical composition of 65 atomic per cent Na. Alloys with a tendency to ionic behaviour, such as Cs-Sb, have been examined, as well as systems which tend to segregate (e.g. Ag-Ge). A general aim is to try to deepen our understanding of these relatively simple binary mixtures, and to learn why it is that some segregate and others form compounds. A soft sphere model of alloys, proposed by a member of the College, may well help in this respect.

A number of rather complicated liquids, such as CD_3COOD, $CDCl_3$ and CD_3OD, continue to be studied using the isotopic substitution technique, as well as polarization analysis, and comparison with X-ray results. For the first time, the three leading terms in a spherical harmonics expansion of the orientational correlation function have been obtained for a molecular system, namely acetonitrile. It may be possible to obtain a larger number of terms in the expansion of the case of chloroform. Comparisons with model calculations should then be very fruitful. Progress has also been made in our understanding of the inelasticity corrections to the coherent part of the scattering from simple molecular liquids such as nitrogen, in part as a result of detailed comparisons between D4 data and data from the Harwell linac machine. The emphasis is now on more difficult molecules such as D_20 and DBr.

Aqueous Solutions

In previous work it was unambiguously shown that for concentrated solutions of $NiCl_2$ in D_2O, the hydration number of the Ni^{2+} ion is six water molecules. The experiments have now been extended to two quite different solutions : NaCl in D_2O of molality 5.32, and $CaCl_2$ in D_2O of molality 4.47. In spite of the different characteristics of the cation, the nature of the hydration around the anion is essentially the same in both cases (5.5 $\pm$ 0.2 water molecules). This shows that a once and for all calculation of the coordination characteristics of the ion-water system will be a good approximation, appropriate to a wide range of solutions.

Glasses

The kinetics of devitrification of TiO_2 nucleated alumino-silicate glass have been observed in situ at 1100 K by neutron small angle scattering. The controlled separation of particles (believed to be AL_2TiO_5) reaching a maximum radius of 120 Å , regularly disposed in the glass with an interparticle radius of ~ 600 Å, occurs only after a preliminary nucleating heat treatment at ~ 1050 K has been given. The mechanism followed is that of nucleation and growth rather than spinodal decomposition. Heat treatment at 1100 K, without the nucleation procedure, leads to uncontrolled crystallization with separated particle sizes exceeding 500 Å . In each case an induction period of 30 - 40 minutes precedes the main growth curve, which appears to saturate after 3 hours.

Liquid crystals

During 1977 considerable effort has been devoted to an unambiguous test of the Meyer-MacMillan theory for the tilted smectic phases. This microscopic theory predicts an orientational ordering of the molecules around their long axes, linked to the existence of a strong dipole-dipole interaction which is itself responsible for the tilted character of these phases.

Earlier measurements in the H phase of TBBA, by incoherent quasi-elastic scattering, failed to reveal any orientational ordering. Furthermore the elastic incoherent structure factor (EISF), i.e. the ratio of the elastic incoherent intensity to the total intensity, showed that the motion in the normal H phase had to be more " isotropic " than uniaxial rotation, implying an additional motion which has been attributed to (anisotropic) fluctuations of the long axes.

A more detailed study of the supercooled H phase (smectic B_c), and of the VI phase (smectic E_c) of TBBA has now been undertaken. The EISF and the quasi-elastic lineshapes were analysed in terms of two models which permit orientational order about the long axis. Values for the orientational order parameters $< \cos\phi >$ and $< \cos 2\phi >$, for the polar and bipolar models respectively, were then extracted (Figure 17). In the normal and the supercooled H phase, $< \cos \phi > = \cos < 2\phi > = 0$, as expected. For the VI phase the neutron data cannot discriminate between the two models. The model with two sites, where the molecules are allowed to flip by π , is however more consistent with X-ray diffraction results.

Incoherent quasi-elastic neutron scattering experiments on aligned samples of smectic B and smectic E phases of IBPBAC have suggested that long range

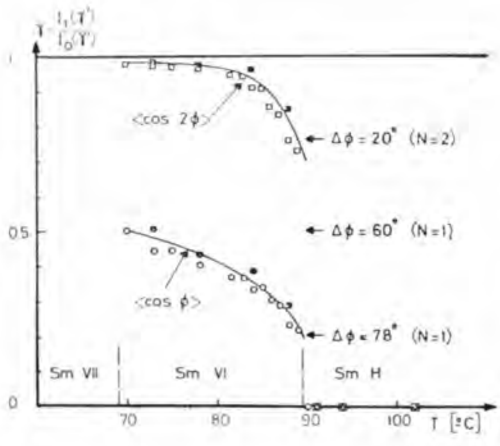


Fig. 17. - Values of the order parameters < cos φ > and < cos 2φ > as a function of temperature for TBBA in the supercooled H and VI phases : N = 1 and N = 2 correspond respectively to the polar and bipolar models described in the text.
The corresponding mean angular fluctuation amplitudes Δ φ are indicated for each case. The lines through the points are drawn as guides to the eye.

translational diffusion constants in these phases are less than $10^{-7}\ cm^2s^{-1}$. Analyses of the scattering from faster components (correlation time $\lesssim 10^{-10}s$) of the molecular motion have shown that current models for these phases are not wholly adequate. The conventional view that there is uniaxial rotational diffusion about the long molecular axes which is isotropic in the smectic B phase, but restricted in the smectic E, has been confirmed. However it has also been shown that there is an important diffusive motion in a direction perpendicular to the layers. The amplitude of this motion increases with temperature until the smectic layers are lost in the nematic or isotropic liquids.

Critical Scattering

There has been a detailed investigation ($|T-T_c|/T_c$ as small as 10^{-4}) of the critical exponents γ and ν, both above and below the critical temperature for liquid-liquid immiscibility, in the K-KBr system. When properly corrected for density effects (density being extracted from neutron transmission measurements), these exponents are in accord with results based on the lattice gas-model. On the other hand the critical exponents measured for the alkali metal - ammonia system, which also displays a non-metal to metal transition as a function of metal concentration, are more of the mean-field type. One is led to speculate that there may be different classes of non-metal to metal transition.

SUMMER SCHOOL

A highly successful NATO Advanced Study Institute, on the Microscopic Structure and Dynamics of Liquids, was held in Aleria, Corsica, during the summer. The school was strongly supported by the ILL, financially, scientifically, and administratively. About 10 ILL scientists participated. The Proceedings are to be published.

It is a pleasure to thank P. Chieux for his fine work as College Secretary over the past two years.

Secretary : J.R.D. COPLEY

college 7
"imperfections"

MEMBERS OF THE COLLEGE :

Anders R.
Bletry J. (CNRS, Grenoble)
Dorner B.
Escribe C.
Freund A.
Givord D.
Goeltz G.
Hayter J.
Heidemann A.
Heitjans P. (Univ. of Heidelberg)
Hewat A.
Just W.
Körblein A. (Univ. of Heidelberg)
Kostorz G.
Lechner R.E.
Mezei F.
Murani A.P.
Roth M.
Scheuer H.
Schweizer J. (CENG)
Scherm R.
Suck J.B.
Wagner V. (Univ. of Würzburg)
Wright A.
Young A.P.
Zeyen C.
Ziebeck K.R.A.

The College has 27 listed members of whom about 10 are more actively involved in the scientific programme of the college i.e. act most frequently as local contacts for experiments falling within the domain of the college. The other members have their primary activities linked with other colleges.

GENERAL SUMMARY

The scientific activities of the college have been divided into the following groups, which partially overlap in some cases :

1 Mixed magnetic systems, i.e. magnetic impurities, alloys
2 Crystalline electric field including valence states
3 Non-magnetic defects and disorders
4 In-beam NMR experiments
5 Inelastic scattering associated with defect states
6 Diffusion in bulk materials
7 Superionic conductors

The experiments falling within the above groups have been carried out on the instruments listed in the table below, which gives the number of instrument days for each instrument used by the college during 1977 and the corresponding number of experiments.

	IN1	IN2	IN3	IN4	IN5	IN7	IN8	IN10	D1	D5	D7	D9	D10	D11	D17
Inst. days	18	—	—	24	22	24	—	17	6	15	60	6	32	20	2
No. of expts.	2	—	—	4	5	3	—	3	1	1	8	1	2	10	1

The following table gives the statistics of proposals submitted and accepted for College 7 during 1977

March 1977

Subgroup	No. of proposals submitted	No. of proposals accepted
01	16	13
02	8	4
03	16	14
04	1	1
05	1	1
06	8	2
07	3	2
	Totals : 53	37

October 1977

Subgroup	No. of proposals submitted	No. of proposals accepted
01	14	14
02	7	6
03	5	5
04	—	—
05	3	3
06	14	10
07	5	4
	Totals : 48	43

SCIENTIFIC TRENDS AND HIGHLIGHTS IN 1977

The scientific trends during the year appear to be towards an increasing interest in the study of spin glasses, both metallic alloys and amorphous systems, and also in the study of rare earth systems whose physical properties suggest the interconfiguration fluctuation behaviour or the intermediate valence state. The general scientific activities of the college may be best illustrated by the following brief review of a few of the experiments carried out during the year.

1. Mixed magnetic systems, i.e. magnetic impurities, alloys

Diffuse scattering study of Fe-Ni alloys containing 30-35 % Ni with unpolarized neutrons show evidence of chemical short range order and inhomogeneous magnetisation, but the exact relationship between the two is still unclear. It was found, however, that after irradiation with fast electrons pseudoperiodic magnetization inhomogeneities are produced, which are throught to be connected with a kind of chemical spinodal decomposition (Chambroid, Billard, Roth). Small angle neutron scattering measurements on Co-rich Co-Ga alloys have been performed by Cywinski, Booth and Rainford. These show that the critical composition for ferromagnetism is around 55 at.% Co, and the alloys with lower Co concentrations ($50<c<55$ at.% Co) show strong superparamagnetic behaviour with regions of correlated spins extending over approximately 60 Å.

Spin glasses continue to provide subjects of interesting research. Low temperature inelastic scattering from a Cu-5at.%Mn alloy show dispersionless inelastic peaks which the authors, Scheuer, Loewenhaupt and Suck, have attributed to spinwave-like excitations. Further measurements to verify these findings are in progress. The separation of elastic and inelastic scattering from a Cu-8at.%Mn alloy using high resolution energy analysis (~ 1 μV on IN10) show that the Edwards-Anderson order parameter for a spin glass is strongly dependent on the time constant of measurement; the results obtained here (with $\tau \sim 10^{-9}$s) being markedly different from those obtained earlier on IN5 where the elastic energy resolution was $\sim$ 200 μV and the corresponding $\tau \sim 10^{-11}$s) (Murani and Heidemann). It has long been known that very high concentration Cu-Mn alloys develop atomic and magnetic short range order around the [1, 1/2, 0] type positions. A systematic investigation of the short range order in a Cu-45at.% Mn alloy has been started by Coles, Rainford, Burke and Givord using the polarization analysis technique on D5. The results obtained so far indicate that the magnetic short range order persists well above the freezing temperature and that field cooling the sample leads to a dramatic decrease of the spin-flip scattering cross-section.

Another investigation of a concentrated spin glass with short range order is the study of spin dynamics of a disordered Pd_3Mn alloy by Lilley, Rainford, Stirling, and Ziebeck, who plan to continue this investigation with higher energy resolution on the IN10 spectrometer. The temperature and field dependence of magnetic short range order in amorphous spin glasses such as $Al_2Mn_3Si_3O_{12}$ and $Al_2Co_3Si_3O_{12}$ have been studied by Prandl, Knorr, Nägele, Convert and Buevoz. In the former sample where the Mn ions have negligible local anisotropy and which the authors call the Heisenberg spin glass, magnetic short range order is observed at relatively high temperatures whereas in the latter sample where the Co^{2+} ions have strong local anisotropy, and therefore the system termed an Ising type, the magnetic short range order was observed only at the very lowest temperature of 3K.

2. Crystalline electric field including valence states

A knowledge of the crystalline electric field parameters of rare earth systems is essential to the understanding of their magnetic properties. With this aim in view, an investigation of the CsCl structured compounds of Ce, Pr, Nd with Mg and Ag was undertaken by Morin, Pierre and Schmidt on IN7. They have also studied the influence of cooperative Jahn Teller effect of the crystal field level scheme in the compound TmZn. The influence of magnetic rare earth impurities on the transition temperature of superconductors is determined principally by the low-lying crystal field states. The latter have been investigated for dilute concentrations of Tb and Pr solute atoms in LaAg, $LaAl_2$ and $LaSn_3$ superconductors by Hoening and Loewenhaupt on the D7 spectrometer.

A systematic study of the dynamical susceptibility of several interconfiguration fluctuation (ICF) compounds such as TmSe, $CePd_3$, $CeSn_3$, $YbCu_2Si_2$ and others has been carried out by Holland-Moritz, Loewenhaupt, Steglich, Wohlleben, Just and Suck, who find a broad temperature independent quasi-elastic scattering linewidth for all the ICF systems whereas the normal magnetic rare earth systems have a linewidth which is two orders of magnitude smaller and linearly dependent on the temperature. Other measurements on related systems include those on YbCuAl by de Boer, Mattens, Lander and Murani who find a quasi-elastic peak at high temperatures but which develops into two inelastic peaks at low temperatures. These measurements bear strong resemblance to earlier measurements on $CeAl_3$ by Murani, Knorr and Buschow. There again the low temperature scattering showed inelastic structure, thought to be due to two crystal field transitions, but which collapsed into a broad quasi-elastic peak at higher temperatures.

3. Non-magnetic defects and disorders

Several experiments on non-magnetic defects, clustering, decomposition of alloys, and radiation damage have been carried out during the year, mostly involving small angle scattering.

The kinetics of decomposition in Al-Zn alloys was studied in-situ by Allen, Stewart, Messoloras, Guyot, Laslaz and Kostorz especially above and below the spinodal temperature suggested by other workers. They found only a gradual change in the aging kinetics and in the form of small angle scattering when crossing this temperature. Another spinodal system Au-Pt was examined by Singhal, Herman and Kostorz using liquid- and solid-quenched samples. The solid-quenched alloy (Pt - 40%Au) showed rapid aging at 550° C whereas the liquid-quenched alloys displayed slower aging in the bulk but also discontinuous precipitation at grain boundaries. Investigation of Al-Mg single crystals by Dauger, Boudili and Roth has shown non-isotropic and non-random configuration of Guinier-Preston zones in the alloys after aging at room temperature. A study of the formation of voids in quenched β'-NiAl has been completed providing detailed information on the size and shape of voids after various heat treatments (Epperson, Berner, Ortiz, Gestenberg and Kostorz).

Among the investigations of defect scattering the continuing work (Roth) on some aspects of scattering by superficial tarnishing layers is also very interesting. This follows earlier observations of strong surface contribution to small angle scattering from Al-Si alloys (Kostorz) and solids in general such as glass, aluminium and vanadium (Roth).

4. In-beam NMR experiments

The in-beam spectrometer S6 (Heidelberg group) has been used for studies of atomic diffusion by β-radiation detection of the spin-lattice relaxation of ^8Li in LiAg alloys. Recently similar studies have been started in Li-silicate glasses (Müller-Warmuth) and in $LiNbO_3$. The transfer of polarization from probe nuclei to the nuclei of the host (cross-relaxation) has been observed for ^8Li in Li metal, Lif, $LiNbO_3$ and for ^{20}F in MgF_2. The quadrupolar and dipolar couplings of polarized ^{28}Al nuclei in Al_2O_3 and AlP have also been measured down to 1.6K.

5. Inelastic scattering associated with defect states

Magnetic dipole transitions have been observed by neutron scattering from Co^{2+} ions in Mg0 using the IN4 TOF spectrometer by Wagner and Koidl. The measurements show that the fine structure of the crystal field ground sate of the Co^{2+} in Mg0 is due to electron phonon interaction which may be described in terms of a dynamic Jahn-Teller effect, giving rise to the two observed vibrionic levels.

6. Diffusion in bulk materials

Measurements of self diffusion of vacancies in Na single crystals have been continued on the IN10 spectrometer by Seeger, Mehrer, Goeltz and Heidemann. The diffusion constants for the different vacancies agree well with results of tracer measurements. A detailed data analysis, however, showed that the neutron results are not in full agreement with theoretical predictions of Wolff based on the migration of mono and di-vacancies. Further measurements to supplement and verify these findings are planned.

The physics of hydrogen in metals such as Pd continues to remain an interesting area of research. Measurements of the Debye-Waller factor of αPdH carried out by Ross, Anderson and Carlile show a systematic difference between the two crystal directions (200) and (220) even at low q's, suggesting either that the proton is not resident in a central position on the octahedral site or that higher order derms of the Debye-Waller factor are large. The same authors have investigated diffuse scattering in β Pd-D in order to understand the specific heat anomaly at 50 K in the system. They observe that a peak in the diffuse scattering around 1.8 $Å^{-1}$ develops close to this temperature, which they interpret as due to the re-ordering of deuterons among the octahedral sites in Pd and a possible cause for the specific heat anomaly.

7. Superionic conductors

Investigations of the superionic conductor α-AgI have been performed on the IN5 TOF spectrometer by Funke, Echold and Lechner who conclude that for times shorter than $\sim 10^{-12}$s the cations (I^-) essentially perform local liquid-like diffusion of cations through the system of voids and channels provided by the anion lattice becomes important. The authors have carried out a systematic investigation of the temperature dependence of these effects betwen 160° and 300° C.

Secretary : A.P. MURANI

college 8
"structural biology"

MEMBERS OF THE COLLEGE

At ILL :

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Chauvin C. (CENG)
Dianoux A.
Haas J.
Ibel K.
Jacrot B.
Lehmann M.
Lewit A.
Mason S.
Suck J.
Timmins P.
Torbet J. (Euratom)
White J.
Zaccaï G.

At EMBL :

Berthet C.
Cusack S.
Gabriel A.
Hulmes D.
Lindley H.
Miller A.
Ngo Tri H.
Tocchetti D.
White S.

GENERAL SUMMARY

College 8 is concerned primarily with the elucidation of molecular structures of biological systems. This may be to atomic resolution as in the case of protein crystallography or to a somewhat lower resolution, using the various low angle scattering techniques. Systems investigated are often protein-nucleic acid complexes as in ribosomes, chromatin or viruses, fibrous molecules as in connective tissue, or membranes. These systems are studied as solutions or oriented (1, 2 or 3 dimensional specimens).

A small amount of inelastic scattering for the investigation of the dynamics of biological macromolecules or their associated water is also carried out.

Most of the work of College 8 is centred on the low angle scattering machines D11 and D17 but with a significant amount on D8 and D16 and small amounts on the inelastic machines IN5 and IN10. There were 71 proposals submitted in 1977 of which 46 were accepted. In addition test time was allocated on D11 and D17 for the carrying out of short feasibility studies. These figures are very similar to those for 1976 and are indicative of a growing maturity in the field with increasing emphasis on experiments which are more difficult or require more sophisticated biochemical back-up.

At the March Scientific Council the demand for a Staff Scientist in the field of protein crystallography was reiterated and in May S. Mason was appointed to this position. Two new 5-year physicists in the field of Biology were appointed : G. Bentley (for work in protein crystallography) and A. Lewit, bringing up to 7 the number of ILL scientists whose primary interest is biology.

Experiments performed by outside users with help from ILL scientists continue to play a major role in the biological field. In this domain work on the 50S subunit of the ribosome (Stuhrmann et al.) has culminated in publication of a model which is in excellent agreement with others, particularly from electron microscopy. Studies on chromatin and nucleosomes are continuing by several groups each of which have produced important models, in particular that of Pardon et al. which has been strikingly confirmed by the recent E.M. and X-ray work of Finch et al. Studies on tRNA-tRNA-synthetase binding by two groups (Paris, Strasbourg) with strong ILL support (Zaccaï, Jacrot) are beginning to throw light on the interaction between the aminoacyl tRNA-synthetases and their cognate RNA. In the field of lipid bilayer studies an important phase in the study of deuterium labelled lipids has been concluded and a publication accepted (Büldt and Zaccaï).

Several essentially internal projects have been making good progress. In the field of protein crystallography the task of calculating a neutron scattering density map from the 17000 reflections to 1.5 Å resolution now measured, is well under way. Some of the necessary programs have been implemented and preliminary calculations carried out. The contrast variation study of tomato bushy stunt single crystals (Lewit and Timmins) is progressing well. Fig. 18 shows a 2° "oscillation photo-

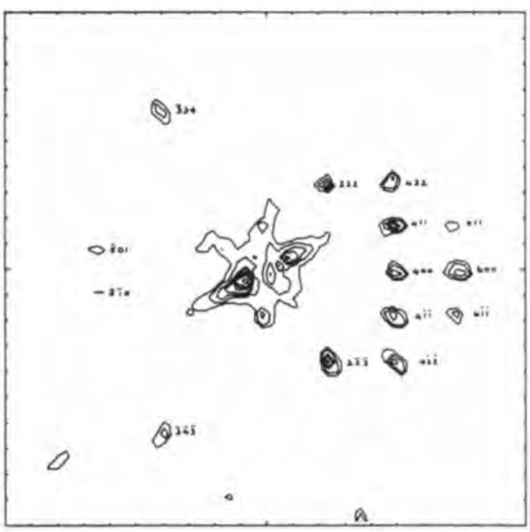

Fig. 18. - Tomato bushy stunt virus single crystal (I23, a = 386 Å) 2° " oscillation photograph " on D17 multidetector, λ = 11.5 Å , Δλ/λ = 10 %, sample-detector = 1.41 m. The heavy scattering close to the centre comes primarily from the quartz capillary in which the crystal is enclosed. The crystal was soaked in 43 % D_2O so that the scattering pattern is dominated by the RNA.

graph " from a crystal soaked in 43 % D_2O. The first mass per unit length measurements using neutrons have been carried out (Torbet) on the pf and fd filamentous bacteriophages and the results allow a clear distinction to be made between conflicting models. Two notable publications have been produced in virus solution scattering : a molecular weight determination and structural information on Satellite Tobacco Necrosis Virus and a comparative study of the extent of RNA penetration and stability in five spherical viruses (Chauvin, Jacrot and Witz). Improvements made to D16 have enabled data of exceptional quality to be collected on samples of the purple membrane of **halo-bacterium halobium.** Using phases derived from electron microscopy a map of the exchangeable hydrogens in the plane of the membrane has been obtained (Fig. 19).

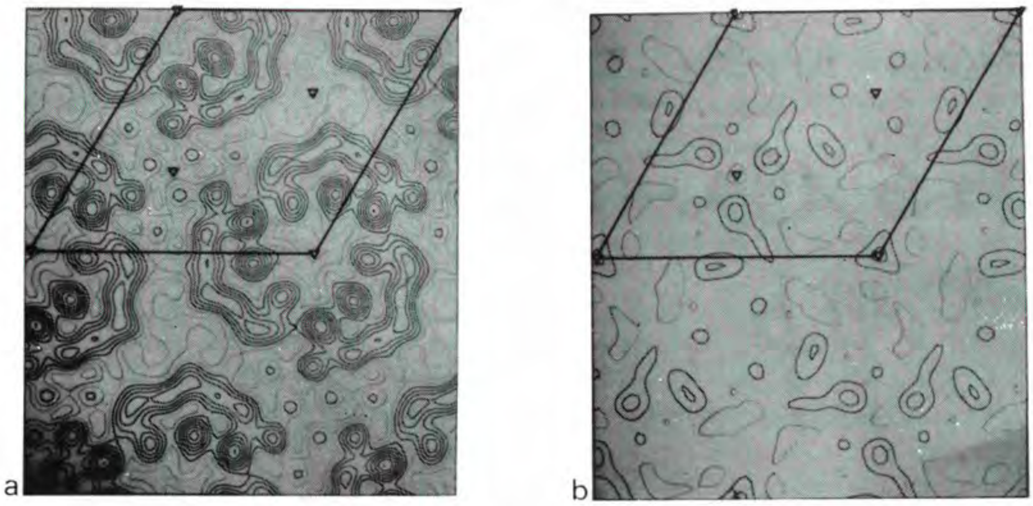

Fig. 19 (a) and (b). - Neutron scattering density of the purple membrane of halo-bacterium halobium. (a) Membrane in H_2O; (b) Difference density between membrane in D_2O and in H_2O, thus showing the location of exchangeable atoms. Heavy contours are positive and light contours negative density in the difference map. In the H_2O map high density indicates protein, thus a comparison of the maps shows more exchangeable hydrogens in the lipid region.

Collaborative experiments with EMBL have continued in the field of connective tissue. Diffraction studies on the intervertebral disc showed the fixed angular separation of collagen fibres and contrast variation studies implied the probable attachment of some non-collagenous moiety at regular intervals along the fibrils.

In the field of inelastic scattering the most promising experiments are those on the flexibility of DNA in solution and the dynamics of water in proteins, in particular collagen. This latter investigation (carried out in collaboration with EMBL) has shown conclusively the existence of two states of water with different dynamical properties in collagen.

The biochemistry laboratory continues to provide important preparative and control facilities supplying a range of equipment complementary to that available at the EMBL.

WORKSHOPS, CONFERENCES AND SEMINARS

A workshop on Small Angle X-ray and Neutron Scattering in Biology organised jointly with EMBO was held at Villard-de-Lans in March. This proved to be a great success and was attended by approximately 100 participants from Europe and the U.S.A. Many useful discussions were held and a successful cross-fertilisation between the X-ray and neutron fields was achieved.

Secretary : P. TIMMINS

college 9 "chemistry"

MEMBERS OF THE COLLEGE :

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Carlile C.	(Rutherford Lab.)
Chieux P.	
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Haas J.	(Univ. Mainz)
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Heitjans P.	(Univ. Heidelberg)
Howells S.	
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Jenkin G.	
Lehmann M.	
Leslie M.	
Mason S.A.	
Mezei F.	
Richardson R.	(Univ. Exeter)
Riekel C.	
Rustichelli F.	(Euratom)
Tabony J.	
Timmins P.	
Tomkinson J.	
Volino F.	(CNRS)
Wright A.	

GENERAL SUMMARY

The Chemistry College is active in the following fields : small angle neutron scattering is carried out on polymers, including co-polymers and polymer mixtures, in the bulk and in solution. The inelastic scattering experiments on polymers involve both low energy diffuse motion and vibrational modes. The main effort in beam time however is in inelastic scattering. In the field of molecular spectroscopy, quasi-elastic scattering is used to study diffusion, reorientational motions and tunnelling, whilst inelastic scattering studies H-bonding and vibrational and torsional modes. For multicomponent systems we now have inelastic studies of diffusion in lamellar phases and some colloid chemistry problems such as micellar phases and water in clays. A lot of effort is also going into surface studies (physisorption and chemisorption) using both diffraction techniques and inelastic scattering.

Of the diffraction instruments the Chemistry College uses mainly D11 and D17 and most of the time goes to the polymer users. The only triple axis machine used is IN1, but in its beryllium filter mode for work on molecular spectroscopy.

The rest of the time is used on the three inelastic instruments IN4, IN5 and IN10. The year saw D17 becoming scheduled and the polymer groups have taken advantage of this.

The number of experiments accepted seems to have settled down to about 100. There is also an increase in the amount of inelastic work, especially on IN4. The use of the main instruments is as follows :

D11 D17	26 experiments 12	40 days 25
IN1	9	71
IN4	15	89
IN5	14	53
IN10	18	97

The year saw a move towards accepting fewer proposals and allocating them enough time to complete the experiment. This was particularly true for the inelastic work where users were encouraged to finish off continuation experiments.

SCIENTIFIC TRENDS AND HIGHLIGHTS IN 1977

1) Polymers

During the year the work on polymer materials was essentially a continuation of studies already started. In the field of stretched chains the CRM-Saclay group has now been joined in this type of study by the Imperial College group. The interesting results are anisotropic in form so the experiments are time consuming and are likely to last several years.

The study of the crystalline solid state is the preoccupation of three groups : Bristol for polyethylene, Mainz for polyethylene oxide and Strasbourg for isostatic polystyrene. All the groups involved in neutron scattering also perform characterization of polymer conformation in solid amorphous state and in solutions, on a set of various polymers. One new study in this field is by the CRM Saclay Group with partially labelled chains which allow them to study the interaction between chains.

In the field of solutions, experiments have been carried out to test the predictions of two theories ; the mean field theory approach and the scaling law approach, which agree for dilute solutions but differ for the semi-dilute and concentrated regimes.

The activities of the polymer users were presented during their annual meeting in London on July 3, 1977 and the influence of the ILL can be judged by the number of publications (about 100) that have appeared since 1970.

2) Molecular spectroscopy - quasielastic

Tunneling experiments continue to give interesting results. For example measurements of Clough (Nottingham) on MDBP are entirely consistent with expectations based on very extensive studies using other techniques. They also provide new evidence in favour of two recent proposals concerning the character of thermally activated CH_3 motion, namely the existence of "flip flop" motion and that at low temperature these motions occur mainly within the ground torsional state.

3) Molecular spectroscopy - inelastic

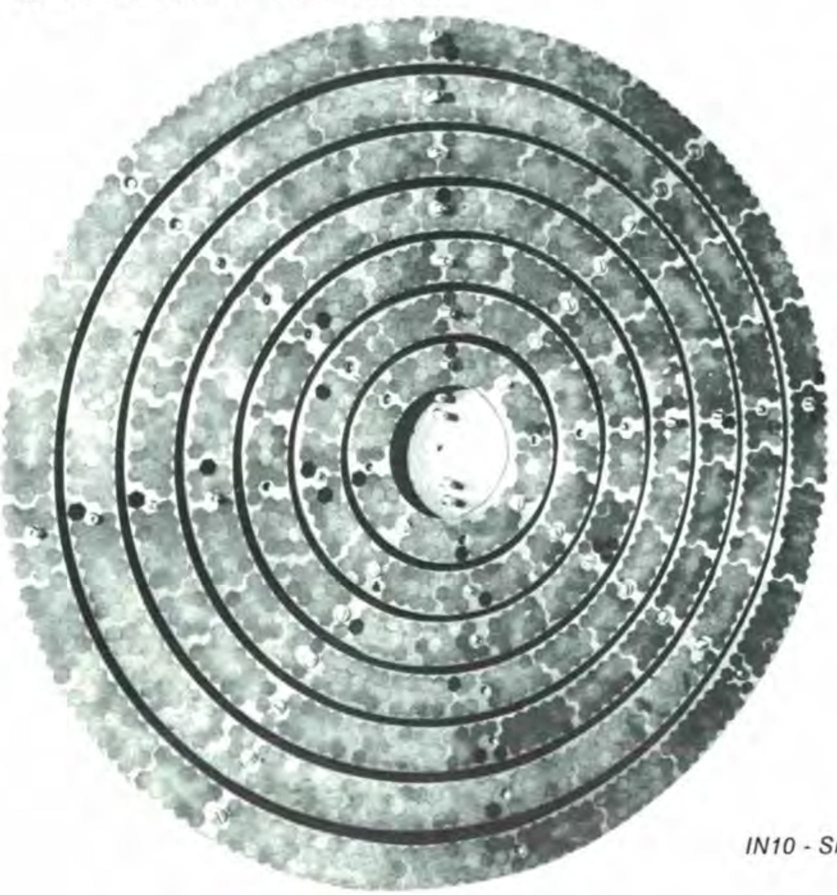
Molecular spectroscopy is now a well established field of study at the ILL using the instruments IN1B and IN4. The experiments on IN4 are still dealing with torsional barriers whilst the work on moderately high energy transfer vibrations is conducted on IN1B.

It is interesting to note that a spectroscopy experiment conducted to determine methyl torsional bands from the Raman spectrum of n-methyl acetamide leads on to a serious re-examination of the accepted crystal structure. Furthermore, after having solved the crystal structures of some hydrogen bonded compounds, crystallographers are now returning to study the vibrational spectra.

The field of molecular spectroscopy is also heavily involved in the research conducted on surfaces. Many organo metallic " model " compounds are being studied in an attempt to understand the changes in vibrational spectra induced by absorption on solid surfaces.

4) Multicomponent systems

Diffraction and inelastic studies have been carried out by the Oxford group to study the rate of intercalation of hydrogen and deuterium into C_8K. The results are consistent with the formation of clusters of potassium and hydrogen atoms or ions, randomly distributed, forming an amorphous phase. Later these migrate and nucleate to form crystallites of $C_8KH_{2/3}$. The diffusion coefficient is determined by the diffusion of these clusters.



IN10 - Small angle analyser.

In the field of quasielastic scattering from clays, a lot of data has been accumulated on IN5 which can be analysed using models of diffusion processes to yield constructive information for different ions and clays. For example, the Oxford Group have measured the diffusion of 1, 2 and 3 layers of H_20 in Li montmorillonite. However in order to produce a detailed model for analyzing IN5 data, IN10 measurements are essential. The Birmingham Group have measured Ca and Mg montmorillonite on both instruments and the results are somewhat contradictory and further experiments are planned to resolve this.

5) Physisorption

Important results were gained this year in physisorption.

Adsorption of ^{35}Ar was compared on two iodine planes (belonging to MnI_2 and PbI where distances are slightly different. On MnI_2 the registered structure of solid argon monolayer was confirmed (even the position of Ar relative to Mn was established). These results agree with the entropies inferred from adsorption isotherms. In the same experiments good bidimensional liquid (or glass) rings were observed for the first time.

The question of liquid or glass was solved for CD_4 on graphite through quasi-elastic measurements : the disordered structure is very mobile (the two-dimensional liquid is quite special because it can have 50 % of vacancies).

A more complex situation arises with N_20_2 on graphite :
at 7 K two non registered solid structures α (N_20_2 lying flat ?) and β(N_20_2 upright ?) which melt above 90 K,

at 10 K the β solid, but also an unexpected new structure which could not have been suspected by classical thermodynamical methods.

This case emphasized the potentialities for complex molecules, but the studies of simple cases (rare gases) were even more rewarding : the stabilization of registry, probably by pinning on defects, was confirmed with Kr on graphite at temperatures and coverages where the solid monolayer is non registered on very clean substrates.

Last but not least, the existence of static distortion waves was demonstrated with Ar on graphite ; i.e. the non registered two dimensional argon monolayer is modulated by the substrate. In the future a " registry degree " has to be introduced ; it is the second order parameter needed to explain complex adsorption phase diagrams with singularities which can be called tricritical points.

Secretary : S. HOWELLS

european molecular biology laboratory, grenoble

EUROPEAN MOLECULAR

The EMBL Grenoble Outstation was opened for use by ILL users in October 1976. Since that time some 14 user groups, all external to both EMBL and ILL, have used the equipment of EMBL. The equipment is also used by the ILL staff, especially the group directed by Dr. B. Jacrot. Initial difficulties with access to EMBL from ILL have been solved, thanks to excellent cooperation from the Security Departments of both ILL and CENG. Now all holders of an ILL magnetic card (also issued to neutron users) have free access to the EMBL. Only the 300 m between the EMBL and Neutron Guide Hall remains an obstacle ! It is still requested that prospective users of EMBL give about two weeks notice of their intention so that staff can assure that the required equipment is prepared.

The research programme on connective tissue and muscle. is underway and in the last year some new results were obtained. A complete correlation is now possible between the one dimensional structure of a native animal tissue (tendon) and the X-ray diffraction pattern to virtually amino-acid resolution. This has been used as a base from which to investigate how collagen interacts with other molecular species to produce composite tissues such as bone or cartilage. In the case of bone, a mineralising tendon system was chosen as a model, and a combined X-ray and neutron study allows an understanding of the relative locations of collagen and the inorganic crystallites of hydroxyapatite.

The intervertebral disc contains fibro-cartillagenous material in the **annulus fibrosus** which forms its outer ring. This has been studied by X-rays and neutrons and is now being subjected to microanatomical dissection for comparative biochemical assay of its fine structure. The aim is to investigate the **in vivo** interaction between collagen and the other main constituent proteoglycans. These studies have also been supported by the Arthritis and Rheumatism Research Council (U.K.).

In collaboration with Dr. J.W. White (ILL) and colleagues, success has been achieved in observing phonons in both collagen (of tendons) and muscle by Brillouin light scattering. This promises to be a useful bridge between the molecular structure and the function of biological fibres.

It is worth emphasising that research collaboration has developed between the ILL and EMBL. Six ILL scientists have been co-authors on the in-house EMBL research group publications.

Now that the EMBL is functioning in Grenoble, it is planned to gradually widen the research programme. The first steps in this direction, linked with a service facility, is the establishment of a deuteration laboratory. This will come into operation in 1978 and staff are now being recruited. The aim is to provide a source of organisms (initially bacteria and perhaps a cell culture) which are almost fully deuterated. These organisms will be available to ILL neutron users.

During 1977 we have enjoyed the benefit of several senior visitors, postdoctoral fellows and stagiaires. The EMBL/ILL series of Biology Seminars has continued.

A. MILLER

technical department

mechanical construction and maintenance section

The main fields of activity of the section have been the construction and installation of new and special instruments, maintenance and modification of instruments in operation and the quest for technological improvements.

1) New instruments
   — at design, construction or installation stage : D18A, IN5B, IN12, IN13
   — completed : PN5, P13C.

2) Additional equipment on : D5, D11, D17, IN5, IN7.

3) Major modification or maintenance work on :
   D1A, D1B, D7, D10, D16, IN1, IN3, IN8, IN10, PN6.

4) Support or preparation of special instruments : S1, S25, S28, S39, S40, S42, S44.

5) Major work on neutron guides : H15 (insertion of monochromator position for IN5B in guide CH22).

6) Construction of platforms for IN5, D15, supports for IN1, IN11, D1A.

7) Improvement of operating conditions of instruments :
   7.1. In-service control : production of standard monitoring boxes for spectrometers
   7.2. New technologies : air-cushion pads for moving instruments or shielding
   Development of air-tightness labyrinths, application to disk choppers and selectors
   Application of magnetic seals to choppers, for static and dynamic vacuum
   Development and application of new motorised encoder modules for Tanzboden spectrometers.

8) Safety tests
   — Test of the failure of a protection box for a chopper in case of a shaft failure.

In addition technical assistance has continued to increase, with the supply of standard equipment (rotating plates, goniometers, pneumatic components, etc.), with the loan of measuring and control instruments and with the provision of services to various ILL departments, particularly the operation department (reactor and experimental instruments).

project office

The Project Office is responsible for preparing the budget, following up and checking on investment expenditure on the experimental activity. Despite a considerable reduction in funds, this permitted :

— improvements to 8 instruments (mechanical adjustments, shielding, extension of measuring capacity, handling facilities, etc)

— technical and financial coordination of the construction of the triple axis spectrometer on cold neutrons IN12, the interferometer D18 (despite the fact that this was considerably slowed down due to a lack of funds), and of the new ultra-cold neutron source.

On the technical side, the Project Office has

— worked closely with the scientists concerned on design studies and the preparation of preliminary projects for the instruments IN13 and IN5B, the construction of which has been planned and partly financed

— coordinated the study for the improvement of experimental working conditions in the neutron guide hall

— followed up the installation of a number of special instruments :
  - installation of an evaporator for producing polarizing mirrors
  - measurement of protein in maize grains
  - preparation of the guide H21 for use for measuring the ratio h/m for the neutron

— contributed to the preparation of a plan for the improvement and renewal of the scientific instruments over a period of years.

workshops, fittings and maintenance

WORKSHOPS

1. The mechanical engineering and sheet metal workshops, with the same staff as the previous year (8), carried out approximately 11,000 hours of work which covered 280 requests for work lasting more than one day, divided as follows : approximately 75 % for the experiments, 15 % for the reactor and 10 % for general requirements.
   The most note-worthy jobs were a major contribution to the construction of new instruments and the modification of existing ones, on the basis of studies by the " Mechanical construction and maintenance section ".

2. The " Self-service " workshop has increased its activity with 12 to 14 technicians using it each day for mechanical engineering jobs under the supervision of a skilled workman. Although this workshop is on a small scale because of

the facilities available, the quality of the work has maintained its high level this year and made an important contribution to the work required for the experiments.

3. The " Special products " workshop, with one employee, has continued to produce the usual radioprotection material (polyurethane/boron carbide, lithium fluoride scintillators, gadolinium, etc). Mention should be made of the increasing interest in enriched lithium fluoride for the instruments, but at the same time of some supply difficulties and technical problems associated with the sintering using the facilities available at the Institut.

4. The general " Primary materials " store continues to be operated by one employee for all the requirements of the Institut.

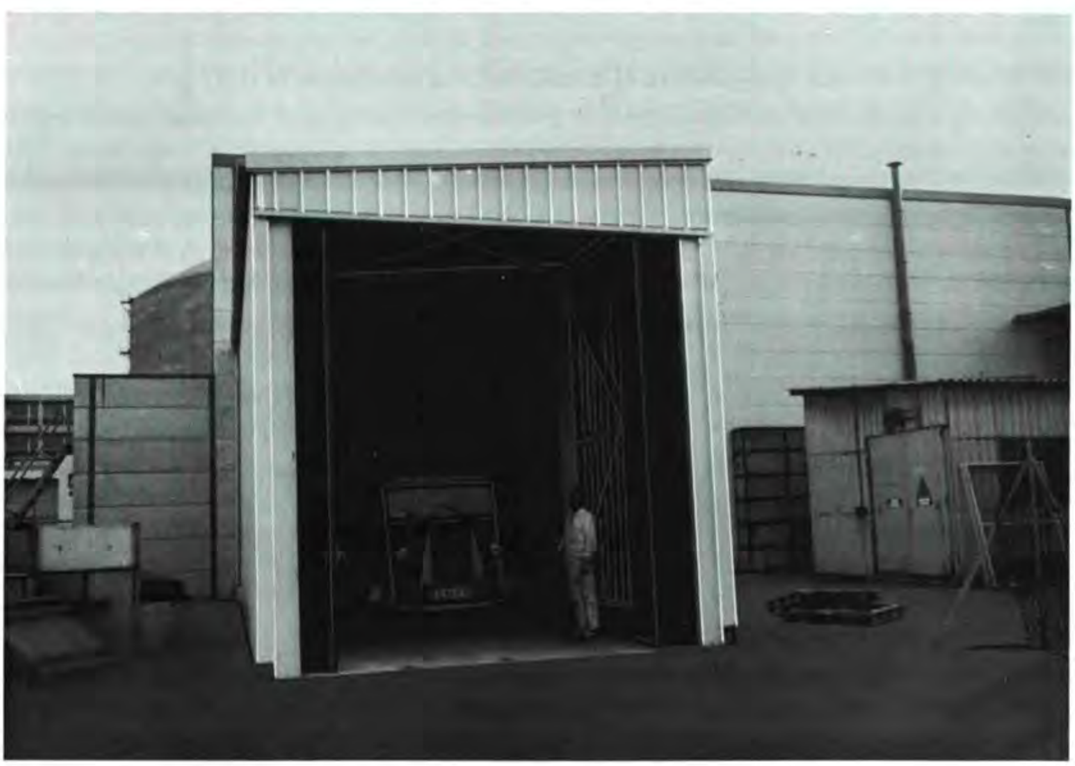
FITTINGS AND MAINTENANCE

The activities of this group are in the following fields :

1. Design studies, placing orders, checking work given to outside firms for new work, major maintenance or modifications to existing installations.

   The most important items are :

   — improvement of working conditions in the neutron guide hall (fitting, ventilation, lorry " air locks ", dust-free zones)
   — replacement of the underground liquid supply services to building ILL9



Lorry " air lock " at the end of the neutron guide building.

— improvement of temperature conditions in scientists' offices in ILL 17 (external blinds ordered)
— design study and invitation to tender for a goods reception area and improvement of the general store
— contribution to the design study with the CENG for a new joint sewer for special effluents, on which work is in progress.

2. Part or all of the associated fitting and equipment work.

3. Connection to the supply of fluids and of minor associated work for the experiments at the request of the scientists.

4. All handling and transportation within the ILL and to some extent outside.

5. Maintenance and repair of the general technical facilities, partly by ILL staff and partly by outside firms. In 1977 this sector was responsible for a considerable work load due to the noticeable aging of certain installations (lifts, goods, lifts, cranes, pipes for liquids and effluents).

6. Ensuring that the installations conform with the safety regulations, and work to improve safety conditions in general.

7. Cleaning and general maintenance of buildings, lawns and roads by external contracts.

8. Organisation and maintenance of furniture for the whole Institut.

The total value of work carried out by outside organisations is nearly two million Francs and covers approximately 70 firms.

safety and radioprotection section

GENERAL SAFETY

1. Internal safety commission (CIS)
Studies on safety, organization of working meetings : e.g. study of the methods and facilities required at ILL for handling and detection of alpha emitters, examination of the instrument OSTIS, etc.

2. Improvement of working conditions
Measurement of harmful effects in working areas : noise (neutron guide hall, reactor computer room).
Control of air quality in the experimental halls (dust, hydrocarbons, heavy metals, etc).

3. Organization of the health and safety committee (CHS)
Visit to work - places, organization of meetings, investigation of industrial accidents, reports to the factory inspector.

4. Prevention of accidents
Periodical tests of the fire detection network. Supervision of the improvement and extension work on this system.
Calibration of the deuterium leak detection systems in the detritiation building and the cold source.

5. Training and information of staff
   Organization of a safety week with talks followed by films on electrical risks, explosions, physical behaviour at work, etc.
   Training of staff in the use of handling and lifting equipment
   Training of staff in the use of first aid equipment (extinguishers)
   Instruction of shift staff on safety problems

6. Maintenance and checking of emergency equipment

7. Technical assistance
   to the experimentalists : for the control and storage of dangerous samples (introduction of a new procedure with forms)
   to the works doctor : for inspection and examination of places of work.

RADIATION PROTECTION

1. Radioprotection in all the reactor installations and around the instruments
   - daily check on shielding and irradiated samples. Assistance and information to physicists and instrument technicians.
   - periodic checking and sampling of fixed and portable detectors.

2. Laboratory work
   Gamma spectrometry of liquids and gaseous samples
   Analysis of 250 liquid samples (D_2O, H_2O, pump oil)
   Analysis of 700 solid samples (smear tests, waste)
   Analysis of 200 gaseous samples
   Analysis of tritium by liquid scintillation : 10,000 samples (wash-bottles, smear tests, urines).

3. Dosimetry
   Distribution and control of films : evaluation of the results
   films distributed in 1977 : individual : 5,560
   environment dosimetry : 1,020
   800 films were distributed to non-ILL staff in 1977 (guest scientists and staff of outside firms).

4. Preparation and control of all work in radioactive areas, particularly during reactor shut-downs.

5. All decontamination work.

6. Monitoring of liquid and gaseous radioactive waste.

7. Processing and control of solid and liquid radioactive waste before transfer to CENG for processing.

8. Assistance in radiation protection on problems of operation of the reactor and instruments : alpha laboratory, detection of alpha emission on experiments, monitoring of effluents at the chimney, gamma detection around the central core of the reactor (experimental hall).

9. Training and instruction of staff.

10. Safety duty at night and week-ends
    Assistance to shift staff, monitoring of working areas. Inspections on request or in case of incident.

reactor operation department

reactor operation in 1977

As the system of operation used since the beginning of 1975 has proved acceptable, the same schedule was maintained in 1977.

6 operating cycles were therefore planned : each cycle lasts 8 weeks and consists of 44 days of continuous operation followed by a shut-down of 12 days, except for the month of October when a shut-down for a period of about 5 weeks permits major maintenance and reconstruction work.

ACTUAL TIME TABLE

Cycle 1-77 : commenced Tuesday 4 January, ended Thursday 17 February.
This cycle was interrupted by one shut-down followed by an immediate restart, and more seriously by a poison-out following disturbances in the mains supply. The lost time was not recovered, in order to permit the planned installation of the ultra-cold neutron loop on the beam IH3.

Cycle 2-77 : commenced Tuesday 1 March, ended Thursday 14 April at 12.45 a.m.
There was no incident during the cycle, but it was shortened by several hours because of the complete consumption of the fuel element in less time than usual.

Cycle 3-77 : commenced Tuesday 26 April, shut-down delayed until Sunday 12 June at 11 p.m.
During the cycle there were several disturbances, 3 of which involved Xenon poisoning. One of these shut-downs was connected with an internal technical fault, and the other two were due, one to a strike and the other to a twenty-minute mains power cut.

Cycle 4-77 : commenced Tuesday 21 June, shut-down delayed until Friday 5 August at 11.30 p.m.
During the cycle there were also several brief shut-downs followed by immediate restart and one poison-out at the end of the cycle. There was also a contamination incident with ^{56}Mn in powder form on the experiment D5 in the experimental hall.
The contamination found on the skin and clothing of the experimentalist was removed without difficulty. The area concerned was also decontaminated immediately.

Cycle 5-77 : commenced Wednesday 17 August, shut-down delayed until 2 October at 8 a.m.
This cycle was interrupted by the failure of mechanical equipment of one of the two main heavy water pumps (which it was intended to replace during the annual shut-down). Power was reduced to 45 MW for 5 days, then the reactor stopped for 2 days to permit replacement of the pump.

Annual shut-down : October

The essential part of the work planned was completed satisfactorily in accordance with the time-table. However certain problems were noted connected with necessary maintenance and other work (e.g. during general power cuts on certain circuits, and when ventilation and removal of gaseous effluents is interrupted, etc). It will be possible to make certain improvements in the future, but it will be impossible to avoid completely all difficulties in connection with such work.

Cycle 6-77 : commenced Tuesday 8 November, ended Thursday 22 December. There were 2 shut-downs followed by immediate restarts. Towards the end of the cycle there was a third shut-down prolonged by Xenon poisoning following an unscheduled shut-down of the internal diesel-generated power supply.

DATA FOR 1977

— Number of days originally scheduled	264
— Actual number of days of operation	257
— Actual operating time (Equivalent days at full power)	253.36
— Actual operating time in relation to time scheduled	97.3
— Actual operating time (percentage of year)	70 %
— Number of fuel elements used	6
— Number of fuel elements actually dispatched for reprocessing	6
— Number of unscheduled shut-downs	38
— Number of shut-downs with Xenon poisoning	7

The reactor operation can be regarded as satisfactory as regards the overall ratio between actual operating time and number of days scheduled, i.e. 96 %. However it should be pointed out that in three cycles out of five the date of the end of the cycle had to be postponed to compensate for days lost by shut-downs during the cycle.

ANALYSIS OF UNSCHEDULED SHUT-DOWNS

The total of unscheduled shut-downs includes all incidents involving the unplanned opening of the safety circuit except for actual test periods. This number is considerably higher than the number of incidents actually observed by the scientists, since it corresponds essentially to disturbances during the start-up or restart phases after a shut-down.

The number of shut-downs with Xenon poisoning (7) is between the figures for 1976 (2) and 1975 (8). This is related to the number of unscheduled shut-downs (38 this year), as any shut-down occurring after the 30th day of a cycle necessarily results in a poison-out because of lack of reactivity.

The number of unscheduled shut-downs (the definition of which has been slightly extended in relation to that of 1976) is comparable from one year to the next, despite the efforts to reduce it. This is connected partly with the variety of possible causes of a shut-down, and partly with the difficulty or impossibility of completely eliminating the known causes (e.g. voltage fluctuations on the mains power supply). It nevertheless seems desirable to pursue the efforts to reduce the recognized causes of incidents before the inevitable aging of certain installations leads to additional causes of shut-downs.

OPERATION OF THE SUB-ASSEMBLIES

The cold and hot sources have continued to operate satisfactorily as in the past. The detritiation plant has operated in accordance with requirements.

Quantity of heavy water treated in 1977 :	HFR	51 587 l
	External	3 017 l
Quantity of tritium sent to Marcoule		89 945 Ci

The problem of increase in radioactivity in the heavy water circuits referred to in 1976 has increased to some extent. Investigations are being made to identify the reason for this increase, which has still not been explained. The total radiations received by the operating staff in 1977 has certainly been increased by this phenomenon.

The heavy water distillation unit, which was commissioned at the beginning of the year, is raising decontamination problems ; decontamination is necessary to permit the repair of a leak detected on this unit.

The computer-controlled supply system is operational and is functioning satisfactorily. However the absence of accumulators makes it impossible to avoid power cuts if the mains supply fails for more than 0.5 second. The possibility of the installation of accumulators is being studied.

MAJOR WORK AND MODIFICATIONS

CONTROL

New ionisation chambers for reactor control have been installed in the swimming pool. This system will also be adopted for the safety chambers. This should permit the life of this equipment to be doubled in addition to solving the problems of leak-proofing encountered up to the present.

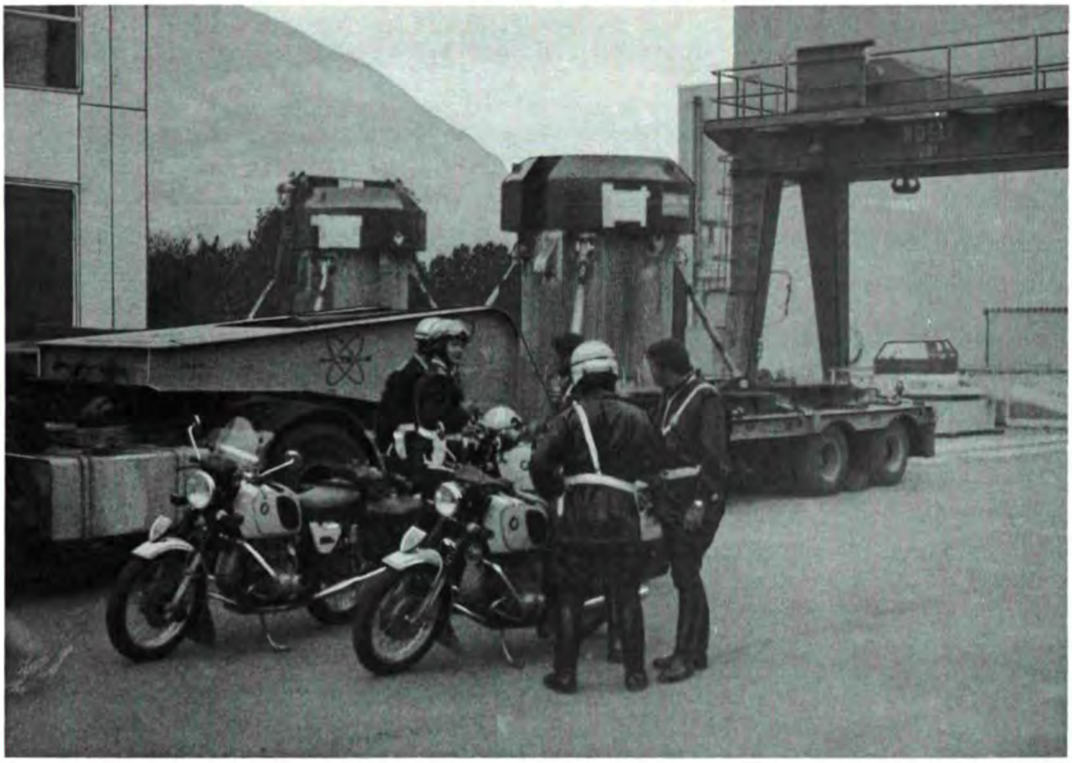
SAFETY RODS

A complete safety rod has been replaced by a new element. This should make it possible to evaluate the life of the absorbent elements of these bars.

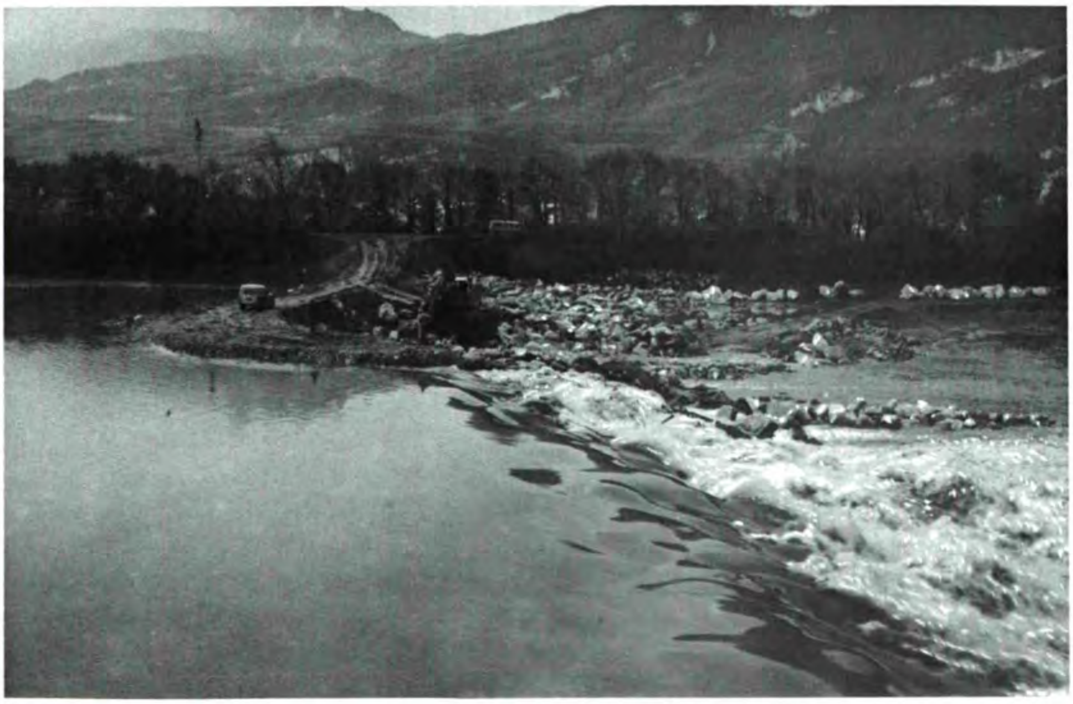
FUEL ELEMENTS

The successive delays in connection with signature of the contract for reprocessing led to a difficult situation during the summer of 1977. Two parallel courses of action were followed to deal with this problem. One of these, for the medium term, was to negotiate with the CEA for the use of a pool on which work was in progress at Cadarache. The other was to increase our own storage capacity for used elements. The request for authorization was submitted and approved : 6 additional storage positions thus became available, which corresponds to more than one year's operation of the reactor.

In addition the first four fuel elements were sent to the reprocessing plant at Savannah River. Two further elements due for dispatch are held up by an American dockers' strike. Nevertheless it can be considered that the question of storage and reprocessing of used fuel elements is no longer a major problem, at least for 1978.



The first fuel element containers ready for departure for reprocessing in the USA.



The rockfill dam on the river Drac from which cooling water is drawn for the Reactor. In the background is the temporary dyke built to protect the area where the repair work is in progress.

DAM ON THE RIVER DRAC

The cooling water for the reactor is supplied by drawing water from the river Drac at a rockfill dam.

The lowering of the river bed downstream from this dam, due to the extraction of building materials, is already worse than the most pessimistic hypothesis envisaged at the time of its construction in 1969, and continues to threaten its stability. A breach in the dam opened during the year has had to be repaired and consolidated. Negotiations have been started with the " Direction de l'Equipement " with a view to the possible construction of a second dam downstream from the first, to stabilize the river bed for the future.

ULTRA-COLD NEUTRON LOOP

This loop, designed to produce very long-wavelength neutrons, has been inserted in the inclined beam IH3. It is connected to the reactor circuits of demineralised water to ensure its cooling, and to the safety circuits to stop the reactor automatically if there is a leak or a cooling failure.

MODIFICATIONS ASSOCIATED WITH EXPERIMENTS ON ALPHA EMITTERS

Modifications connected with the use at ILL of alpha-emitting samples have been carried out to permit these samples to be handled in normal safety conditions. These modifications involve the establishment of an alpha radioactivity control network at the experiments, in the new alpha laboratory and on the air extracted via the chimmey. The work is in progress and each part is starting operation as soon as it is ready.

Modifications have also had to be carried out on the integrated experiments (H6 and canal Beta) to permit the use of these samples.

Finally the reactor department has designed and installed the ventilation and air extraction system in the alpha laboratory.

sample environment section

1. VACUUM

Maintenance of the following stock :
209 primary pumps
45 secondary pumps
39 special groups
25 air pumps
5 helitests
640 interventions, of which 177 were major repairs.
760 leak tests for various users.

Design and construction of 20 absolute filters to protect the primary pumps from alpha contamination.

The number of secondary pumps is insufficient to satisfy the demand and needs to be increased by ten.

2. CRYOGENIC FLUIDS

2.1. Liquid nitrogen
Consumption : 337 177 litres (+ 4 %) at 0.47 F/litre

2.2. Liquid helium
Consumption : 46 011 litres (+ 12 %)
Average cost per litre, including losses : 11 F
Gas supplied under self service system : 4 735 m^3
Gas losses : 7 216 m^3 (21 %).
Starting this year gas imperfection corrections have been taken into account in the calculation of gas returned under high pressure to CENG. This correction reduces by 10 % the evaluation of the quantity of gas returned. As a result the losses in previous years have been underestimated. The apparent stabilization of losses at a level of 21 % in fact corresponds to a reduction in losses of 10 %.
Very high consumptions (100 to 200 litres per day) have been observed for two special instruments. Although these consumptions were limited to short periods of a few days, they have dangerously unbalanced the usual distribution system for liquid helium. A considerable increase in the storage capacity will be required to meet these new needs.

3. CRYOSTATS

3.1. Current operation
The ILL now has 48 cryostats, 28 of which are allocated to an instrument. With 27 cryostats it is possible to obtain temperatures below 4.2 K, and 15 cover the whole range 1.5 to 300 K.
33 different instruments have used a liquid helium cryostat at least once during the year.
The ratio between number of cryostats and the number of instruments, at 1.45, is approximately half that of equivalent establishments (Brookhaven, Harwell, etc.), which indicates a particularly heavy rate of use.

More than 70 % of the experiments have required a cryostat.

The 202 requests for loans were satisfied.

New problems have arisen with the marketing of cryostats developed at the ILL because of the quality of the results obtained. These cryostats represent such progress in comparison with previous models that the experimentalists would like to use these exclusively. Their small number (5) makes it impossible to meet all requests.

The use of the two closed-circuit refrigerators has not been intensive, despite their undeniable advantages, as a result of their limitation to the lowest temperatures around 9 to 10 K. Perhaps the novelty of this equipment has also put off a certain number of potential users.

3.2. Development

Improvements have been made to an experimental model of an ILL type cryostat and have shown that the minimum temperature for routine use could be reduced to 1.1 K and perhaps even to 1 K (previous minimum temperature : 1.5 K).

3.3. Very low temperature ($T < 1$ K)

As a result of an internal move in June 1977 a qualified technician has been working full time on this problem.

His first job was a major change in the dilution cryostat to adapt it to measurements of liquid helium, and to permit the return to use of the cryostat in November 1977. These operations were carried out exactly as planned, and to schedule.

A second technician will start work on the same problems at the beginning of 1978, and it is hoped that it will finally be possible to obtain very low temperatures at ILL in relatively easy conditions of use.

As in all other fields of sample environment, the aim will be not to obtain performances at the limit of technology, but to develop robust equipment which can be used as easily as possible.

4. FURNACES

Approximately 10 % of the experiments required a furnace.

Temperatures from 20° to 1600° C are now routinely obtained, with a stability of $\pm$ 0.5° C.

A special 200° C horizontal-axis furnace has been designed and its construction is in progress.

The developments have been devoted essentially to the standardization of furnaces and control electronics, and to improvement of details the usefulness or necessity of which have been shown by experience.

New developments are necessary in three directions :

(a) higher temperatures

(b) improved temperature stability (0.1° C $T < 800°$ C)

(c) automation.

5. CONCLUSION

More than 80 % of experiments are carried out at non-ambient temperatures. Apart from the load which results for the whole group, this shows the absolute necessity of a continual improvement in the equipment as a function of the change in needs.

A precise study has shown that a considerable time was devoted by the experimenters to changes of temperature. It seems more and and more necessary to be able to control the temperature by means of the computer operating the instrument, so that in the end temperature will be a parameter like the others, for which the sample can be " positioned " in the same way.

A preliminary technical study has been made to evaluate the technical possibilities and the requirements. Pilot experiments will probably be made starting in 1978 on the control of furnaces, cryogenic controls being left to a later stage.

central group

As in previous years the group has provided routine daily assistance to the instruments by the distribution, handling, control and recuperation of cryogenic fluids and gases, and by being available for the mounting and dismounting of experimental apparatus. This work has increased to a great extent this year, due to the increased use of liquid helium and liquid nitrogen, particularly by the Special Instruments, and due to the large number of experimental changes that have taken place. During the year almost every instrument's biological shield has been partly or completely dismantled at least once for modifications or repairs, and four entirely new experimental positions have been created.

In collaboration with the Reactor circuits group the installation and standardisation of the water, compressed helium, air and effluent circuits has continued. General electrical interventions have included installation and maintenance of normal and guaranteed supplies, beam shutter controls and indicators, and safety interlock systems.

In addition to the routine work of providing services and carrying out minor modifications for individual instruments, the group has also carried out general development work, and has been involved in special projects in collaboration with other groups, some of which are indicated below.

— Construction and fitting out of two new laboratories in the experimental hall of the reactor ; one for handling low-activity samples, and the other for pre and post-irradiation examinations, manipulations and storage of hazardous samples (in particular α emitters).

— Equipment of a new workshop for the use of the instrument technicians.

— Study of modifications to existing vacuum evaporation laboratory.

— Definition of new effluent gas line for the Neutron Guide Building with installation to be carried out in 1978.

— Examination of the working conditions in the guide hall have resulted in each vehicle access being equipped with an " air-lock " to avoid sudden temperature changes. Detailed proposals are now being prepared for the replacement of individual instrument cabins by the installation of two large air-conditioned zones, which will group together the computers and control electronics from a number of instruments.

— In collaboration with the Project Office and the Radioprotection Group the necessary shielding has been defined for the following instruments : IN12, OSTIS, IN5 bis, D10, S21, S30B, S 42, D13A, B and C.

— Modifications to the interior of the D2/D8 casemate to reduce the fast neutron background, and to the shields of IN8, D9, D3/IN7, D1A/D1B and IH1 to reduce the γ background.

— In collaboration with ILL and in some cases CEA experts, safety assessments have been made for a number of hazardous materials including ^3H, T_2O and isotopes of Pu, Am, Th, Np, Bk and Ra. The Central Group is responsible for ensuring that the recommended working and handling procedures specified by the experts are followed, and that procedures are established for use in emergency.

— Work has continued on the development of an UHV system, incorporating a liquid helium cryopump, which will eventually be used with a micro-balance on D1B for adsorption studies. During the year apparatus was constructed for adsorption isotherm studies of ammonia on graphite and H_2O and D_2O on silver iodide.

— In collaboration with the Detector group, tests have been carried out on a resistant anode position sensitive detector, and on two models of a new type of position sensitive monitor constructed at ILL. A 16-cell fission detector monitor is under construction for D11.

— A program has been written for the PDP 10 to plot the resolution curves of the individual wires of multidetectors under test.

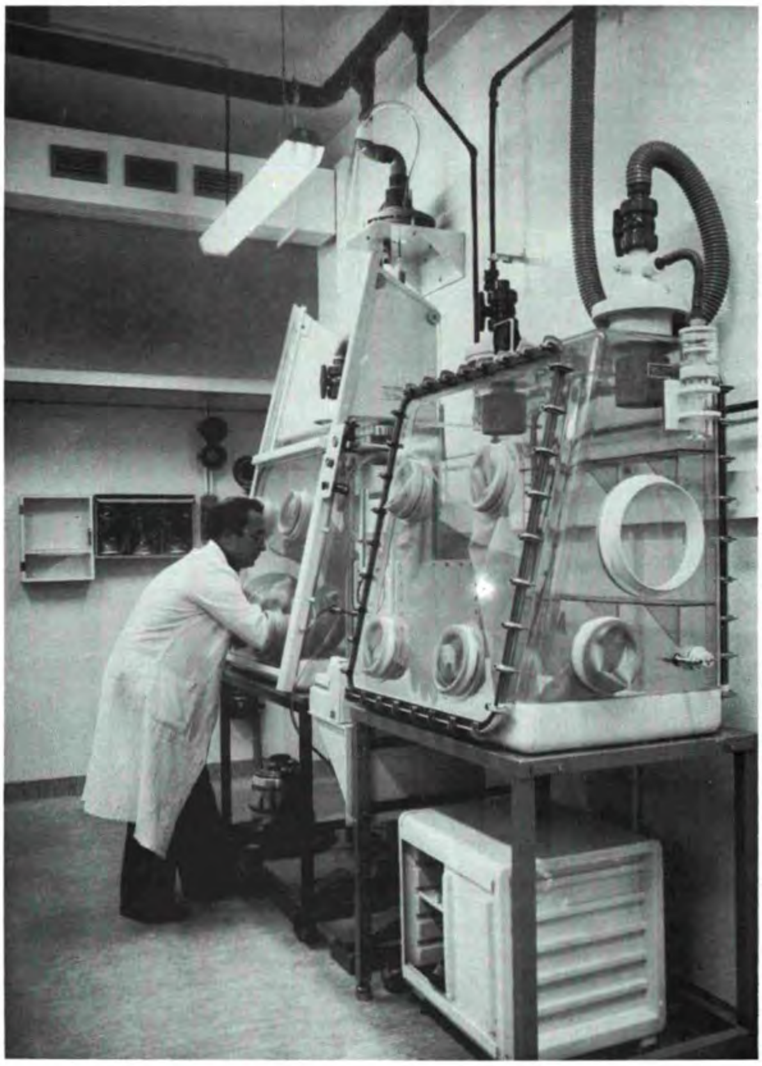
— The commissioning of the IN11 Neutron Spin Echo Spectrometer has involved design and construction of a 600 A 100 V power supply, 15 metres of vacuum flight tubes, spin flip coils, $\frac{\pi}{2}$ turn coils, field correction and shim coils, and the fabrication of a super-mirror polariser and analyser.

— The design specification for an evaporator for on-line production of supermirrors. This evaporator has now been delivered and will be operational in 1978.

— Electrical control system for the organic crystal growing apparatus.

— To assist in the alignment of single crystals the following devices have been designed and built :

- A micrometer controlled adjustable collimator based on a kinematic precision hinge, allowing the neutron beam to be swept accurately and reproducibly over a zone of 12 mm in the X and Y direction. Seven of these have so far been built and installed.
- A miniature translation head for use with the D10 cryostat, and with single stage displex cryorefrigerators allowing $\pm$ 3 mm adjustment in X, Y and Z.
- An adjustable support for use with a 2-stage cryorefrigerator on D15 or D16, incorporating pumping ports, electrical feedthroughs, and telescopic vacuum and cryo shrouds to give access to the crystal.
- Variable beam definers for the monochromatic beam of D8.



The new laboratory for alpha emitters.

computing and electronics department

1977 saw the start of the implementation of the replacement for the NICOLE control system. This should ofter offer flexibility, more on-line computer power and, hopefully, better reliability.

Otherwise, the emphasis has continued to be on maintaining the existing facilities in good working order. This becomes increasingly time consuming, and the Department looks forward to the Modernisation Programme as a means of alleviating the situation.

1 instrument control and data acquisition service

This Service is responsible for developments, improvements and maintenance of ILL electronic equipment, instrument control electronics, instrument computer systems and detectors.

The assignment of instruments to control systems at the end of 1977 was as follows :

In routine operation

CARINE systems (using Télémécanique T2000 computers)
- CARINE 1 : D1A, D1B, D2, D5, D9
- CARINE 2 : D10, IN1, IN2, IN3, IN8
- CARINE 3 : Stand-by, test and development

NICOLE systems (using Telefunken TR86 computers)
- NICOLE 1 : D7, IN4, IN5, PN1
- NICOLE 2 : Stand-by, test

Freestanding PDP 11s (various types) : IN10, IN11, D3, D17, PN2, PN3 (GAMS 1), PN3 (GAMS 2/3)

Freestanding computers (other than PDP 11) : IN7, D15/16

Running, but not yet fully checked out

Freestanding PDP 11/40s : D8 (tranferred from CARINE 1) ; D11A/B (D11A transferred from NICOLE 1)

Under development

Individual PDP 11/34s sharing a PDP 11/55 as concentrator : D7, IN4, IN5, PN1 (to transfer from NICOLE)
Freestanding SOLAR 16/40s : IN12, D1B (to transfer from CARINE 1)
Freestanding PDP 11/34 : D19
Microprocessor : D18

1.1. MAINTENANCE

At the present time, with only limited resources available for the replacement of aging systems, the efficient maintenance of existing equipment is a vital aspect of the Service's activities.

An increasing frequency of faults in the CARINE computer memories necessitated a comprehensive diagnostic survey to reestablish their characteristics. This may well result in a need to replace some modules. Loss of instrument measuring time due to faults in the CARINE control electronics has been serious during 1977 and is giving some concern.

NICOLE, alone amongst the instrument control systems, has to be taken out of service for weekly preventive maintenance. The failure rate has recently dropped however, almost certainly as a result of system development having been terminated.

Maintenance of general electronic devices constitutes a growing burden. With the quantity of such material steadily increasing, it may become necessary to review the organisation of this work.

1.2. IMPROVEMENTS (EXISTING INSTRUMENTS)

Plans for replacing the NICOLE system are now well in hand. Four instruments D7, IN4, IN5, PN1 are each being supplied with a PDP 11/34 for time-critical control and data acquisition functions, these being linked to a more powerful PDP 11/55 equipped with a full set of peripherals to provide program preparation facilities and data inspection. To handle the high data rates and very large number of data channels (128 K on IN4 and IN5) data acquisition will be via external CAMAC memory (as already installed on D11 and D17). On-line testing of this system is expected to start early in 1978.

The other NICOLE instrument, D11A, has been switched to the PDP 11/40 of D11B. This dual system was put into routine use at the end of the year.

As a consequence of this, very few modifications have been made to NICOLE. Exceptionally, PN1 has been equipped with on additional 4 K of memory.

Replacement of the CARINE systems is not possible in the immediate future. A few instruments which make the most severe demands on the system are being supplied with their own computers. D8 now runs on a PDP 11/40, and a SOLAR 16/40 is on order for D1B. This latter machine, built by the French company SEMS is felt to be a good alternative to the PDP 11 on instruments where the data rate is not too high. The remaining instruments have had to be content with general improvements to the software, such as a better line-up procedure for triple-axis machines, better diffractometer support programs and a more efficient swapping procedure, Some longer term possibilities are discussed below (section 1.4).

Various improvements have been made to the PDP-11 and PDP-8 based systems. The PDP 11/20 which became available when D6 was closed down is to form the basis of a multiparameter analyser for nuclear physics experiments.

Improvements and enhancements have been made to the detectors on several instruments. Additional individual detectors have been installed on IN4, IN5, IN7. Small multidetectors have been tried out on D4 and D16.

As always there has been a need for new and improved electronics, not only on instruments but also for portable devices such as recorders and cryostats.

1.3. NEW INSTRUMENTS

The PDP 11/40 on D17 is now considered fully operational, although the full potential of the system for data inspection has not yet been realised. To a certain extent the same is true for the equivalent system on D11 A/B, but this has benefited from the prior existence of programs to analyse D11A data on the PDP-10, most of which have been transferred to the PDP 11/40.

The new triple-axis spectrometer IN12, which had been originally foreseen as running on CARINE has, in view of the latter's response time problems, been assigned its own SOLAR 16/40. In consequence, the previously acquired CARINE-compatible electronics has been modified, the CAMAC now being controlled by an INTEL 8080 microprocessor.

The portable multidetector intended for use on diffractometers, D19, has been under construction during the year. The detection elements lie on a curved surface spanning 64° horizontally and 4° vertically with resolutions of 0.125° and 0.25° respectively, and is filled with He^3 at 12 bars. A PDP 11/34 has been selected to handle data acquisition, to achieve compatibility with D8.

Despite the fact that the project was frozen for part of the year due to lack of funds, considerable progress has been made with the electronics for D18, the neutron interferometer. In the absence of money for a mini-computer, control will initially be handled by a Motorola M6800 microprocessor.

1.4. STUDIES, PROTOTYPES AND LONG-TERM DEVELOPMENTS

The possibility of integrating microprocessors into CARINE to speed-up response times was investigated, but rejected as being impractical. However the replacement of DC motors by stepping motors appears to offer some advantage for the fine positioning and a prototype is to be tested on IN8.

The only real solution to CARINE'S problems, however, is complete replacement of computer, electronics and motors, and it is hoped that this can be achieved as part of the Modernisation Programme. To this end, a study group of physicists and engineers is in the process of examining the state-of-the-art in respect of shaft positioning and angle encoding.

The acquisition of two SOLAR 16/40 computers, with the posibility of more to follow, has led to the idea of a SOLAR concentrator to play a role equivalent to that of the PDP 11/55. Technical problems relating to the setting up of such a network of SOLAR computers are under investigation.

General development work in the field of multidetectors continues. The general tendency is to stay with gas-filled detectors since their performance is very good at long wavelengths. In parallel with this are efforts to reduce the dead-time and cost of the associated electronics.

It is also felt worthwhile to continue to develop the use of external memories for fast data acquisition. The newly produced high-density chips hold 16 K bits each, thus making it possible to house 128 K 16 bit words of memory in one CAMAC module. Several other research institutes have shown interest in acquiring such modules, and by purchasing the chips in bulk considerable price reductions are possible.

2 central computer service

2.1. OPERATIONS

The DEC System 10 Central Computer continues to provide general computing facilities for the ILL staff together with restricted data handling facilities for visitors, but its resources are coming under increasing pressure.

The overall throughput of work is governed, in the first instance, by the period of operator cover which remains at about 75 hours/week. Thus the overall central processor throughput has now levelled off at about 3200 hours in the year. Even the users who take the machines themselves overnight are now required to accept other users up till midnight.

An additional 64 K words of reconditioned memory has been installed (bringing the total to 224 K) as the only remaining practical possibility for improving the efficiency of the system. This is the only addition to the configuration that has been possible this year.

2.2. DATA HANDLING

The amount of data being received from the instruments has increased slightly during the year mainly as a result of D17 coming into regular use, and is now running at about 220 Mwords/ year.

A very significant development has been the integration of data from certain PDP-11 controlled instruments (initially D11 and D17, to be followed by D8) into the general experimental data base previously restricted to CARINE and NICOLE instruments.

2.3. GRAPHICS

The " Versatek " electrostatic printer, which was installed at the end of 1976, has caused a certain amount of inconvenience because although it produces diagrams of excellent quality, it requires a great deal of processor time to generate the picture image. Considerable effort has gone into resolving this problem including improving on the manufacturers software and using the PDP 11/55 to generate the input tape. However it is foreseen that ultimately the only satisfactory solution may be to have the plotter run on the 11/55.

Otherwise, effort has gone into unifying the software which supports the many different types of display devices. Unfortunately although unified software is convenient from the user's viewpoint, inefficiency can arise if one fails to take account of the characteristics of the device being used.

2.4. GENERAL PROGRAMMING SUPPORT

Active programming effort is still necessarily restricted to supporting a few key-areas. The Rutherford Laboratory (Atlas DIv.) version of the X-RAY crystallographic package has been installed, giving ILL for the first time a complete up-to-date version of this very popular program. Thanks are due to the Rutherford Lab. staff for much assistance in this matter.

Limited availability of effort has also restricted the developments possible on the mathematical subroutine library, but the acquisition of libraries and individual routines from other research institutes has been possible.
The suite of management services programs which handles travel expenses and related statistics has required certain modification during the year, and because of its complexity it has not yet proved possible to hand over its running completely to Administration Dept.

2.5. TRAINING COURSES

Several series of lectures and training courses have been held on subjects of greatest interest to users. Introductory courses in operations are also held as required to enable users to run the machine themselves.

2.6. SYSTEM-10 REPLACEMENT

It has been felt for some time that it would be necessary to replace the System-10 in about 1980. Since this date falls within the timescale for the Institut's general Modernisation Project the replacement is being included in those proposals. For the purposes of making advanced budgetary estimates an appraisal of the Institut's computing needs in the 1980's has been made. To meet this timescale it will be necessary to start a serious examination of possible machines early in 1978.

administration

The Administration and Finance Department comprises the Personnel, " Relations Sociales " and Finance sections.

On 25 July 1977 the ILL " Convention d'Entreprise " (internal agreement) was signed by the Director and the unions CGT, CFDT and FO. This agreement takes account of the particular situation of the ILL. It replaces the Staff Conditions and Regulations in force up to that date.

personnel

PERSONNEL

Among the different fields relating to Personnel it may be interesting to bring out in 1977 the questions concerning the staff of the Institut and the staff representatives, who play an essential role in the relations with the Management.

1. STAFF

I. STAFF SITUATION

		Changes in 1977				
Categories (1)	Position on 31.12.76 (2)	Recruitment and internal changes (3)	Departures and internal changes (4)	Difference + or — (5)	Position on 31-12-77 (6)	Change % column 4 compared with column 2 * (7)
1. Scientists	73	19	16	+ 3	76	22
2. Technical and administrative " Cadres "	58	3	1	+ 2	60	2
3. Thesis Students	25	10	5	+ 5	30	20
4. Technicians	142	5	3	+ 2	144	2
5. Others	99	9	3	+ 6	105	3
Total	397	46	28	+ 18	415	7

* The percentage of ILL staff who left the Institut in 1977, in comparison with effective strength on 31.12.76.

As in previous years the major staff movements are essentially due to the limited-term contracts of the scientific staff. It should be noted however that although the number of new staff was the same as in 1976 (46), the number of resignations diminished considerably (28 instead of 44).

Remarks :

1) The number of female staff on 31.12.77 was 55 or 13 % of the total staff of the Institut.
2) NB : One retirement, the first since the ILL was set up.

II. BREAKDOWN OF STAFF BY NATIONALITY: 1973, 1974, 1975, 1976, 1977

Categories	French					German					British					Others					Total				
	73	74	75	76	77	73	74	75	76	77	73	74	75	76	77	73	74	75	76	77	73	74	75	76	77
Scientists	19	18	17	17	18	25	26	22	21	18	7	13	22	22	26	17	11	12	13	14	68	68	73	73	76
Cadres and engineers	38	35	38	40	41	15	9	11	11	11	5	5	5	7	8	—	—	—	—	—	58	49	54	58	60
Thesis students	18	15	15	9	10	10	7	5	9	11	1	2	7	7	9	2	2	2	—	—	31	26	29	25	30
Non-Cadres	182	195	196	193	192	19	18	18	19	21	9	14	21	25	29	4	3	4	4	7	214	230	239	241	249
Total	257	263	266	259	261	69	60	56	60	61	22	34	55	61	72	23	16	18	17	21	371	373	395	397	415
Changes		+6	+3	—7	+2		—9	—4	+4	+1		12	+21	+6	+11		—7	+2	—1	+4		+2	+22	+2	+18

Notable increase in staff in 1977 (+ 18), particularly British staff (+ 11).

2. STAFF REPRESENTATION

The ILL staff is represented by :

1) Three unions (CGT, CFDT, FO).
   The establishment of a new union branch (FO) at ILL during the year should be noted
2) The Members of the " Comité d'Entreprise " (works committee).
   The elections for this committee took place in February 1977.
3) The representatives on the CHS (Health and safety committee).
4) The " Délégués du Personnel " (staff representatives).
   The elections took place in March 1977.
5) The representatives on the " Commission Paritaire des carrières " (joint careers committee).

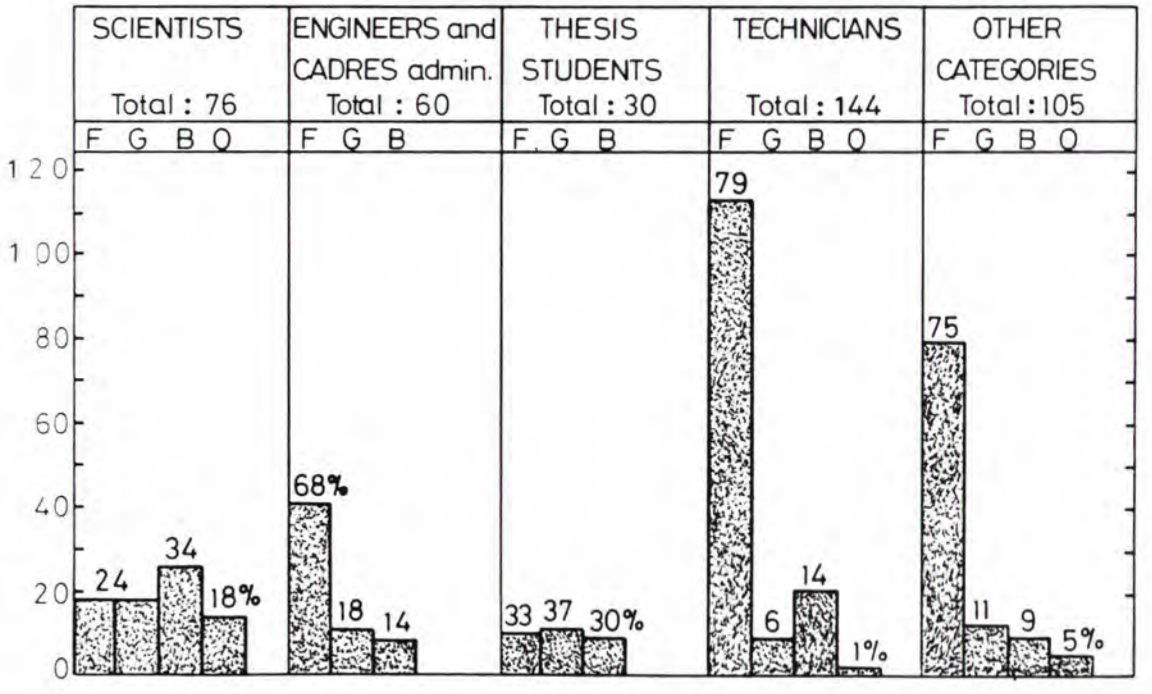
COMITE D'ENTREPRISE

The " Comité d'Entreprise " (works committee), in conformity with its legal functions, played an important part in the life of the ILL. In the economic field the Comité has consultative functions. In the field of work it has cooperated with the Management in improving the conditions of work at the Institut. In addition, in connection with its social functions, the Comité d'Entreprise organized, controlled or participated in the management of all staff amenities organised within the ILL for the benefit of the employees.

III. STAFF BY CATEGORY AND NATIONALITY ON 31.12.77

Total staff	415
French	261
German	61
British	72
Others	21

F French
G German
B British
O Other



"relations sociales"

(figures up to 15.11.77)

The main work of this section is :

— reception of staff and guest scientists

— medical and social matters

— reimbursement of travel costs to ILL staff and guest scientists, and the related statistics

— staff training

An important change has occurred this year in the medical field. With a view to finding the best arrangement on medical problems, the ILL has set up an independent medical service with a young works doctor working part time. He has undertaken with efficiency and energy the monitoring of staff and long-term visitors. He is working in close cooperation with the section heads in order to become familiar with the work of the staff and any associated risks. He has regular contacts with some of the medical services of the CEA (French Atomic Energy Authority), particularly their Marcoule centre, and with the appropriate hospital departments in Grenoble .

There have been examinations by the ILL medical service of the following :

Staff working in the restricted area more than 200 hours per year :

202 ILL staff

32 guest scientists

Staff working less than 200 hours per year in the restricted area :

123 ILL staff

6 guest scientists

Staff not working in the restricted area :

103 ILL staff

1 guest scientist.

Guest scientists working in the reactor are required to attend a medical examination if they are unable to submit a medical certificate indicating that they are fit to work under ionizing radiation.

— Industrial accidents :

19 accidents, 7 of which resulted in a total of 114 days' sick leave (20 in 1976 for 49 day's sick leave)

— Other sick leave :

	Cadres	Non-Cadres	Total	Absence more than 30 days	Total number of days' absence
1975	20	115	135	9	1558
1976	13	85	98	6	1666
1977	31	107	138	12	1692

Maternity : 8 cases resulted in 856 days of absence in 1977.
Health cures : 2 cases involved 38 days of absence in 1977.
The total number of days' absence for industrial accidents, illness, maternity, health cures represents 2.28 % of the theoretical total of days worked.

SOCIAL SECURITY

The number of cases of illness, maternity, etc checked and the documents forwarded for reimbursement to the Social Security has increased over the last four years, as has in parallel the number of supplementary refunds paid by the ILL "Société Mutualiste" and the number of cases forwarded to IRRAPRI (superannuation for Cadres) for surgical and particularly maternity cases.

		Société Mutualiste		IRRAPRI	
	Social Security	Number of cases	Amounts reimbursed	Number of cases	Amounts reimbursed
1975	5580	4800	172,289 F	194	26,745 F
1976	6170	4715	210,843 F	218	39,095 F
1977	6380	4675	205,623 F	271	45,047 F

GUEST SCIENTISTS

The expression "guest scientists" includes the scientists coming to the ILL :
as users of the reactor to carry out experiments approved by the Scientific Council
to give seminars
to spend a sabbatical year.

The following table shows the number of visits by guest scientists from French, German, British, or other **laboratories**, regardless of the nationality of the persons coming from these laboratories.

	French	German	British	Other	
With expenses paid					
up to 3 months	144	214	240 (1)	74	
3 months to 1 year	3	6	—	2	
more than 1 year	3	10	1	—	
	150	230	241	76	= 697
Without expenses paid					
up to 3 months	157	94	112	139	
3 months to 1 year	3	2	7	11	
more than 1 year	2	2	4	7	
	162	98	123	157	= 540

(1) Estimates

With the aid of the Computing Department a number of statistics have been obtained in collaboration with the Scientific Secretariat.

ASSISTANCE FOR HOUSING

This takes different forms :

1) Looking for flats or houses for new arrivals, existing staff or long-term guest scientists.

   We have helped about 40 families in this way. Inquiries are made by telephone to agencies and by advertisements in newspapers etc. As the ILL is now quite well known, we receive many unsolicited offers.

2) Investment of the " 1 % fund "

   Employers are required to devote 1 % of the gross salaries to assistance for staff on housing within very strict legal provisions. The ILL complies with this law mainly by granting loans complementary to a principal loan (from Crédit Foncier, for example) free of interest, to be reimbursed in ten years, to staff purchasing flats or houses under construction in accordance with the limits laid down by the law. The maximum loans are also determined by the law (e.g. 21 000 F for 3 rooms + kitchen, 27 000 F for 4 rooms + kitchen, maximum 34 000 F).

   The section gives advice and guidance to staff interested in buying property and helps them to prepare the necessary documents in connection with the requests for loans from banks or other organizations.

   The table below shows the number of requests and total loans obtained or in progress during the last four years in connection with the " 1 % law " through the " Comité Grenoblois d'Aide au Logement ".

	Number of recipients			Total loans
Year	Cadres etc	Non-Cadres	Total	
1974	3	6	9	95 000
1975	4	11	15	173 000
1976	3	18	21	253 000
1977	4	16	20	438 000
in progress on 15.11.77	1	4	5	97 000
Total	15	55	70	1 056 000

SCHOOLING

The average number of non-French children attending the Houille Blanche primary school was 50 for the school year 1976/77, and will be of the same order for the current year. The composition of the experimental classes is based on the following principles :

- a maximum of 25 children per class, including 15 French (from the district near the school) and 10 non-French, children of staff of ILL, the Max Planck Institut, etc.

— 2 German and 2 British teachers are attached to this school, and there is a French teacher to give tuition in French to the foreign children when they arrive at Grenoble.

The 6ème and 5ème classes at the Eaux Claires secondary school represent the normal continuation of the primary school. It seems that the new heads of this " collège d'enseignement secondaire " are more aware of the problems of teaching foreign children. Efforts are in progress to obtain from the local education authority the authorization to continue the experimental classes up to the 3ème inclusive.

STAFF TRAINING

As in previous years, a training programme was prepared giving staff the possibility of attending courses of various lengths in languages, technical subjects or general education.

The extent to which applications for training are connected with work is striking. They aim at improving knowledge and technical skills, or at the improvement of relations within the organization, for example by the desire to learn the languages most currently used at work (French, English).

The educational organizations on which we rely the most are CUEFA (Centre Universitaire d'Education et Formation pour Adultes), APPS (Association pour l'Enseignement Professionnel et la Promotion Sociale), and the Centre de Formation Professionnel pour Adultes at Pont-de-Claix.

finance

1. BUDGET AND ACCOUNTS

The budget approved for 1977 provided for a total expenditure of 99.3 million F. Of this 2.0 million F were to be covered by the ILL's own income, while the contributions of the associates were set at 97.3 million F.

The following is the actual expenditure according to the provisional accounts for 1977, in comparison with the actual expenditure for 1976 (excluding taxes) :

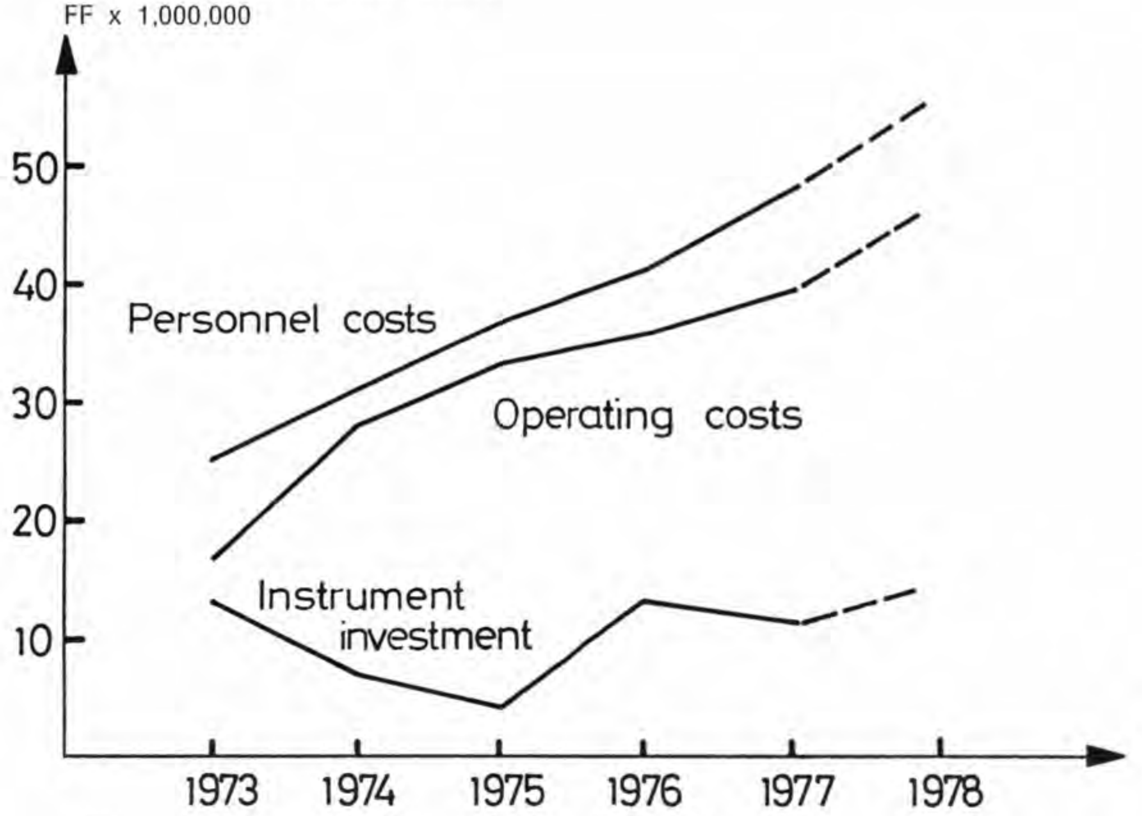
	1977 (x 1000 F)	% of total	1976 (x 1000 F)	% of total
a) Operation				
Consumable materials and small equipment	6 200	6.4	6 323	7.1
Fuel elements	14 170	14.5	9 913	11.1
Staff costs	48 000	49.2	41 833	46.7
Taxes	121	0.1	97	0.1
Long-term service contracts	8 600	8.8	7 555	8.4
Other work, supplies and services from third parties	5 900	6.0	5 492	6.1
Transport, removal and travel expenses	890	0.9	978	1.1
Miscellaneous administrative costs	3 125	3.2	2 815	3.1
Total operation	87 006	89.1	75 006	83.7
b) Investments				
Buildings	325	0.3	218	0.2
Equipment (except experimental equipment)	1 307	1.3	1 078	1.2
Experimental equipment	7 200	7.4	8 567	9.6
Other investments	1 800	1.9	4 711	5.3
Total Investments	10 632	10.9	14 575	16.3
Total expenditure	97 638	100.0	89 581	100.0

	1977 (x 1000 F)	% of total	1976 (x 1000 F)	% of total
c) Income				
ILL's own income	1 980	2.0	2 115	2.4
Grants from Associates	95 658	98.0	87 466	97.6
Total Income	97 638	100.0	89 581	100.0

1.1. The operation expenditure increased from 75.0 million F to 87.0 million F (+ 16 %) in comparison with the previous year. This increase was mainly due to the reprocessing of used fuel elements in the USA, which began in the second half of 1977, to increases in the costs of purchases and of manufacturing the fuel elements, and to increases in staff costs.

1.2. The investment expenditure was reduced from 14.6 million F in the previous year to 10.6 million F. The higher investments figure for 1976 included the expenditure for the purchase of the central computer system at 3.1 million F. Unforeseen delays in delivery — particularly on experimental equipment — led to certain orders from 1977 and previous years (a total of 1.5 million F) not being completed as planned by the end of the year, so that the expenditure was not incurred until the beginning of 1978. The total expenditure for investments in 1977 is therefore lower by this amount than anticipated.

2. EXPENDITURE TRENDS 1973-78



1973 to 1977 show actual expenditure, 1978 is a budget figure.

3. PURCHASING

In 1977 a total of 5 187 purchase orders — in comparison with 5 541 in the previous year - were handled by the purchasing section.

There is close cooperation with the technical and scientific areas on all purchases. The distribution of orders in the partner countries was as follows :

	1977 (x 1000 F)	% of total	1976 (x 1000 F)	% of total
Total orders	33 226	100.0	29 487	100.0
Distribution				
— France	16 800	50.6	16 493	55.9
— Germany	11 900	35.8	8 555	29.0
— U.K.	906	2.7	3 143	10.7
— Others	3 620	10.9	1 296	4.4

Despite considerable efforts it was not found possible to improve the distribution of contracts among the partner countries.

The reduction in orders placed in the United Kingdom was due primarily to delivery dates and the price competition.

Our efforts will continue to achieve a better distribution of orders in future.

EXPERIMENTS PERFORMED AT THE ILL 1977

The following is a list of the experiments performed at the ILL from October 1, 1976 to September 30, 1977 for which reports have been received up to January 31, 1978.

Please refer to the Annex of the Annual Report for a detailed study of the results.

(* Reports marked with an asterisk are not available for publication.)

COLLEGE 3

03 01 018 A0	Investigation of the emission probability of delayed neutrons Pn, of individual nuclei (Rb and Cs isotopes). C. Ristori, J. Crançon (CEN-G) K.L. Kratz, W. Rudolph, H. Ohm (Mainz) K.D. Wünsch, G. Jung (Giessen and ILL)	PN6
03 01 027 B0	Spectroscopy of β^-—delayed neutrons from ^{95}Rb decay in coincidence with γ-rays depopulating excited states in the final nucleus ^{94}Sr. H. Ohm, K. Sümmerer, K.L. Kratz (Mainz) K.D. Wünsch, G. Jung (Giessen and ILL) C. Ristori, J. Crançon (CEN-G)	PN6
03 01 027 BO	Delayed-neutron spectroscopy of Cs precursors with ^{3}He ionization chambers. H. Ohm, K.L. Kratz (Mainz) C. Ristori, J. Crançon (CEN-G) G. Jung, K.D. Wünsch (Giessen and ILL)	PN6
03 01 027 A0/B0	Analysis of the delayed neutron spectrum following β^-decay of 0.38s ^{95}Rb. H. Ohm, K.L. Kratz (Mainz) K.D. Wünsch, G. Jung (Giessen and ILL) C. Ristori, J. Crançon (CEN-G)	PN6
03 01 050	Plasma time measurements for fission fragments incident on silicon surface barrier detectors E.C. Finch, A.A. Cafolla, C.F.G. Delaney (Dublin) M. Asghar (ILL) M. Forte (Ispra) P. Perrin (CEN-G)	PN1
03 01 056 (03 01 008 B)	Q_β-measurements in mass chains of short-lived fission products. H. Berg, U. Keyser, F. Münnich, R. Stippler (Braunschweig) R. Decker, B. Pfeiffer (Giessen) E. Monnand, F. Schussler (CEN-G) K. Hawerkamp, H. Schrader (ILL)	PN1
03 11 003	Nuclear charge distribution of heavy mass region fission products at variable kinetic energies (Chain 134 (isomeric ratio) and Chain 136). H.O. Denschlag, W. Faubel, H. Braun, H .Meixler (Mainz) A.C. Wahl (St. Louis) H. Schrader, G. Siegert (ILL)	PN1
03 11 012	Nuclear charge distribution of fission products. G. Siegert, E. Koglin (ILL) J. Greif (Giessen)	PN1
03 11 013	Nuclear charge distribution of fission products measured with collision X-rays. G. Siegert, E. Koglin, T.v. Egidy (ILL) H. Wollnik, J. Greif, W. Kaiser (Giessen)	PN1
03 02 002	The (n, γ) reaction on ^{153}Eu. P.T. Prokofiev, L.I. Simonova (Riga) K. Schreckenbach, W.F. Davidson, J.A. Pinston (ILL)	PN3
03 02 017	Study of M1-admixtures in γ-vibrational bands in rare earth nuclei. W. Gelletly (Manchester) K. Schreckenbach (ILL)	PN2
03 02 042	Determination of the change in the s electron densities at the nucleus between Eu metal and oxide. K. Schreckenbach, T.v. Egidy (ILL) M.G. Kalvius (Garching)	PN2
03 02 043	Precision measurements of gamma lines of Au^{198}, Hg^{200} and Cd ^{114}. T.v. Egidy, F. Braumandl, K. Schreckenbach (ILL)	PN3, PN4
03 02 044	Low-lying states in ^{109}Pd from the $^{108}Pd(n, \gamma)$ ^{109}Pd reaction. R.F. Casten (Brookhaven) K. Schreckenbach, W.F. Davidson, H.G. Börner, J.A. Pinston (ILL)	PN2, PN3

03 02 045	The $^{148}Nd(n, e)$ ^{149}Nd reaction. T.v. Egidy, J.A. Pinston, K. Schreckenbach (ILL)	PN2
03 02 046	Low-lying levels in ^{194}Os and the prolate-oblate phase transition. R.F. Casten (Brookhaven) A. Namenson (Washington) D. Warner, W.F. Davidson, H. Börner (ILL)	PN3
03 02 048	High precision measurements of Q-values and primary transition energies in the thermal neutron capture process. T.v. Egidy, F. Braumandl, K. Schreckenbach (ILL)	PN2
03 02 050	γ-spectroscopy of highly excited intrinsic states in ^{168}Er. J. Simic (Belgrade) W. Gelletly (Manchester) W.F. Davidson, K. Schreckenbach, D.D. Warner, H.G. Börner (ILL)	PN2, PN3, PN4
03 02 054	Collective excitations in ^{235}U. Measurement of the excitation energy of ^{235m}U. J. Almeida (ISN) P. Van Assche, T.v. Egidy, K. Schreckenbach, H. Börner, W.F. Davidson (ILL).	PN2, PN3
03 02 055	Nuclear level structure of ^{155}Gd above 1 MeV. T.v. Egidy, K. Schreckenbach (ILL) W. Stöffl (München)	PN2
03 02 057	Investigation of the beta- and antineutrino spectrum from fission products. K. Hawerkamp, K. Schreckenbach, G. Siegert, H. Schrader, W. Mampe, T.v. Egidy (ILL).	PN2
03 02 064	Nuclear structure of ^{155}Gd above 1 MeV. T.v. Egidy, H. Börner, D. Warner (ILL) W. Stöffl (München)	PN3, PN4
03 02 066	Auger lines of gold. K. Schreckenbach, P. Jeuch (ILL)	PN2
03 02 067	X-rays from double K vacancies. J.P. Desclaux (CEN-G) K. Schreckenbach, H.G. Börner (ILL)	PN3
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5 24 24 (5 25 68B) (5 24 102B) — Methane on graphon — D1B
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T.D. Trewern (Oxford)

5 24 104 — Structure of nitric oxide adsorbed on graphite. — D1B
J.P. Coulomb, J. Suzanne,
M. Bienfait (Luminy)
N. Matecki, A. Thomy (Nancy)
C Marti (ILL)

5 24 105 — Test of D16 to study physisorbed Ar or Kr on graphite. — D16
C. Marti, P. Thorel (ILL)

05 25 28R — Structures of $Pd_{2-x}MnSb$. — D2
P.J. Webster,
R.M. Mankikar (Salford)
K.R.A. Ziebeck (ILL)

5 25 29 — Etude de la cémentite. Réaction avec l'hydrogène. Structure magnétique. — D1B
D. Fruchart (CNRS Grenoble)
J.P. Senateur (INP Grenoble)

5 25 30 — Molecular exchange reactions in dichalcogenides. — D1B
C.O. Fischer (Berlin)
C. Riekel (ILL)

5 25 31 — Homogeneity and mosaic spread of orientated clay-water and organo-clay systems. — D16
M.H.B. Hayes, D.K. Ross,
P.L. Hall (Birmingham)

5 25 64A — Diffraction from clay-water systems. — D1B, D11A
R.H. Ottewill, R.K. Thomas,
D.J. Cebula (Oxford)
J.W. White (ILL)

5 25 65 — Phase change kinetics in the montmorillonite : γ -butyrolactone system. — D1B
J.M. Thomas, J.M. Adams,
C. Breen (Aberystwyth)

5 25 67 — Electrochemical reduction of layered dichalcogenides. — D1B
C. Riekel (ILL)
H. Reznik (Münster)

5 25 111A — Molecular exchange reactions — D1B
C. Riekel (ILL)
C.O. Fischer (Berlin)

5 31 1 — Test experiment to determine extinction parameters in URh_3. — D9
G.H. Lander (CEN-G and Argonne)
A. Delapalme (CEN-G)
P.J. Brown (ILL)

5 31 17 — Anisotropy in magnetisation density of Pu^{3+}. — D3
G.H. Lander (CEN-G and Argonne)
P.J. Brown (ILL)

5 32 4 — Magnetisation distribution and co-valency in $FeCl_2$. — D3
K.R.A. Ziebeck, P.J. Brown (ILL)

5 32 007A — Magnetisation density and ordering in Au_4V. — D3
P.J. Brown, K.R.A. Ziebeck (ILL)

5 32 10 — Magnetic spin density in manganese (II) Phthalocyanine. — D3
R. Mason, B.N. Figgis,
G.A. Williams (Brighton)
J.B. Forsyth (Rutherford)

5 32 21A — Magnetisation distribution in Fe_2MnSi — D3
K.R.A. Ziebeck, P.J. Brown (ILL)

5 32 22 — Polarized neutron study on $NiFe_2O_4$. — D5
F. Kajzar (Léon Brillouin, Paris)
C. Zeyen (ILL)

5 32 23A — Antiferromagnetic domains in CoF_2. — D5
P. Radhakrishna
(Léon Brillouin, Paris)
D. Ronzaud, P.J. Brown (ILL)

5 32 26A	Covalency in $K_2 ReCl_6$. J.B. Forsyth (Rutherford) P.J. Brown (ILL)	D3
5 32 27	Magnetic spin density in cobalt (II) Phthalocyanine. R. Mason, B.N. Figgis, G.A. Williams (Brighton) J.B. Forsyth (Rutherford)	D3
5 32 28A	Electron delocalisation for Mn^{2+} with D_2O and H_2O and ND_3 ligands. B.E.F. Fender, S. Golledge (Oxford) J.B. Forsyth (Rutherford)	D15
5 32 38	Magnetisation density in $CoCl_2$. C. Escribe K.R.A. Ziebeck P.J. Brown (ILL)	D3
5 32 41	Spin density in a discrete binuclear copper (II) complex. R. Mason, B.N. Figgis, G.A. Williams, A.R.P. Smith (Brighton)	D3
05 32 44	Spin density in FeSi. D. Bloch, C. Vettier, J. Voiron (CNRS Grenoble) F. Tasset (ILL)	D3
5 33 30A	Studies of the use of the polarization analysis technique for investigating amorphous materials. F.F. Freeman B.H. Meardon, W.G. Williams (Rutherford)	D5
5 34 14	Magnetisation distribution in the metallic phase of VO_2. P.J. Brown, K.R.A. Ziebeck (ILL)	D3
5 34 15	Diffuse magnetic scattering scattering from ^{242}PuP. G.H. Lander (CEN-G and Argonne) P.J. Brown (ILL)	D5
5 34 51	Paramagnetic scattering of MnSi. P.J. Brown, K.R.A. Ziebeck (ILL)	D5
5 35 16B	Scattering from polarized hydrogen in LMN. G. Jenkin, J.W. White (ILL) M. Leslie (ILL and Oxford)	D5

COLLEGE 6

06 00 002	Incoherent scattering cross-section of He^3. R.A. Cowley (Edinburgh) R. Scherm, W.G. Stirling (ILL) P.A. Hilton (Edinburgh and ILL)	D5
06-01-009D	Molecular motions in liquid crystals. A.J. Leadbetter, D.H. Bonsor (Exeter) C.J. Carlile (Rutherford and ILL)	IN5
06 01 014A*	Molecular dynamics in liquid cyclopropane. M. Besnard, A.J. Dianoux (ILL) J. Lascombe, J.C. Lassegues (Bordeaux)	IN5
06 01 030	Neutron quasielectric scattering studies on the rotational motions in liquid acetonitrile. J. Yarwood, P.G. Woodcock (Durham)	IN5
06 01 034	Low momentum transfer excitations in superfluid ^4He: pressure dependence. W.G. Stirling, J.R.D. Copley (ILL) 9 P.A. Hilton (Edinburgh and ILL)	IN5
06 02 013	The scattering law of liquid rubidium at low momentum transfers. J.B. Suck, J.R.D. Copley, B. Dorner (ILL)	IN2, IN3
06 02 032	Colective excitations in liquid aluminium N.H. March (London) D.I. Page (Harwell) A.D. Taylor (Rutherford)	IN8
06 02 033	Inelastic neutron scattering on liquid aluminium. O.J. Eder, B. Kunsch (Wien) J.B. Suck (ILL)	IN4
06 02 034	The structure factor of liquid rubidium at high temperatures. F. Hensel, W. Freyland (Marburg) W. Glaeser, E. Schneider (München) J.B. Suck (ILL)	D1A
06 03 007DR	Li-Na alloys. H. Ruppersberg (Saarbrücken)	D4
06 03 067R	See 06 08 001	
06 03 076A	Static approximation distortions in the total diffraction pattern of an amorphous solid. R.N. Sinclair (Harwell) A.C. Wright, P.A.V Johnson (Reading)	D4
06 03 077A	The structure factor for liquid vanadium tetrachloride and liquid vanadium oxy-trichloride. I.P. Gibson, J.C. Dore (Kent)	D4
06 03 083	Quasielastic neutron scattering from liquid NaOH. J.G. Smit, H. Dachs (Berlin) R.E. Lechner (ILL)	IN5
06 03 085	Partial structure factors of the molten eutectic 37 Cu 63 Sb alloy. W. Knoll (ILL)	D4

06 03 086 (06 03 079) (06 03 007BR)	Li and Li alloys. H. Ruppersberg (Saarbrücken)	D4
06 03 087	Structure of molten iron-carbon. S. Steeb, M. Weber (Stuttgart)	D4
06 03 089	Structure of molten Cs-Sb-alloys. W. Martin, S. Steeb (Stuttgart)	D4
06 03 092	Structure of molten Au-Cs-melts. W. Martin, S. Steeb (Stuttgart)	D4
06 04 001*	Scattering with molten Fe at low momentum transfer. S. Steeb, M. Weber (Stuttgart)	D7
06 04 002	Structure of $ErCo_2$ amorphous ferrimagnet. B. Boucher (Saclay) A. Lienard, J.P. Rebouillat (CNRS Grenoble) J. Schweizer (CEN-G)	D5
06 05 001	Neutron diffraction studies of the structure of water. Temperature variation effects for heavy water. J.C. Dore, I.P. Gibson (Kent)	D2, D4
06 05 003	Structure factor of liquid methyl halides (CD_3 Br and CD_3 I). M.D. Zeidler (Karlsruhe) M.B. Klein (Karlsruhe and ILL)	D4
06 05 004	Structure factor of liquid chloroform. M.D. Zeidler, D. Leicht (Karlsruhe)	D4
06 05 008	Incoherent scattering on liquid glycerol. M. Soltwisch, D. Quitmann, B. Steffen (Berlin)	IN5, IN10
06 05 09	The mechanism of diffusion in H_20 and in H_20/D_20- Mixtures studied by quasielastic neutron scattering (test). R.E. Lechner (ILL) H. Rauch, A. Zeilinger (Wien)	IN5
06 05 011	Determination of the structure factor of liquid acetic acid. H.G. Hertz, H. Bertagnolli, D. Leicht (Karlsruhe)	D4
06 05 012	Structure factor of liquid chloroform. H. Bertagnolli, D. Leicht (Karlsruhe)	D4
06 05 13 (06 05 002)	Structural studies of liquid methyl and ethyl alcohol. 1. Measurement of the structure factor for liquid methyl alcohol (CD_3OD) and ethyl alcohol (C_2D_5OD). J.C. Dore, I.P. Gibson (Kent)	D4
06 06 002	Na+ ion motion in Na β - alumina J.D. Axe, S.M. Shapiro (Brookhaven) R.E. Lechner (ILL) D.B. McWhan (Murray Hill)	IN5
06 07 001	Structural properties of aqueous solutions. G.W. Neilson, J.E. Enderby (Bristol)	D4
06 07 001 (06 03 016G)	Structural properties of aqueous solutions. J.E. Enderby, S. Cummings (Bristol)	D4
06 07 002	Pressure studies on aqueous solutions. J.E. Enderby, G.W. Neilson (Bristol)	D2
06 07 03	Aqueous solutions (pressure studies). G.W. Neilson, J.E. Enderby (Bristol)	D2
06 07 04	Structural properties of aqueous solutions. J.E. Enderby, S. Cummings (Bristol)	D4
06 08 001	Size effects in liquid Li alloys. S.K. Burke (London)	D4
06 03 067R	Amorphous Te-Si alloys. H. Ruppersberg, P. Glozbach (Saarbrücken)	
06 08 003	Scattering law for vitreous silica at high Q values. R.N. Sinclair (Harwell) A.C. Wright (Reading)	IN1
06 09 001	Molecular motions in liquid crystals D - TBBA. A.J. Dianoux (ILL) H. Hervet (Paris) F. Volino (Montpellier and ILL)	IN5
06 09 002	Molecular motions in liquid crystals. A.J. Leadbetter, J. Frost (Exeter) R.M. Richardson (Exeter and ILL) C.J. Carlile (Rutherford and ILL)	IN5, IN10

06 09 003	Neutron diffraction study of the smectic C - smectic A phase transition of TBBA. F. Volino (Montpellier and ILL) A.J. Dianoux (ILL) G. Albertini (Ancona) S. Lagomarsino (Roma) F. Rustichelli (Ancona, ILL and Ispra)	D1B
06 09 004	Q.E.S. in plastic quinuclidine. C. Brot (Nice) B. Lassier-Govers (Saclay and Nice)	IN5
06 10 002	Adsorption of D_2O on silver iodide. G. Bomchil (ILL) J. Tabony (CEN-G and ILL) R.K. Thomas (Oxford) J.W. White (ILL)	D1B
06 10 003	Mobility of a two-dimensional adsorbed fluid. M. Bienfait, J.P. Coulomb (Marseille) P. Thorel (ILL and CEN-G)	IN5
06-10-004	Two-dimensional structure of Ar adsorbed on MnI_2. Y. Lahrer, B. Gilquin (Saclay) P. Thorel (ILL and CEN-G) C. Marti (Paris)	D1B
06 10 005	Structure of Kr and N_2 bilayers on graphite. C. Marti (Paris) P. Thorel (CEN-G and ILL)	D2
06 11 001	Critical small angle scattering investigation of the $Na-ND_3$ system. P. Damay, G. Lepoutre (Lille)	D11A
06 11 002 (06 03 036A)	Solutions of potassium in potassium bromide. J.F. Jal, P. Chieux (ILL) J. Dupuy (Lyon)	D11A, D17
6 11 03	Critical scattering at the smectic A/nematic phase transition in d-CBOOA H.H. Stiller, H.M Conrad (Jülich)	IN10

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07 01 052	Small angle scattering from PdFe and PdMn alloys. B.R. Coles, B.D. Rainford (London) B.H. Verbeek, C. Van Dijk (Petten)	D11
07 01 054	Spin dynamics and structure of Pd 0.75 Mn 0.25. B.D. Rainford, P.D. Lilley (London) W.G. Stirling, K.R.A. Ziebeck (ILL)	IN8
07 01 055	Spin dynamics of intermediate valence systems. E. Holland-Moritz, M. Loewenhaupt (Jülich)	IN4, D7
07 01 056	Dynamical susceptibility of $CeAl_2$. M. Loewenhaupt (Jülich) F. Steglich, S. Horn (Köln)	D7
07 01 059	Neutron scattering by Heisenberg and Ising amorphous spin glasses in strong magnetic fields. W. Prandl, K. Knorr, W. Nägele (Tübingen) P. Convert, J.L. Buevoz (ILL)	D1B
07 01 062	Magnetic diffuse scattering from Co-Ga and related alloys. J.G. Booth (Salford) R. Cywinski, B.D. Rainford (London)	D11A
07 01 068	Dependence of critical magnetic scattering on the momentum transfer. R. Anders, G. Kostorz (ILL) K. Stierstadt, W.v. Hörsten (München)	D11
07 01 071	Stress-induced bicritical behaviour and crossover effects in nickel. W.v. Hörsten, K. Stierstadt (München) R. Anders (ILL)	D11A
07 01 078	Small angle scattering from dilute palladium nickel alloys. B.D. Rainford, R. Cywinski, S.K. Burke (London)	D17
07 01 081	Polarization analysis study of spin ordering in concentrated CuMn. B.R. Coles, B.D. Rainford, S.K. Burke (London)	D5
07 02 029	Valence fluctuations in YbCuAl. G. Lander (CEN-G and Argonne) F.R. de Boer, W. Mattens (Amsterdam)	IN4
07 02 030	Dynamical susceptibility of dilute Tb intermetallic compounds. M. Loewenhaupt (Jülich) H.E. Hoenig (Frankfurt)	D7
07 02 032	Crystal field in rare earth intermetallics with CsCl structure. P. Morin, J. Pierre, D. Schmitt (CNRS Grenoble)	IN7

07 02 036	Crystal fields in rare earth intermetallics with Cu_3Au structure.	IN7	K. Knorr, W. Gross (Mainz)
07 03 017A	Short range order of carbon vacancies in actinide and transition metal carbides.	D7, D1A	C.H. de Novion, V. Maurice (Fontenay-aux-Roses) B.E.F. Fender (Oxford)
07 03 040	Void formation in NiAl.	D11A	J.E. Epperson, C. Ortiz, D. Berner, K.W. Gerstenberg (Stuttgart) G. Korstorz (ILL)
07 03 045	Neutron diffraction topography	S20	M. Schlenker (CNRS Grenoble and ILL) J. Baruchel, J. Linares-Galvez (CNRS Grenoble)
07 03 050	Chemical inhomogeneities in invar alloys.	D7, D11	A. Chamberod, L. Billard (CEN-G) M. Roth (ILL)
7 03 056	Diffuse scattering in RbI in the pressure region of structural metastability.	D10	O. Blaschko (Wien) G. Ernst, G. Quittner (Seibersdorf) W. Just (ILL)
07 03 057	Diffuse neutron scattering from an ω -phase ZrNb alloy.	IN10, IN2	J.D. Axe (Brookhaven) A. Heidemann, W.S. Howells, R. Pynn (ILL) S.C. Moss (Houston)
07 03 058	Investigation of the interaction effects between impurities (S.R.O.) in binary FeSb and ternary alloys.	D7	M.C. Cadeville, F. Gautier, A. Biolluz (Strasbourg)
07 03 059	Investigation of the precipitation structure in AlMg and AlZnMg alloys.	D7	P. Auger, M. Bernole (Rouen) O. Blaschko, G. Ernst (Seibersdorf) M. Roth (ILL)
07 03 60	Détermination de l'ordre à courte distance sur des échantillons c.f.c. de Ni 30 % Cr.	D7	P. Coulomb, N. Clément (Toulouse)
07 03 062/65	Temperature and stress dependence of the precipitation in nickel based superalloys.	D11	G. Kostorz (ILL) R.J.R. Miller (Harwell) S. Messoloras, R.J. Stewart (Reading)
07 03 065	Study of Al-Zn decomposition by neutron small angle scattering interference effects.	D11A	P. Guyot, G. Laslaz (Grenoble)
07 03 073	Collective behaviour of OH^- in KCl.	IN5	C. Jacolin (Marseille) J. Joffrin (ILL)
07 03 075	Short-range order of carbon vacancies in actinide and transition metal carbides.	D1A	C.H. de Novion, V. Maurice (Fontenay-aux-Roses) B.E.F. Fender (Oxford)
07 03 077	Phase decomposition in quenched Au-Pt.	D11A	H. Herman, S.P. Singhal (Stony Brook) G. Kostorz (ILL)
07 03 083*	The distribution of Cd oxide in soda lime silica glass.	D9	R.N. Sinclair (Harwell) A.C. Wright (Reading)
07 04 002A	Diffusion induced spin-lattice relaxation in solid ^7LiAg and ^7LiAg alloys.	S6	H. Ackermann, W. Buttler, K. Dörr, D. Dubbers, F. Fujara, H. Grupp, G. Kiese, H.J. Stöckmann (Heidelberg) P Heitjans, A. Körblein (ILL)
07 04 002A	β -ray detected hyperfine interactions of ^{28}Al in Al_2O_3 and AlP.	S6	H. Ackermann, W. Buttler, K. Dörr, D. Dubbers, F. Fujara, H. Grupp, G. Kiese, H.J. Stöckmann (Heidelberg) P. Heitjans, A. Körblein (ILL)
07 04 002A	Elimination of dipolar line widths by spin decoupling. Application to the hyperfine-anomaly of neutron activated ^8Li relative to ^7Li .	S6	H. Ackermann, K. Dörr, D. Dubbers, F. Fujara, H. Grupp, H.J. Stöckmann, A. Winnacker (Heidelberg) P. Heitjans, A. Körblein (ILL)

07 04 003 Ionic diffusion in glasses studied by spin-lattice relaxation of ^{8}Li. S6

W. Müller-Warmuth,
B.D. Mosel (Münster)
H. Ackermann, K. Dörr, F. Fujara,
H. Grupp, G. Kiese,
H.J. Stöckmann (Heidelberg)
P. Heitjans, A. Körblein (ILL)

07 05 003B Measurement of dispersion curves on aluminium reactor-irradiated at 4.6 K. IN8

K. Böning (München)
G.S. Bauer, H.J. Fenzl (Jülich)
R. Scherm (ILL)
R.M. Nicklow (Oak Ridge)

07 05 020 Electron-phonon-interaction of Co^{2+} in MgO IN4

P. Koidl (Freiburg)
V. Wagner (Würzburg and ILL)

07 06 007A* The local mode parameters of hydrogen in α -palladium hydride. IN1

W. Kley (Ispra)
D. Tocchetti (EMBO Grenoble)

07 06 040 Investigation of the diffusion of H in Nb $H_{0.02}$ and $VH_{0.07}$ single crystals. D7

V. Lottner, A. Heim (Jülich)
T. Springer (ILL)

07 06 044 Self diffusion in Na below the melting point. IN10

A. Seeger, H. Mehrer (Stuttgart)
G. Goeltz, A. Heidemann (ILL)

07 06 046 Stability curve for phase separation of D in Nb and Ta. D11A

G. Alefeld, W. Münzing (München)

07 06 047* Interaction energies of D in Nb. D7

W. Münzing (München)
G. Bauer, W. Schmatz (Jülich)

07 06 048 Relaxation effects for acoustical phonons in niobium-hydrogen alloys. IN3

A. Magerl, N. Stump, G. Alefeld,
W.D. Teuchert (München)
R Scherm (ILL)

07 06 049 Optical phonons in intermetallic hydrides. IN1B

D.K. Ross, I.R. Harris,
S.J.C. Irvine (Birmingham)

07 06 050 The validity of the Chudley-Elliott theory for H diffusion in bcc metals IN10

V. Lottner, D. Richter (Jülich)
T. Springer (ILL)

07 06 052 Tunneling of protons in Nb-N-H. IN5

T. Springer (ILL)
G. Alefeld, H. Wipf, N. Stump,
A. Magerl (München)
D. Richter (Jülich)

07 06 053 Hydrogen trapping in $NbV_{0.01}H_{0.05}$ IN10

D. Richter, A. Kollmar (Jülich)

07 06 055 Investigation of the Debye-Waller factor in α -PdH. D10

D.R. Ross,
I.S. Anderson (Birmingham)

07 06 056 Diffusion of hydrogen in β palladium hydride. IN10

D.K. Ross,
I.S. Anderson (Birmingham)

07 06 057 Investigation of diffuse scattering from β -PdD below room temperature. D7

D.K. Ross,
I.S. Anderson (Birmingham)

07 06 059 The stability curve for phase separation of D in Nb and Ta. D11

G. Alefeld,
W. Münzing (München)

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08 01 017 Water in coenzyme B_{12} crystals D8

J.L. Finney (London)
P.A. Timmins (ILL)

08 01 019A A low resolution neutron diffraction study of crystallized spherical plant virus. D17

P.A. Timmins, B. Jacrot,
A. Lewit, G. Bentley (ILL)
J. Witz (Strasbourg)

08 02 012C/D Determination of the quaternary structures of ribosomes and RNA polymerase by the label triangulation method. D11A

W. Hoppe, W. Zillig, Z. Cejka,
H. Heumann, S. Lorenz, R. May,
P. Stöckel, I. Strell (Martinsried)
H.G. Wittmann (Berlin)

08 02 012D Determination of the quaternary structure of RNA polymerase by the label triangulation method. D11A

W. Hoppe, W. Zillig, P. Stöckel,
R. May, I. Strell, Z. Cejka,
H. Heumann (Martinsried)

08 02 012E* Quaternary structures of ribosomes and RNA polymerase. D11

W. Hoppe, W. Zillig, Z. Cejka,
S. Lorenz, R. May, P. Stöckel,
I. Strell (Martinsried)
H.G. Wittmann (Berlin)

08 02 023B Structure and confirmation of E.coli ribosomes. D11A
H.B. Stuhrmann (Mainz)
R. Parfait (Louvain)
M.H.J. Koch (Hamburg)

08 02 023C Structure of E.coli ribosomes. D11A
H.B. Stuhrmann (Mainz)
M.H.J. Koch (Hamburg)
R. Parfait,
R.R. Crichton (Louvain)
D. Engelman, P. Moore (New Haven)

08 02 029A Investigation on tRNA's, aminoacyl-tRNA synthetases' and their complex by neutron small angle scattering. D11A
S. Blanquet,
P. Dessen (Palaiseau)
G. Zaccai, B. Jacrot (ILL)

08 02 029B Investigation on tRNA's, aminoacyl-tRNA synthetases and their complexes by neutron small angle scattering. D11
S. Blanquet,
P. Dessen (Palaiseau)
B. Jacrot, G. Zaccai

08 02 036* Molecular structure of a membrane protein of photosynthesis. D11A
D.M. Sadler, D.L. Worcester,
A.R. Crofts (Bristol)

08 02 038 Investigation on tRNA's, tRNA synthetases and their complexes. D11
J.P. Ebel, R. Giege, D. Moras,
J.C. Thierry (Strasbourg)
B. Jacrot, J. Zaccai (ILL)

08 02 038A Investigation on tRNA-tRNA synthetase interaction : valine and and phenylalaline systems. D11
R. Giege, D. Moras,
J.C. Thierry (Strasbourg)
B. Jacrot, G. Zaccai (ILL)

08 02 042 Investigation of structural principles of ribonucleoprotein strand formation in ribosomes. D11, D17
I.N. Serdyuk (Poustchino)

08 02 043 Neutron small-angle studies of chromatin subunit particles and assemblies. D11
J.F. Pardon, J.C. Wooley,
B.M. Richards,
R.I. Cotter (High Wycombe)
D.L. Worcester (Harwell)

08 02 043A Neutron small angle scattering studies of chromatin assemblies. D11
J.F. Pardon, D.M.J. Lilley,
B.M. Richards, R.I. Cotter,
B.T.M. Willis (High Wycombe)
D.L. Worcester (Harwell)

08 03 002D Neutron scatter studies of chromatin. D11
E.M. Bradbury, J.P. Baldwin,
B.G. Carpenter, R.P. Hjelm,
P. Suau,
G.G. Kneale (Portsmouth)

08 03 002E Continuation of neutron studies of chromatin. D11A
E.M. Bradbury, J.P. Baldwin,
B.G. Carpenter, G.G. Kneale,
R.M. Stephens, R.P. Hjelm,
P. Suau, G. Braddock,
J.K. Simpson (Portsmouth)

08 03 005 The structure of spherical viruses by neutron small angle scattering. D11
B. Jacrot (ILL)
J. Witz,
P. Pfeiffer (Strasbourg)
G. Chauvin (CEN-G and ILL)

08 03 014A The structure of the corneal stroma. D11
G.F. Elliott (Oxford)
P.A. Timmins (ILL)

08 03 015R The filament lattice of smooth muscle. D11
G.F. Elliott, A.E. Woolgar (Oxford)
P.A. Timmins (ILL)
R.A. Murphy (Virginia)

08 03 027 Elastic scattering from collagen D2
A. Miller,
C. Berthet (EMBL Grenoble)
J.W. White, G. Jenkin (ILL)

08 03 028 Elastic scattering from collagen D16
A. Miller (EMBL Grenoble)
G. Jenkin, J.W. White (ILL)

08 04 004 Inelastic scattering from collagen in water at variable humidity. IN5
G. Jenkin, J.W. White,
P.A. Timmins, R. Ghosh (ILL)
A.D. Taylor (Rutherford)
A. Miller (EMBL Grenoble)

08 04 004A Inelastic scattering from collagen. IN10
A. Miller,
S. White (EMBL Grenoble)
J.W. White, G. Jenkin (ILL)

08 04 008A Low-frequency vibrations in hen egg-white lysozyme. IN5
H.D. Bartunik (München and ILL)
P. Jollès, J. Berthou (Paris)
A.J. Dianoux (ILL)

08 04 012
08 04 012A Acoustic wave propagation in DNA in solution. IN5
R. Oberthür (Mainz)
R.E. Lechner (ILL)

08 04 014	Molecular dynamics of hydrated proteins. J. Randall (Edinburgh) H.D. Middendorf (London) A.D. Taylor (Rutherford)	IN10
08 05 001D	Selectively deuterated membranes. G. Büldt, J. Seelig (Basel) G. Zaccai (ILL)	D16
08 05 012D	Neutron study of purple membrane. R. Henderson, D. Gilmore (Cambridge) G. Zaccai (ILL)	D16
08 05 013A	Structure of photosynthetic membranes. D.M. Sadler (Bristol) D.L. Worcester (Harwell)	D11A
08 05 019	Neutron diffraction by normal and partially De-proteinated mammalian erythrocyte membranes. J. Randall, A.H. Maddy, S. Gilmour (Edinburgh) J. Torbet (ILL) D.L. Worcester (Harwell)	D11
08 06 006	Neutron small-angle scattering study on two different precipitin types of pig anti-Dnp antibodies. L. Cser (Dubna) F. Franek, I. Novotny (Prague)	D11A

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09 01 007	Conformation of polymers in the bulk and in solution. A. Maconnachie, R.W. Richards, J.S. Higgins, G. Allen (London)	D11A
09 01 007A	The time dependence of the conformation of an elongated polymer chain. T. Springer (Jülich) A. Maconnachie, R.W. Richards, G. Allen (London)	D11A
9 01 201	Study of hot stretched polystyrene. F. Boué, J.P. Cotton, B. Farnoux, M. Nierlich, C. William, H. Benoit, R. Duplessix, C. Picot (Saclay)	D17, D11
9 01 202	Conformation of macrocyclic dimethyl siloxanes J.A. Semlyen (York) J.S. Higgins (London)	D11
9 01 204	Rotational thermal motion and structure of polyethylene. E.W. Fischer, M. Stamm (Mainz)	D1B
9 01 204	Conformation of chain molecules in polymer melts and in crystalline polymers. E.W. Fischer, M. Dettenmaier, P. Herchenröder, M. Stamm (Mainz)	D11
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09 01 212	The time dependence of the conformation of an elongated polymer chain. T. Springer (ILL) R.W. Richards, A. Maconnachie, G. Allen (London)	D11
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09 01 215	The effect of temperature on the dimensions of a polymer chain in solution. R.W. Richards, A. Maconnachie, G. Allen (London)	D11, D17
09 01 218	Measurement of pair correlation functions in semi-dilute polyelectrolytes solutions. M. Rinaudot (CERMAV Grenoble) H. Benoit, C. Picot, R. Duplessix, C. Williams, M. Nierlich (Strasbourg) P.G. de Gennes (Paris) C. Wolff (Brest) B. Farnoux, G. Jannink (Saclay) F. Boué, J.P. Cotton (Léon Brillouin, Paris)	D11, D17
09 01 218	Study of all partially labelled chains. F. Boué, J.P. Cotton (Léon Brillouin, Paris) B. Farnoux (Saclay) M. Nierlich, H. Benoit, R. Duplessix, C. Picot (Strasbourg)	D17
09-01 222	Micellar and microemulsion systems. P. Delord, C. Cabos (Montpellier) C. Taupin, R. Ober (Collège de France Paris)	D11A

09 02 002 F — Copolymer conformation in dilute solutions and in bulk. — D11
H. Benoit (Strasbourg)
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09 02 002 G — Conformation of a crystalline polymer in bulk (isotactic polystyrene). — D11
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G. Jannink (Saclay)

09 02 013B (09 01 204) — Configurations of chain molecules in polymer melts and in crystalline polymers. — D11
E.W. Fischer, M. Dettenmaier, P. Herchenröder, M. Stamm (Mainz)

09 02 201 — Study of molecular motions in n-alkane crystals by means of quasielastic neutron scattering. — IN10
R. Richter (Jülich)
B. Ewen (Mainz)

09 02 202A — Investigation of potential barrier to rotation of side groups on polymer chains. — IN5
G. Allen, J.S. Higgins (London)

09 02 203 — Dynamics of polymer networks. — IN10
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09 02 204 — Neutron scattering on silicon polymers. — IN4
R. Kosfeld,
H. Offergeld (Aachen)
B. Alefeld (Jülich)

09 03 201 — Angular dependence of the tunnel matrix elements in NH_4Cl0_4. — IN10
M. Prager, W. Press, A. Hüller, B. Alefeld (Jülich)

09 03 202 — Methyl group tunneling in picolines and lutidines. — IN4, IN5, IN10
W. Müller-Warmuth,
R. Schüler (Münster)
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09 03 206 — Methyl group tunneling in 2,4-hexadiyne. — IN10
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J.R.M. Cockbain (Oxford)
J.W. White (ILL)

09 03 208 — Fluxionality in pentacoordinate complexes. — IN10
J. Tomkinson (ILL)

09 03 212 — Torsional modes of CH_3 groups in MDBP. — IN4
S. Clough (Nottingham)
K. Tilli (Helsinki)
B. Alefeld (Jülich)

09 03 213 — Tunnel splitting of the CH_3 group in MDBP. — IN10
S. Clough (Nottingham)
B. Alefeld (Jülich)

09 03 216 — Collective aspects of rotational motions in molecular crystals. — D12B
A.J. Leadbetter,
J. Frost (Exeter)
R.M. Richardson,
A.F. Wright (ILL)

09 03 216 — Collective rotations in molecular crystals. — IN5, IN10
A.J. Leadbetter,
J. Frost (Exeter)
R.M. Richardson (ILL)

09 04 201 — Internal torsional modes in transition metal ammines. — IN4
J. Howard,
T.C. Waddington (Durham)

09 04 202A — The study of torsions of coupled rotors by inelastic neutron spectroscopy. — IN4
K.P. Brierley,
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09 04 206* — Tris-ethylene complexes. — IN4
T.C. Waddington,
J. Howard (Durham)

09 04 209 — Dynamics of n-butane. — IN4
S. Suzuki (Salford)
G. Allen, H. Takeuchi (London)

09 04 210 — Incoherent quasi-elastic scattering by single crystal of adamantane $C_{10}H_{16}$. — IN5
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M. Besnard (ILL)
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09 05 038 — Down scattering spectra of N-methyl acetamide. — IN4
F. Fillaux (Thiais)
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09 05 202A — Structure and ordering in concentrated oxide sols. — D11A
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09 05 203 — Lyotropic liquid crystals. — IN5
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09 05 204	Diffusion of water in clays. R. Ottewill (Bristol) R.K. Thomas, D.J. Cebula (Oxford) D.K. Ross, M.H.B. Hayes (Birmingham) A.D. Taylor (Rutherford) J.W. White (ILL)	IN5
09 05 205	Concentrated oxide sols. D.I. Page, J.D.F. Ramsay (Harwell) R.W. Richards (London)	D11A
09 05 206/207	Diffusion of water and ions in clays - High resolution studies. D.K. Ross, M.H.B. Hayes, J.J. Tuck (Birmingham)	IN10
09 06 004A	H_2 in Pt zeolite. A. Renouprez, P. Fouilloux (Villeurbanne)	IN1
09 06 008A	Intercalation compounds R.K. Thomas, I. Marlow, T.D. Trewern (Oxford) J.W. White (ILL)	IN10, D1B
09 06 010	Particle size distribution and crystallite shape for adsorbed ammonia on graphite. R.K. Thomas, J.W. White, N.M. Harris (Oxford) J. Tabony (ILL)	D11A
09 06 203	Water chemisorption on Raney nickel. A. Renouprez, P. Fouilloux (Villeurbanne)	IN1B
09 06 205	Hydrogen adsorption upon platinum black. C.J. Wright (Harwell) T.C. Waddington, J. Howard (Durham)	IN1B
9 06 205A	Hydrogen chemisorbed on platinum black. T.C. Waddington, J. Howard (Durham) C.J. Wright (Harwell)	IN1B
09 06 209	Clays. J.M. Adams (Aberystwyth) C. Riekel (ILL)	IN10
09 06 210A*	Hydrogeneous gases adsorbed on platinum black. T.C. Waddington, J. Howard (Durham)	IN4
9 06 210* 9 06 216*	The study of the O dependence of the modes of vibration of hydrogen on platinum. Low frequency inelastic neutron scattering from chemisorbed species on platinum. T.C. Waddington, J. Howard (Durham) C.J. Wright (Harwell)	IN1B, IN4
09 06 211	$HxTaS_2$. C.J. Wright (Harwell)	IN1
09 06 213	TaS_2 - NH_3. C. Riekel (ILL) B.E.F. Fender (Oxford) G.C. Stirling (Rutherford)	IN10
09 06 213A	TaS_2 $(C_5H_5N)_{0.5}$ B.E.F. Fender (Oxford) C. Riekel (ILL) G.C. Stirling (Rutherford)	IN10
09 06 215	Methane on graphon. R.K. Thomas, M.V. Smalley (Oxford)	IN4
09 06 222	Low angle scattering from the graphon/ammonia adsorbed system. J. Tabony, J.W. White (ILL) N.M. Harris (Oxford)	D11A
09 06 (Test)	Low angle test experiment of the sodium Laurate/polystyrene latex adsorbed system. J. Tabony, J.W. White (ILL) N.M. Harris (Oxford)	D11A
TEST CHEMISTRY	Polystyrene microbead test. J. Tabony, J.W. White (ILL) N.M. Harris (Oxford)	D11A

LIST OF THESES

The experimental work of which was carried out at ILL.

77PO29 P.F.J. PONCET, Thesis submitted for the degree of Dr. of Philosophy, Reading (Jan. 1977). The Structure of Molten Rubidium Chloride by Slow Neutron Scattering.

77GE33 G. GERMAIN, Diplôme d'Ingénieur CNAM en Physique Nucléaire, Grenoble (Janvier 1977). Contribution au Développement, à la Réalisation et aux Essais d'une Source de Neutrons Ultra-Froids.

77GL87 Y. GLAIZE, Diplôme d'Ingénieur CNAM en Physique Nucléaire, Grenoble (Avril 1977). Essai d'Analyse en Charge Nucléaire des Produits de Fission délivrés par Lohengrin à l'Aide d'une Chambre d'Ionisation.

77HA108 J.A. HAAS, Doktorarbeit, Mainz (R.F.A.) (June 1977). Wasserstoff - Deuterium - Austauschreaktionen des Myoglobins und Apoferritins. Transportvorgänge bei Apoferritins. Eine Untersuchung mit Hilfe der Neutronenkleinwinkelstreuung.

77WO116 P. WOLFERS, Thèse de Doctorat d'Etat, Grenoble (Juin 1977). Structures et Propriétés Magnétiques de Quelques Composés du Système MX-(UX_2) (M = Métal 3d, X = S ou Se, n= 1 ou 2). De l'Anisotropie et de la Délocalisation Magnétique de l'Uranium.

77LA195 J.R. LARYSZ, Thesis focr the degree of Dr. of Philosophy Manchester (June 1977). Thermal Neutron Capture Studies of ^{172}Yb and ^{174}Yb.

77BA256 W. BAUSPIESS, Doktorarbeit, Dortmund (Oct. 1977). Präzisionsbestimmung von Streulängen mit dem Idealkristall-Neutroneninterferometer.

CONFERENCES AT ILL IN 1977

Workshop on Future Fission Research at the ILL (organized by ILL)	January 19, 1977
Workshop on Small Angle Scattering of X-Rays and Neutrons in Biology (organized jointly by ILL : G. ZACCAI, B. JACROT and EMBL : A. MILLER, H.B. STUHRMANN - and held in Villard de Lans).	March 20-25, 1977
Workshop on Neutron Optics and Ultra-Cold Neutrons (organized by ILL)	June 17, 1977
Meeting on Nuclear Fission (organized jointly by ILL and CENG)	Sept. 29-30, 1977
Workshop on Magnetic Structures and Spin Densities (organized by J. BROWN and E.F. BERTAUT)	October 10-11, 1977
Workshop on Fundamental Physics Experiments with Reactor Neutrons and Neutrinos (organized by ILL)	October 10-11, 1977
Workshop on Recent Developments of Semiclassical Approaches in Nuclear Physics (organized by M. BRACK and P. SCHUCK)	Nov. 23-25, 1977

ILL PUBLICATIONS 1977

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AB	first two letters of the first author's name.
065	serial number.

The letters T or S after a code number indicate that this report is an INTERNAL TECHNICAL or SCIENTIFIC report respectively.

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76A78
G. ALBERTINI, A. BOEUF, S. MAZKEDIAN, S. MELONE, V. ROZZI, F. RUSTICHELLI, J. Appl. Crystallogr. **10**, 118 (1977). Comparison of Curved Monochromator Neutron Data with the Prediction of a Simple Model.

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PUBLICATIONS INDEX BY AUTHOR

This is intended as an index to the previous list. It gives all the publications in which a person has cooperated, but need not have been the principal author.

though truth and falshood bee
Neare twins yet truth a little elder is ;
Be busie to seeke her, beleeve mee this,
Hee's not of none, nor worst, that seekes the best.
To adore, or scorne an image, or protest,
May all be bad ; doubt wisely ; in strange way
To stand inquiring right, is not to stray ;
To sleepe, or runne wrong, is. On a huge hill,
Cragged, and steep, Truth stands, and hee that will
Reach her, about must, and about must goe ;
And what the hills suddenne resists, winne so ;
Yet strive so, that before age, deaths twilight,
Thy Soule rest, for none can worke in that night.
To will, implyes delay, therefore now doe ;
Hard deeds, the bodies paines ; hard knowledge too
The mindes indeavours reach, and mysteries
Are like the Sunne, dazling, yet plaine to all eyes.

John Donne (1571-1623)
SATYRE III I.I. 72-88.

ACKNOWLEDGEMENTS

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This form is available on request from the Office of the Scientific Secretary at the ILL and for British Users also from Mr D. Salter SRC, Rutherford Lab., Chilton Oxon

guide-lines

for the submission of a research proposal for use of neutron beams of the ILL high flux reactor

Dear Colleague,

Before completing the attached form, you are requested to carefully read the following points which are essential for the forwarding of your proposal to the Scientific Council of the ILL.

CONTENTS OF THE APPLICATION

Insufficient information on your research project may lead to a postponement of your proposal. It is essential that amongst other information, the proposal should contain :

- An outline of the scientific background and relevant features of the envisaged experiment.
- The reasons for carrying out the experiment at the HFR.
- A realistic date for the availability of all experimental equipment including samples (not provided by the ILL).
- The dates when it is absolutely impossible for you to carry out your experiment (see attached reactor schedule) in the scheduling period under consideration.
- The key-word number (see reverse side) and up-to-date list of references.

Please respect also the following points when completing the proposal form :

MAILING OF YOUR PROPOSAL :

Each experimental proposal should be addressed to the Office of the Scientific Secretary (Dr Bernd MAIER, Institut Laue-Langevin, 156X, Centre de Tri, 38042 Grenoble-Cedex, France) from where it will be forwarded automatically to the pertinent review-boards.

DEAD-LINES FOR SUBMISSION :

The various subcommittees of the ILL which, in general, review each proposal, meet twice a year. For the submission of a proposal, a dead-line of one month prior to the subcommittee meetings has been established in order to allow for sufficient time to pass the proposal on to the different refereeing boards.

The dead-lines are :

FEBRUARY 15 and
AUGUST 31, respectively.

The dead-line is one week earlier in each case for ILL personnel and long term visitors.

The Office of the Scientific Secretary has to be very strict in respecting the dead-line. Proposals arriving after the dead-line will be automatically eliminated from the forthcoming review and submitted to the subsequent Council meeting 6 months later.

N.B. : If you intend submitting a proposal by post allow sufficient time for delivery before the dead-line.

FILLING-IN OF THE FORM :

It is compulsory for proposals to be submitted in English, since the members of the various review boards are of different nationalities.
The text must be type-written.
The available space on the form has to be strictly respected. Additional sheets will not be photocopied !!!

CONTINUATION OF PROPOSALS :

If you intend to submit a proposal which implies a continuation of experiments you should not forget to send a report on the previous measurements. Experimental groups which have failed to supply a report will receive no further allocations of beam-time by the Scientific Council.

For these reports only the standard form issued by the Office of the Scientific Secretary will be accepted. The form is available on request from this Office or at the reception desk at ILL (for British users also from Mr D. Salter, Rutherford Lab., Chilton, Oxon).

ADDITIONAL INFORMATION WITH RESPECT TO YOUR PROPOSAL

LOCAL CONTACT :

The ILL requires that all external users have a permanent member of the scientific or technical staff of the Institut assigned to their experiment (local contact). The local contact would assist the user to prepare and perform his experiment with respect to scientific and technical aspects. Furthermore, as he will have had experience in running the instrument concerned, he will thus ensure an efficient utilization of the allocated beam time.

If necessary the pertinent College Secretary will help to establish such contacts. In case he cannot find an ILL collaborator interested in the research subject concerned, the external user is asked to proceed in one of the two following ways :

a - The user comes to Grenoble and discusses the envisaged measurements with competent ILL staff members and, this way, tries to find an interested local collaborator by himself.

b - The user sends one of his co-workers to the ILL for a sufficiently long period in order to become familiar with the instrument concerned. This co-worker can then fulfill the role of a local contact.

On being informed of the name of his local contact the user communicates with him as soon as possible to discuss the requirements, both scientific and technical, of the forthcoming experiment. For example, monochromator requirements, detectors positions, cryostat availability; all such items must be settled well in advance of the experiment date, in order to minimize losses of beam time.

REVIEW PROCEDURES FOR EXPERIMENT PROPOSAL :

A proposal for an experiment requiring beam time which has been received by the Office of the Scientific Secretary will be submitted to the pertinent College within the Institut and simultaneously forwarded to the members of the sub-committees of the Scientific Council. The College itself examines all new proposals with respect to the practical and technical aspects, with the sub-committees assessing the scientific merit and assigning priorities. There are at present 7 subcommittees :

- «Nuclear and Fundamental Physics»
- «Pure Crystals» (Excitations)
- «Crystallographic and Magnetic Structures»
- «Liquids and Amorphous Substances»
- «Imperfections»
- «Biology»
- «Chemistry».

The Scientific Council of the ILL receives and reviews the recommendations from the various subcommittees and acts as an advisory committee to the Director who has the final authority. This Council serves mainly to coordinate the various projects, to establish general guide-lines for the scientific policy and to define priorities within the experiment programme of the Institut.

SCIENTIFIC COUNCIL DECISIONS :

Immediately after each meeting of the Scientific Council the user will be informed by the Scientific Secretary whether or not his research proposal has been accepted. He will also be informed at the same time of the name of his local contact.

EXPERIMENT TIME SCHEDULES :

Six monthly time schedules incorporating the Scientific Council decisions are normally compiled in the few weeks following a Council meeting.

It is therefore essential that requests for specific dates and modifications to suggested dates are communicated to the Scientific Secretary as soon as possible (by telephone or preferably in writing).

TIME VALIDITY OF ACCEPTED PROPOSALS :

The sub-committees of the Scientific Council will accept only as many experiments as can be actually carried out in a period of 8 months following a Council meeting. All proposals accepted and not carried out due to special reasons within 8 months from the date of acceptance will normally be automatically removed from the instrument programme, although the Council will, in a few necessary cases, deviate from this rule. If the applicants still maintain an interest in their proposal after the expiration of this time limit, they are then requested to resubmit their proposal to the next meeting of the Scientific Council. In this case an informal letter addressed to the Office of the Scientific Secretary will do. Since the Office of the Scientific Secretary, in general, gives three months notice of the time schedule for the experiment, the applicant will be able to see whether his work can still be carried out within the 8 months period, and still have sufficient time to meet the proposal dead-lines of February 15th and August 31st with a possible re-submission.

PUBLICATIONS :

a - Co-authors of the ILL in scientific publications :

ILL staff have spent a considerable time building up the existing facilities which are put at the disposal of users.
The Institut therefore, considers it natural that ILL staff participating extensively in the performance of user experiments will have a just chance to become co-authors of publications. Co-authorship should be discussed before starting an experiment.

b - Acknowledgement of the ILL in scientific papers :

For an organisation such as the ILL, providing experimental facilities and a forum for scientific discussions to a large number of scientists affiliated to other research institutes or universities, it is essential, for the enhancement of its professional and scientific reputation, that full acknowledgement be given in any relevant publication.
It is suggested that a foot-note to the title of the paper be added on the first page, mentioning a temporary affiliation to the ILL for the duration of the work carried out and in addition the publication should contain an acknowledgement, following the usual procedure, of the names of all ILL staff (as well as any ILL co-authors) who have made a major contribution to the preparation, performance or evaluation of the results of the experiment.

PAYMENT AND REIMBURSEMENT OF EXPENSES BY THE ILL

It should be noted that the ILL, in general, provides the neutron beams and standard measuring equipment, such as existing spectrometers, counters, standard cryostats and shielding equipment. It is normally assumed that any necessary special equipment including samples, will be provided by the neutron beam users.

The INSTITUT does not provide salaries for visiting users. If required, however, the ILL may reimburse for one experimentalist only, if his affiliation is a British, French or German laboratory or university, one round trip fare and per diem for a limited period, in which the experimentalist concerned actually prepares and carries out the measurements. If scientists from different laboratories are included on the original proposal, the above rules apply separately. It is only in exceptional cases that travel and subsistence fees for more than 1 experimentalist from the same laboratory can be supported by the ILL. Transport costs for major experimental facilities cannot be paid by the ILL. No subsistence allowances are granted for data analysis after the conclusion of an experiment. Exceptions to this rule need the approval of the Scientific Secretary.

Institut Laue-Langevin, 156X Centre de Tri,
38042 - GRENOBLE CEDEX - FRANCE
Tél. (76) 97-41-11

For travel problems, hotel accomodation etc. please telephone extension 82-82.
For all scientific problems (including time schedules) please telephone extension 82-44 (B. Maier) or 81-79 (G.A. Briggs).

keyword system for the classification of proposals

COLLEGE 3 (Fundamental and Nuclear Physics)

3-01 (Lohengrin Experiments), nuclear spectroscopy on fission products
3-11 (Lohengrin Experiments), Fission
3-02 (Gams - and Bill - Experiments) (n, γ) and (n, e) - spectroscopy
3-03 Beam experiments using nuclear reactions
3-04 Beam experiments using nuclear methods in solid state physics, biology, medecine, etc.
3-05 Fundamental physics

COLLEGE 4 (Inelastic Scattering in Simple Solids)

4-01 Lattice Dynamics
- phonon dispersion relations
- pressure effects
- surface phenomena
- Kohn anomalies
- Jahn-Teller effects
- line shape measurements : asymmetries and phonon life-time measurements

4-02 Dynamics of Structural Phase Transitions
- soft modes
- central peaks
- electron-phonon interaction effects (superconducting materials)

4-03 Magnetic Excitations
- magnon dispersion in metals (alloys) and ionic compounds (mixed systems)
- collective modes in low dimensional systems (mixed systems)
- magnon-phonon hybridisation

4-04 Dynamics of Magnetic Critical Scattering
- measurement of critical indices
- line-shape determinations

COLLEGE 5 (Crystallographic and Magnetic Structures)

5-1. **Single Crystal Diffraction**

5-11 Inorganic structures
- mineral structures
- chemical structures
- zeolites
- disordered structures

5-12 Organic structures
- general organic compounds
- organometallic compounds
- organic inclusion complexes
- disordered structures

5-13 Hydrogen positions
5-14 High precision neutron diffraction measurements for electron density work
5-15 Structural changes and phase transitions induced by temperature, pressure, fields, etc.
5-16 Special applications of single crystal measurements
- space group problems
- superstructures
- diffuseness of reflections
- methodic questions (anomalous scattering, extinction, etc.)
- topography

5-17 Magnetic ordering

5-2. **Powder Diffraction**

5-21 General structure problems
- mineral structures
- inorganic and organic structures
- disordered structures
- site occupancy problems

5-22 Structural changes and phase transitions induced by temperature, pressure, fields, etc.
5-23 Magnetic ordering
5-24 Structures of adsorbates and intercalated compounds
5-25 Special applications of powder diffraction
- scattering length determination
- kinetic measurements by diffraction methods
- methodic questions
- lattice dimension and thermal expansion measurements

5-3. **Polarized Neutron Diffraction**

5-31 Magnetic form factors
5-32 Spin density
- delocalisation of moment
- covalency effects

5-33 Polarization analysis
- non-collinear magnetisation
- spin-orbit coupling

5-34 Paramagnetic scattering
5-35 Polarized nuclei

COLLEGE 6 (Fluids and Amorphous Substances)

6-00 General properties and physical constants measurements
6-01 Quantum liquids
6-02 Monoatomic liquids and gases
6-03 Binary liquids alloys
a) Normal or ideal type
b) Compound type
c) Segregation type

6-04 Magnetic properties of fluids and amorphous substances
6-05 Molecular liquids of low molecular weight less than 20 atomes per molecule) and ionic liquids of low melting point (less than 100°C)
6-06 Molten salts
6-07 Ionic solutions (excluding chemical reactions)
6-08 Glasses (pure glasses only) and amorphous materials
6-09 Mesophases (liquid crystals, plastic crystals) pure systems only
6-11 Critical scattering of fluids

(Each item includes the dynamic and the structural aspect)

COLLEGE 7 (Imperfections)

7-01 Mixed magnetic systems
- magnetic impurities
- giant moments
- spin glasses
- magnetic alloys
- critical magnetic phenomena
- magnetic anisotropy
- magnetic phase transitions

7-02 Crystalline electric field
- crystal field parameters
- crystal field transition
- H-bonding in bulk metal hydrides
- valence states

7-03 Defects and disorder in solids
- point defects
- strongly deformed crystals
- strains in crystals
- clusters
- precipitates
- alloys
- ordering effects
- glasses
- solid state phase transformations

7-04 In beam experiments
- NMR - spectroscopy for defect studies

7-05 Impurity and defect states
- inelastic impurity scattering
- hyperfine interactions
- spin waves in alloys
- stiffness constant
- spin relaxation effects

7-06 Diffusion in bulk material
- self - diffusion in bulk material
- diffusion in bulk material
- dynamics of hydrogen in bulk metals
- structure of hydrogen in bulk metals

annex : vortex line spectroscopy

7-07 - Ionic and superionic conductors

COLLEGE 8 (Biology)

8- Biology (All subjects)

COLLEGE 9 (Chemistry)

9-01 Polymers and polyelectrolytes, colloidal systems - Small angle scattering from
9-02 Polymers, polyelectrolytes and oligomers Quasi-elastic and Inelastic Scattering fron
- studies of low energy (diffuse) motions polymers, in bulk or in solution
- vibrational modes in bulk or dissolv polymers
- phonons in polymers

9-03 Molecules in Solution (liquid or solid) Quasi-elastic Scattering from
- diffusion
- chemical reactions
- reorientational motions
- tunnelling

9-04 Molecules in Solution or Solid State - I elastic Scattering from
- H-bonding
- vibrational, torsional modes

9-05 Multicomponent Liquid Crystalline a Colloidal Systems - Dynamics of
- multicomponent liquid crystalline or lam lar phases - diffusion within and betwe layers
- colloid chemistry problems (e. g. Micel or hexagonal phases, water in clays, et

9-06 Dynamics of physisorbed and chemisorbe systems
- catalysis
- molecules chemisorbed on surfaces (e.g. H_2 on Raney -Nickel, C_2H_2 in zeolites, etc.)
- Dynamics of molecules in layered intercalates