Development and present status of research activities at the Centro Atómico Bariloche (C.A.B.) dependent of the COMISION NACIONAL DE ENERGIA ATOMICA

CENTRO ATOMICO BARILOCHE
COMISION NACIONAL DE ENERGIA ATOMICA

INSTITUTO DE FISICA "Dr. J. A. BALSEIRO"
UNIVERSIDAD NACIONAL DE CUYO

SAN CARLOS DE BARILOCHE, RIO NEGRO - ARGENTINA

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The Research Department of the Centro Atómico Bariloche (C.A.B.), is subdivided into five divisions, as follows:

Theoretical Physics

Head: Dr. Mario E. Foglio

14 professionals

Low Temperature Physics

Head: Dr. Ricardo Platzeck

6 professionals
3 technicians

Electron Paramagnetic Resonance Group

Head: Lic. Carlos Fainstein

2 professionals

Metal Physics Division

Head: Dr. Aldo E. Vidoz

12 professionals
3 technicians

Nuclear Physics Division

Head: Dr. Martín Salomón

4 professionals

Division for Physics of Ionic Beams

Head: Dr. Wolfgang Meckbach, also
Head of the Research Department

6 professionals
2 technicians

In the following pages, a brief outline of the development and present status of research in each division is given.

The activities of experimental research in the Centro Atómico Bariloche (C.A.B.), are supported by complementary services concentrated in a separate department subdivided as follows:

Division of Electromechanics (workshops)

Head: Mr. Ernesto Hamann

14 technicians.

Linear Electron Accelerator Division

Head: Lic. J. J. Olcese

2 professionals
2 technicians

Electronics Division

Head: Ingº Roberto W. Frentzel, also
Head of the Complementary Servicee Department

4 professionals
6 technicians

A description of the activities developed in the divisions of the Complementary Services Department is also given in the following pages.

Library

The Library of the Centro Atómico Bariloche (C.A.B.) and the Balseiro Institute of Physics (I.F.B.), holds 3,300 scientific books and is subscribed to 155 of the most important scientific reviews and journals.

Budget

The annual budget of the Centro Atómico Bariloche amounts to U$S 600,000.- (Six hundred thousand American Dollars).

This amount includes:
salaries, equipments and expendables of the Research Department and the Auxiliary Department; administration costs, funds for the building of new laboratories, maintenance costs of staff members' houses, students lodgings of the I.F.B., electricity, transportation services, etc.

THEORETICAL PHYSICS DIVISION

Work in the Theoretical Physics Group is directed towards research in a rather wide variety of topics. This is due, in part, to the tendency to give theoretical support to the experimental groups at the Centro Atómico Bariloche and to the fact, that members of the group are providing the Balseiro Institute of Physics with lecturers and giving training to advanced students in many different fields of theoretical physics.

The theoretical group was started under the direction of Dr. J.A. Balseiro and, since then, has had the collaboration of many scientists from other institutions from Argentina and abroad. For example, Dr. Guido Beck is at the present time in the group, with a contract of the Comisión Nacional de Energía Atómica (C.N.E.A.) and the International Atomic Energy Agency (I.A.E.A.)

Several members of the group have been abroad:

Dr. B. Alascio
Dr. A.M.V.G. de Alascio - California University, Berkeley- Solid State Group.

Dr. M.E. Foglio - Bristol University - with Prof. M.H.L.Pryce Magnetic Properties of Crystals (relaxation times).

Lic. A. García - California University, Berkeley - with Prof. G. Chew - Dispersion Relations.

Lic. A. López - Vienna University - Austria - with Prof. W. Thirring - Many Body Theory.

Lic. W. Mulhall - Institute for Theoretical Physics Copenhagen - Denmark - Nuclear Theory.

Some of the subjects being studied at present by members of the group are listed as follows:

i) Boundary problems of classical electrodynamics and quantum mechanics (e.g. reflection of light in dispersive media).

ii) Generalization of relativistic electrodynamics to dispersive media.

iii) Study of Schrödinger equation: generation of solvable potentials and use of approximate methods.

iv) Coherence phenomena between photons emitted by two atoms; induced emission, as a basis to a future study on laser emission.

v) Nuclear Theory, using many body techniques.

vi) Field Theory, using dispersion relations.

vii) Thermal conductivity in dielectrics at low temperatures.

viii) Use of many body techniques in solid state problems and in liquid helium theory.

ix) Paramagnetic resonance in solids and liquids; interpretation of spectra and theories of spin-lattice relaxation times.

Directly related to the work of experimental groups of the Centro Atómico Bariloche, are the following subjects:

Paramagnetic resonance in solids and liquids;

Collisions between ions and atoms with exchange of charges;

Properties of Liquid Helium;

Size dependence of transport properties at low temperatures.

Below is a list of works done by members of the group at the Centro Atómico Bariloche:

Published Papers:

On the theory of photon packets and the Lennuier effect
L. Falicov - Nuovo Cimento, 16, 247 (1960)

Series development of the solution of an Eigenvalue Problem
A. López - Acta Physica Austriaca, XXI, 3 (1966)

Published papers (Cont'd.)

Definition of nuclear potentials from double dispersion relations in field theory and potential scattering.
F. Morey Terry - Nuovo Cimento, 24, 585 (1962).

Effect of temperature gradients on the Diffusion of Thermal Neutrons.
M. B. Foglio - Revista U.M.A., 19, 303 (1962).

On the construction of low energy nuclear potentials.
F. Morey Terry - Nuovo Cimento, 26, 525 (1962).

Sobre la naturaleza de los potenciales nucleónicos.
F. Morey Terry - Revista U.M.A. - 22, 22 (1964).

A renormalized, ghost-free Lee model.
F. Morey Terry - A. García - Nuovo Cimento, 37, 9 (1965).

Coherence properties of two photon systems.
L.N. Menegozzi - Supplement of Nuovo Cimento (1965).

¿Do the commutation rules for coupled fields depend on their interaction?
L. Másperi - Nuovo Cimento (1966).

E.P.R. of Pentovalent Molybdenum in Liquid Solutions.
M.M.Abraham, J.P. Abriata, M.B.Foglio, B. Pasquini, J. Chem. Phys. (1966).

Internal Reports

Determinación de signos de los parámetros de spin.
M.B. Foglio.

Theoretical Study of the Spin Hamiltonian of a complex with Pentovalent Molybdenum.
M.B. Foglio (Submitted for publication to the Proc. Phys. Soc. - London).

Sobre la influencia de los procesos normales en la conductividad térmica de aislantes y de aislantes ferromagnéticos.
B. Alascio.

Efectos de Borde en la conductividad térmica de aislantes.
G. Carabelli, N.Nazareno, B. Alascio.

Two Particle Green functions and Nuclear structure.
W.J. Mulhall, R.J. Liotta, J.A.Evans and R.P.I. Perazzo (Submitted for publication to Nuclear Physics).

Internal Reports (Cont'd.)

Do the commutation for coupled fields depend on their interaction?

L. Másperi.

External Raman effect in molecular crystals.

A.M.V.G. de Alascio.

Application of the Green function method to the nuclei $^{90}_{Zr}$ and $^{86}_{Kr}$.

W. J. Mulhall and R.J. Liotta.

(Submitted for publication to Nuclear Physics.

LOW TEMPERATURE PHYSICS DIVISION

Research activities in Low Temperature Physics were initiated in 1960 by Prof. F. M. Daniels, from the University of British Columbia, whose stay was possible through a grant of the Argentine National Research Council.

In 1961, the laboratory had the advice and collaboration of Dr. F.W.T. Dabbs, from Oak Ridge National Laboratory, for six months (Fullbright grant).

Finally, the presence of Prof. John C. Wheatley, (1961-1962) was decisive for the installation of the laboratory and the initiation of the present research programs of the Low temperature Group.

Grants from the National Science Foundation, (NSF-G-20304; NSF-GP-329; NSF-GP-3536), as well as support from U.S.A.I.D. made the installation and construction of the present laboratory facilities possible. These are:

Philips Air Liquefier,

Philips Nitrogen Liquefier,

Collins Helium Liquefier and gas re-purifying system,

He^3 demagnetization apparatus, provided with a 10", 20 kOE magnet

Complete Liquid He^4 cryostat.

He^3 demagnetization apparatus, provided with a superconducting magnet, facilitating an experimental space and about 50 cm^3 At present, the construction of this last facility has been completed and test runs will be performed.

Provisions are made for excellent equipments for measurements at very low temperatures, such as:

4 AC resistance bridges which permit measuring heating powers down to 10^{-14} watts.

2 Low frequency mutual inductance bridges made after the design of Pillinger, Jastram and Daunt.

1 High sensitivity ballistic galvenometer for magnetic measurements.

1 L & N Type K-3 potentiometer,

and other complementary equipments.

Staff:

Since 1963, the head of the Low Temperature Laboratory is Prof. Ricardo Platzeck, a physicist of wide experience in many fields of experimental physics.

Three graduates of the I.F.B., Dr. O.B. Vilches, Lic. J. M. Cotignola and Lic. M.E. de la Cruz, acquired experience in Low Temperature work under the direction of Prof. Daniels, at British Columbia University, Vancouver, Canada (October 1959/September 1960).

Their stay was made possible by fellowships from the Argentine National Research Council and the International Atomic Energy Agency, respectively.

After their return, they continued working under the guidance of Dr. Danields, Dr. Dabbs and Dr. Wheatley, together with two more I.F.B. graduates, Lic. F. de la Cruz and Lic. A.C.M. Victoria.

In 1964, Lic. R. Rapp joined the group. Two advanced students of the I.F.B. received laboratory training performing their Licenciado Thesis work.

Original work during the construction of apparatus and installation of the laboratory led to the following publications:

"Electrical Heat Seals for Cryogenic Applications"
W. E. Roach, J.C. Wheatley, A.C.M. de Victoria
Rev.Sci.Instr. 35, 534 (1964).

The following work was initiated at the Bariloche laboratory and finished at Dr. Wheatley's laboratory at the University of Illinois:

"Measurements of the Specific Heat of three Magnetic Salts at Low Temperatures"
O.E.Vilches, J.C. Wheatley
Phys. Rev. 148, 509 (1966)

"Techniques for using Liquid Helium in very Low Temperature Apparatus"
O.E.Vilches, J.C.Wheatley
Rev.Sci.Instr. 37, 819 (1966)

Research projects being developed at the present time are:

a) Thermal conductivity of polycrystaline Zn below 1°K
J.M.Cotignola, M.E. de la Cruz, F. de la Cruz and R. Platzeck. Accepted f/publication in Rev.Sci.Instr.

b) Specific Heat of Helium^3 from 0.015 to 0.10°K
R.Platzeck, A.C.M. de Victoria, R.Rapp
Measurements of the specific heat of He^3 have been done by the Illinois group (1,2) the Yale group (3) and the Oxford group (4), but they do not agree on the value of C/RT for He^3 as $T \rightarrow 0$.
Only the former group has very low temperature measurements, but an improvement in precision is desirable. Knowledge of the limiting value of C/RT is essential for determining the parameters of the phenomenological Landau Fermi liquid theory for He^3.

References:

1) Anderson, Callinger, Steyert and Wheatley, Phys.Rev.Letters, 7, 295 (1961)
2) Anderson, Reese and Wheatley Phys. Rev. 130, 495 (1963)
3) Strongin, Zimmerman and Fairbank, Phys.Rev. 128, 1933 (1962)
4) Brewer and Keyston, Nature, 191, 1261 (1961)

c) Galvanomagnetomorphic effect in Indium films

The electrical conductivity of thin indium films in longitudinal magnetic fields is being studied, Such measurements should yield information on the electronic distribution in the metal.

References:

Magnetoresistance and Size Effect in Indium at Low Temperature
J.L.Olsen
Helv.Phys.Acta, 31, 713 (1958)

Conductivity of thin metallic films in a Longitudinal Magnetic Field
Yi-Han Kao
Phys.Rev. 138A, 1412 (1965)

ELECTRON PARAMAGNETIC RESONANCE GROUP

In 1961/62, Dr. Ake Nilson, from the University of Uppsala, Sweden, who served as a visiting professor of the Balseiro Institute of Physics and as a consultant for research at the Centro Atómico Bariloche (C.A.B.) proposed the installation of a laboratory for electron Paramagnetic Resonance. Through a grant from the International Atomic Energy Agency (I.A.E.A.), a Model V-4500 Varian Associates E.P.R. Spectrometer was purchased and the laboratory installed.

In connection with research programmed for the Paramagnetic Resonance Group, Dr. Mario E. Foglio, a member of the Bariloche staff, was sent to the University of Bristol England, to work under the direction of Prof. M.H.L.Pryce, on a theoretical research project (see Theoretical Physics Division).

Lic. Carlos Fainstein, a graduate of the Balseiro Institute of Physics, joined the laboratory of Prof. J. G. Aston at the Pennsylvania State University, for three years (1962/1965). He built two complete spectrometers for electron paramagnetic resonance (X and K-band) for work at liquid He temperature.

In the meantime, the laboratory received relatively short visits of experts who collaborated in the progress of research.

Dr. George Benski (Bell Telephone Lab.) initiated two advanced students in problems related to Cyclotronic Resonance and impurities in semiconductors.

Dr. Marvin Abraham (Lawrence Radiation Laboratory) suggested and helped in research concerning spectroscopic problems of paramagnetic ions of group 4d of pentovalent

Molybdenum in liquid solutions [1].

Together with Dr. H. Pezzano, Comisión Nacional de Energía Atómica (C.N.E.A.), studies of the spectra of organic substances were performed [2].

Since June 1965, the research program of the group is in charge of Lic. Carlos Balnstein. A program of research in Spin Lattice Relaxation at liquid He temperatures has been undertaken, supported by a grant from the Bariloche Foundation.

Lic. M. T. Causa, a 1964 graduate of the Balseiro Institute of Physics (I.F.B.) is in charge of work with ions of the 4d group to be performed at 3 cm wavelength.

Two students, to be graduated in 1966, are involved in the study of crystal fields by Electron Paramagnetic Resonance at liquid He temperature in the 3 cm wavelength band and in the construction of a spectrometer in the 1 cm band and liquid He temperature. This last project is supported by a grant from O.A.S.

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1) E.P.R. of Pentavalent Molybdenum in Liquid Solutions
M.M.Abraham, J.P.Abriata, M.B.Foglio, E.Pasquini
J. Chem.Phys. (1966).

2) Some observations on the Riboflavin E.P.R.Spectrum
Acta Physiologica Latino-Americana, XV, 2 (1965)

METAL PHYSICS DIVISION

The Metal Physics Division started its activities in 1958 with the aim of doing basic research in the field of Metal Physics. In the beginning it had the valuable assistance and advice of Dr. Robert Cahn, at that time Head of the Metallurgy Department of the University of Birmingham.

From 1960/62, the presence of Dr. Gunther Shöeck was decisive for the development and progress of research in Metal Physics. Since 1966, he again joined the Metal Physics Division of the Centro Atómico Bariloche (C.A.B.) under a five year contract with the Comisión Nacional de Energía Atómica (C.N.E.A.).

Since then, and through several grants from foreign and national institutions (see Ap.I) which complemented the funds provided by the Argentine Atomic Energy Commission and with the assistance of foreign professors (see Ap.II) who besides lecturing for the students of the Balseiro Institute of Physics (I.F.B.) contributed also to the post-graduate programs, the Metal Physics Division has increased its laboratory facilities (see Ap.IV) and its staff (see Ap. V).

A list of published papers, since 1960, is shown in Appendix III.

Research in the Metal Physics Division covers the following lines:

1.- Influence of ordering on the mechanical and electrical properties of alloys.

a) Mechanical Properties

The mechanical properties of ordered and disordered Ni_3Fe and Cu_3Au single crystals, have been investigated under

tension.

For this purpose measurements have been made on the dependence of the characteristics of tensil curve with such parameters as the initial orientation of the tensil axis, the ordered domain size, the degree of order and the test temperature. The change of Young modulus which accompanies the order-disorder transformation is also being measured.

b) Electrical Properties

The ordering kinetics is studied through resistivity and changes of the thermo-electric power measurements in samples of Ni_3Fe. The object of this investigation is to study the influence of the short-range and long-range order on the mechanical and electrical properties in order to elaborate a coherent model to explain the phenomenon of plastic deformation in ordered solutions. The work is supported by grant DA-ARO-392-64-G39.

The participants in this research are:

Dr. Aldo B. Vidoz
Lic. Manuel Mondino
Lic. JoséGaura
Lic. Conrado Varotto
Lic. Máximo Victoria
Lic. Miguel Audero

2.- Interaction between dislocations and solute atoms in body centered cubic materials.

In b.c.c. metals which contain foreign interstitial atoms (like C.C.N) in solid solution, there exists and internal friction peak, the height of which increases with cold work and solute concentration. A model has been proposed to explain this peak by the interaction of solute interstitials with dislocations. The purpose of this work is to study the

behaviour of this peak in various metals. It is hoped to obtain in this way information on the atomistic model of dislocation-impurity interaction and get a better understanding of the phenomena of yielding, hot brittleness and brittle fracture. The work is supported by grant DA-ARO-60-1 and carried out by Dr. G. Schöeck, Lic. M. Mondino and Lic. M. de Achterberg.

3.- Study on mechanism of work hardening in f.c.c. single crystals.

It is intended to investigate the behaviour of the flow stress and work hardening of flat single crystals of Cu and Al oriented for easy glide. Since in the easy glide region the mean free path of dislocations is of the order of 0,5 mm and the crystal thickness is about 0,5 mm also, part of the dislocation loops will escape through the flat surface and in the crystals will remain dislocations perpendicular to that surface. According to the specific orientation, these will be screw or edge dislocations.

The study of temperature dependence of the flow stress down to liquid air temperature will be tried.

It is hoped to get some new information on the mobility of dislocations and on the mechanism of work hardening in f.c.c. crystals and, it might be possible, to discriminate between the existing theories. The work is supported by grant DA-ARO-49-092-64-G27, and carried out by Dr. G. Shöeck, Lic. R. Medrano and Lic. R. Pascual.

APPENDIX I

Grants

1.- To study the interaction between dislocations and solute atoms.

Chief Investigator: Dr. G. Schöeck
U.S.Army Office - DA-ARO-SO-1

2.- To study plastic deformation in ordered solid solutions and its effects in physical properties.

Chief Investigator: Dr. Aldo E. Vidoz
U.S. Army Office - DA-ARO-49-092-63-12

3.- The mechanism of work hardening in f.c.c. crystals

Chief Investigator: Dr. G. Schöeck
U.S.Army Office - DA-ARO-49-092-64-G27

4.- Formation of point defects in b.c.c. metals

Chief Investigator: Dr. G. Schöeck
Argentine Research Council.

APPENDIX II

Visiting Professors:

Name	Year	Period	Sponsored by:
Prof. Robert W. Cahn	1959	3 months	C.N.E.A.
Dr. R.G.Davies	1958/1961	2 years	I.A.E.A.
Dr. Alfred Goldberg	1961/1962	9 months	I.A.E.A.
Dr. John C. Shyne	1963	6 months	I.A.E.A.
Dr. Walter Green	1964/1965	9 months	I.A.E.A.
Dr. Mario Pío Gómez	1965	9 months	I.A.E.A.
Dr. T. Massalski	1966	2 months	C.N.E.A.

C.N.E.A.: Comisión Nacional de Energía Atómica

I.A.E.A.: International Atomic Energy Agency.

APPENDIX III

Publications:

1.- X-ray study of order in $CuAu_3$ alloys
R.G.Davies, A.J.Funes
Act.Met. 9 Nº 10,978 (1961)

2.- Effect of cold work upon order in Au_3Cu alloys
R.G.Davies, A.J.Funes
Act.Met. 9, Nº 10, 979 (1963)

3.- Steady State Creep in $CuAu_3$ alloys
R.G.Davies
Trans AIME 221, 1280 (1961)

4.- On the activation energy for high temperature steady state creep
R.G.Davies
Act.Met. 9, 1035 (1963)

5.- On the yield stress in b.c.c. metals
G.Schöeck
Act.Met. 9, (1063).

6.- Correlations between dislocation length and density
G.Schöeck
J.App.Phys. 33, 1745 (1962)

7.- Steady State creep in Fe - 15 to 20% Al alloys
R.G.Davies
Trans.AIME, 227, 22 (1963)

8.- Steady State creep in Ni_3Fe alloys
R.G.Davies
Trans.AIME, 227, (1963)

9.- Steady state creep in Fe - 2 to 11 Pct Si alloys
R.G.Davies
Trans. AIME, 227, 565 (1963)

10.- Fricción interna debido a la interacción entre dislocaciones y átomos solutos
G. Schöeck
Act.Met. 11, 617 (1963)

11.- Internal Friction due to Interstitials-dislocation interaction in Ta
G. Schöeck, M. Mondino
J.Phys.Soc.Japan, 18, Sup.I (1963)

Publications - Cont'd

12.- Influence of Order on the tensile characteristics of Ni_3Fe
A.E.Vidoz, D. Lazarevic, R.W.Cahn
J.Phs.Soc.Japan, 18, Sup.I (1963)

13.- Remarks on a new theory of work hardening
G. Schöeck
Phil.Mag. 9, 335 (1964)

14.- On the K-state of Fe-Al alloys
R.G.Davies
J.Phys. and Chemistry of Solids
(1963)

15.- The activation energy in high temperature internal friction
G. Schöeck, E.A.Bisogni, J. Shyne
Act.Met. 12, 1466 (1964)

16.- On some models of work hardening of superstructures
A.E.Vidoz
Act.Met. 13, Nº 10, 1099 (1965)

17.- Propiedades Mecánicas de las soluciones sólidas ordenadas
A.E.Vidoz
(to be published in J.Asoc.Brasileira Metais-Brasil).

18.- About work hardening in polycrystaline ordered alloys
C.A.Pampillo
Phil.Mag. 13, 693 (1966)

19.- Creep at high temperatures in Ni-Fe alloys
C.A.Pampillo, A.E.Vidoz
Act.Met. 14, Nº 3, 313 (1966)

20.- Comments on the temperature dependence of the activation energy for diffusion
G. Schöeck
Act. Met. 13,1094 (1965)

(21.- Remarks on a linear theory of strain hardening
G. Schöeck
Phil. Mag. 13, 635 (1966)

22.- Deformation twinning in f.c.c. metals
G. Schöeck
Phys.Stat.Solid. 13, 127 (1966)

Internal Reports

1.- Theory of thermally activated slip in Crystals
C. Hoffmann - presented to the Argentine Physics Association in May 1960.

2.- Factores de correlación para difusión de impurezas en cristales
Presented to the A.Ph.A. in September 1961.

3.- Preliminary report on measurements of activation energies for plastic deformation of metals.
C. Hoffmann

4.- Width of antiphase boundary in ordered alloys.
C. Hoffmann

5.- On yielding in b.c.c. metals and frozen jogs in dislocations
C.Hoffmann

5.- The role of internal stresses in anelasticity due to stress induced order
C. Hoffmann

7.- Ordering kinetics of NiFe alloys near the compositions of Ni_3Fe

C.F.Varotto - Progress Report CAB. 63-FM-003

8.- Ana analysis of internal friction results of Fe-Al alloys
R.G.Davies and R.W. Cahn

9.- About work hardening in f.c.c. ordered solid solutions
C.A.Pampillo

10.- On the dependence of the electrical resistivity with the degree of order in the superlattice state
Roberto Luzzi

11.- Plastic Properties of f.c.c. ordered solid solutions
M.Victoria - Progress Report CAB. 63-FM-002

12.- On the work hardening of superstructures
A.B.Vidoz.

NUCLEAR PHYSICS DIVISION

Research activities in Nuclear Physics, at the Centro Atómico Bariloche, began at the end of 1958 on the occasion of a visit of Dr. Ingmar Bergström, from the Nobel Institute of Physics, Stockholm, Sweden, (presently Head of the Institute). Under his guidance a two-month summer school took place with the participation of graduate students from Buenos Aires, La Plata and Bariloche, and, as a first research project, the development of a simple, unexpensive delayed coincidence technique using fast oscilloscopes for the measurement of nuclear half-lives was developed [1]. Following his stay and Dr. Torsten Lindqvist's (University of Uppsala, Sweden) short visit in May 1960, several members of the staff joined Nuclear Physics groups in Sweden, in order to complete their training at a higher level.

Dr. F. Thieberger, a graduate of the Balseiro Institute of Physics (I.F.B.), worked at the Nobel Institute between September 1959 and June 1962, under the direction of Dr. Bergström mainly, in the development of pulse spectroscopic techniques and the application of these techniques to the study of nuclear transition probabilities.

His work included:

a) the use of oscilloscopes for pulse height analysis [2] and multichannel time analysis [3]

b) a study of the non-proportionality in the response of NaI(Tl) scintillators [4]

c) several pulse spectroscopic studies (5-10) including conventional angular correlations (9) and the application of the time differential method to the study of perturbed angular correlations (10)

In May 1962 he submitted his thesis to the University of Stockholm and obtained his Ph.D. With the help of a grant from the Argentine Research Council and funds supplied by the Atomic Energy Commission (C.N.E.A.) he was able to bring to Bariloche research equipment, which included fast amplifiers, differential discriminators and a 100-channel analyzer of the Hutchinson Scarrot type. When returning from Sweden, Dr. Thieberger worked in some Mössbauer experiments and was mainly involved in the organization of the laboratory. Some work was performed on the origin of spurious pulses in proportional counters (11). A variable discriminator using tunnel diodes was developed (12). He also wrote a theoretical paper on the gravitational mass of antiparticles (13).

Another graduate of the I.F.B., Dr. E. Bonacalza, worked at the Nobel Institute between December 1960 and March 1964, under Dr. Bergström. His work included mainly the application of coincidence techniques to the study of nuclear decays (1,4,5,7,14,17) and included also some work on the present main line of the group, i.e. perturbed angular correlations (14). He obtained his Ph.D. from the University of Stockholm.

The third graduate to be sent to Sweden was Dr. M. Salomón. He worked at the Institute of Physics of the University of Uppsala, between September 1961 and December 1964, in the angular correlation group directed by Dr. Lindqvist. His work was entirely dedicated to the study of perturbed angular correlations using the time differential method. It was the subject of his doctoral

thesis submitted in May 1964 to the University of Uppsala The following subjects were included in his thesis:

Magnetic interactions (18, 19)
the after effects of electron capture (20) and
different aspects of the electric quadrupole interaction in liquids and solids as well as its temprature dependence (21-24).

Before his return, he obtained a grant from the Swedish International Development Authorities (S.I.D.A.) which allowed him to bring back equipment and components necessary to build the first angular correlation station in Bariloche. This station was completed thanks to a grant obtained in 1964, from the Bariloche Foundation, which allowed the purchase of a 400-channel analyzer with accessories and a multicoincidence equipment with five DDL amplifiers and five single channel analysers.

Since his return, he produced a paper on hyperfine interaction (25), the correlation station was built and put into operation and several tests of the equipment were conducted. It was tried to observe the hyperfine interaction in Ta^{181} with the differential method by looking at a HfO_2 source, but no positive effects were observed due to the fact that the interaction frequency was too high.

Ingº T. Cisneros worked with the Uppsala group between September 1964 and August 1965, and he devoted all his time, also, to work in perturbed angular correlations. The main line of work was the study of hyperfine interactions by putting a suitable nucleus with a known magnetic moment in the host lattice where the h.f. field was to be determined (26-27). Temperature dependence was also studied in some cases.

We also obtained a grant from S.I.D.A. which allowed

him to bring enough equipment and components to duplicate the angular correlation set-up. He is now devoted to the construction of a second station.

The group is also trying to design and mount a facility giving a thermal neutron flux high enough to activate isotopes of relatively short half-lives in which perturbed angular correlations or measurements of half-lives of isomeric states can be performed. A Sb-γ-Be neutron source is now being tested, inside water and paraffin moderators but, the flux obtained is not yet satisfactory (ca.10^3 thermal neutrons/cm^2 sec). It is hoped that modifications in the geometry of the Be container and the Sb nucleus will increase the available flux. This work is done with the participation of two students of the I.F.E. to be graduated in January 1967.

References:

1.- The oscilloscope method of measuring nuclear half-lives,
I. Bergström, B. Bonacalza, A. Jech, M. Perez
Nucl. Instr. & Methods, 8, 151 (1960) (x)

2.- Use of cathode ray tubes in pulse-height spectroscopy
P. Thieberger, I. Bergström,
Nucl. Instr. & Methods, 10, 315 (1961)

3.- Wide range time to pulse height converter,
P. Thieberger,
Arkiv Fysik, 22, 137 (1962)

4.- Experimental study of the influence of non-proportional response of NaI(Tl) scintillation crystals upon the energy resolution for gamma rays,
P. Thieberger, B. Bonacalza, H. Ryde
Nucl. Instr. & Methods, 14, 225 (1961) (x)

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(x) Work done at the Bariloche laboratory.

DIVISION FOR PHYSICS OF IONIC BEAMS

Work in the physics of ionic beams started in February 1961, when the late Prof. Dr. S.K. Allison, from the Enrico Fermi Institute for Nuclear Studies, University of Chicago, visited the Bariloche Institute for two months (O.A.S. grant). At that time, a group led by Dr. Wolfgang Meckbach had acquired experience in the production and acceleration of ionic beams [1]. The construction of a 300 KeV Cockcroft-Walton accelerator was in an advanced stage.

These developments suggested the possibility of establishing in Bariloche efficient research in the field of the physics of interaction of ionic beams with matter, a field in which Prof. Dr. S.K.Allison had been working on at the University of Chicago since 1940.

As a result of this visit, Dr. Meckbach joined the Chicago laboratory in September 1961, in order to do experimental work in this field.

His stay in Chicago was made possible through a Fellowship granted by the Argentine National Research Council.

He remained at the Enrico Fermi Institute until December 1962. The research project was concerned with the determination of the effective charge ratio of a He beam with respect to a hydrogen or deuterium beam in solid and gaseous cadmium [2, 3].

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1) W. Assler, W. Meckbach, Rev. Sci.Instr. 30, 330 (1959)

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In the meantime, another member of the Bariloche group, Lic. Pedro Torres, had advanced the construction of the Cockcroft-Walton Accelerator (Kevatron) and, after Dr. Mockbach's return, the machine could be tested in May 1968, in a preliminary and satisfactory way up to a voltage of 200 kV.

Since then, the following work has been in progress at the Bariloche Laboratory:

The installation of the Cockcroft-Walton Accelerator and its controls were completed. Stable and well-focussed beams of up to 1 mA protons were obtained. The maximum accelerator voltage was raised to 330 kV.

The first research project to be undertaken by the Bariloche group was the determination of charge equilibrium fractions of ionic beams in gases and solids.

The following equipment was constructed and installed for this purpose:

- A magnetic deflection system for sorting of the beam delivered by the Kevatron,
- A second magnetic deflection system which serves to analyze the charge equilibrated beam. A special feature of this analyzing system is that it works with a fixed magnetic field and a movable collector for the beam components of different charge, such that the "charge spectrum" is displayed on an x-y recorder.
- A differentially pumped gas cell was added to the equipment and equilibrium fractions of a He beam in He gas measured.

These measured equilibrium fractions are in cor-

plete agreement with those of Barnett and Stier[4] up to 200 KeV beam energy. The measurements in Bariloche were extended with the singly charged $(He^4)^+$ beam up to 320 KeV and, using a beam of doubly charged $(He^3)^{++}$ ions, to an equivalent energy of $(He^4)^+$ of up to 320 KeV.

The work on the charge equilibrium of a He beam in He gas, has been accepted for publication in the Physical Review[5].

The measurements of He-Ne have been performed with the collaboration of Lic. I. Nemirovsky, who is a member of the Bariloche group since 1963.

In June 1963, Lic. F. J. Torres joined the Chicago group as a fellow of the Argentine National Research Council until November 1964. From December 1964 to January 1965, he worked at the Enrico Fermi Institute under A.E.C. contract AT (11-1)-238, on the physics of ionic beams.

He worked on the following research activities:

1) "Partial Atomic and Ionic Stopping Power of Gaseous Hydrogen for Helium and Hydrogen Beams" - Phys.Rev. 135, 2A, A335 (1964).
2) "Average Ionic Charge of Helium and Hydrogen Beams in Cadmium Vapor", presented at the 1965 Spring Meeting of the APS, Washington, D.C., April 1965.
3) "Atomic and Ionic Partial Stopping Powers of Helium Gas for an Helium Beam", presented at the IVth International Conference on the Physics of Electronic and Atomic Collisions, Universite Laval, Quebec, Canada, August 1965.

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4) C.F.Barnett and P.M.Stier, Phys.Rev. 109, 385 (1958)

5) W.Meckbach and I.B.Nemirovsky-To be published in the Phys. Rev.

Lic. Torres returned to Bariloche in February 1966.

Since August 1965, Lic. A.J.Kestelman has joined the group at Bariloche. Up to that time he had been working with the Van de Graaff group at the University of British Columbia, Vancouver, Canada, on the subject of Low Energy Nuclear Reactions.

Prof. Allison's last visit to the Bariloche Center took place during February and March 1965.

At the present time, the measurements of He charge equilibrium fractions are being extended to other gas targets. The preliminary results on N_2 again show good agreement with the measurements of Barnett and Stier who measured up to 200 KeV.

It is of great interest to compare charge equilibrium fractions attained in matter in its gaseous and solid state as suggested by the results of Meckbach and Allison's work [3].

Therefore, as a continuation of the work performed on charge equilibrium fractions of helium in cadmium vapor at Chicago (P. Torres) it is intended to do these measurements on Cd metal. For this purpose, an all glass cell was built in which the metal cadmium foils are prepared by evaporation and traversed by the beam under ultra high vacuum conditions. Preliminary tests showed that the vacuum obtained by getter ion pumping was of the order of 3.10^{-9} torr.

Another facility of the laboratory is a small accelerator which goes up to 60 kV. At present, preparations for the measuring of charge exchange cross sections at these lower energies are in progress.

The intention is to check on results of Hollrichter [6] and Fite, Brackmann and Snow[7] about an "isotopic effect" observed in the capture crossection σ_{10} of protons and deuterons interacting with H_2 and D_2 gas or H and D Atoms.

There are two recently graduated "licenciados" of the Balseiro Institute of Physics, working on this project. A student, due to graduate at the end of this year, will join the group and is right now engaged in the construction of an electrostatic analyzer for the 300 kV accelerator.

Another recently graduated "licenciado" is starting theoretical work on the problem of the "isotopic effect" under the guidance of Prof. Guido Beck.

Since April 1964, the group is supported by a grant from the U.S. National Science Foundation, which is due to expire in March 1967.

In September 1966, Lic. I.B.Nemirovsky joined the group of Dr. C.Y.Fan and Dr. M. García Muñoz, at the Laboratory for Astrophysics and Space Research, Enrico Fermi Institute, University of Chicago, to perform a research project on the physics of ionic beams. His stay is sponsored by a followship from U.S.A.I.D.

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6) O. Hollrichter, Z. Physik 187, 41 (1965)

7) W.L.Fite, R.T.Brackmann and W.R.Snow, Phys.Rev. 112, 1161 (1958)

ELECTRONICS DIVISION

This Division specialized in the following:

1) Design and construction of electronic equipment necessary to carry out measurements and perform controls related with research work in different laboratories of the Centro Atómico Bariloche (C.A.B.).

2) Give advice to other Divisions in problems concerning Electronics, in which this discipline may be of help in the development of research work in progress as well as in planning.

3) Maintenance of all the electronic equipment of the organization, including teaching laboratories of the Balseiro Institute of Physics.

In fulfilment of the above, new equipment has been developed, about which the following publications have been issued:

a) "Equipo regenerador de imanes permanentes"
Revista Telegráfica Electrónica-December 1963-Nº 614
pages 712/13 - R. Frentzel.

b) "Estudio sobre medición de corrientes débiles"
Revista Telegráfica Electrónica - R. Frentzel
April 1964 - 613 - pages 168/170
May 1964 - Nº 619 - pages 228/230
June 1964 - Nº 620 - pages 283, 284, 288.

c) "Análisis generalizado de las propiedades de circuitos reguladores de tensión"
Revista Telegráfica Electrónica - R. Frentzel
September 1964 - Nº 623 - pages 479/482.

d) "Equivalencias entre flujos calórico y eléctrico - Aplicaciones".
Revista Telegráfica Electrónica - R. Frentzel
September 1965 - Nº 634 - pages 429/431.

e) "Circuito para controlar la emisión de filamentos y su estabilización"
Revista Telegráfica Electrónica - R. Frentzel
December 1965 - Nº 637 - pages 643/49.

f) "Análisis de un circuito detector sensible a la polaridad de la señal"
Revista Telegráfica Electrónica - R. Frentzel
February 1966 - Nº 639 - Page 82.

A senior staff member, Ingº F.de Haro, joined the Lawrence Radiation Laboratoryfor one and a half years in 1962, as a fellow of U.S.A.I.D. His work was performed under the direction of M.Nakamara and comprised the following subjects:

"A survey of Scintillation Deivces for Use in Fast Coincidence Techniques" - Engineering Note-33921.

"An Analogue Gain Stabilizer, Mod.I - 13 x 1960"

"An analogue Digital Converter"

In 1965, Ingº H. Cingolani also joined the Lawrence Radiation Laboratory, for ten months, working under the direction of Dr. Fred Golding, in the development of interface equipments for direct computer application in nuclear data processing.

LINEAR ACCELERATOR DIVISION

The Linear Accelerator Laboratory was created in 1951, with the purpose of constructing an S band electron Linac which would serve as a tool for different research projects and for training purposes of graduate students of the Balseiro Institute of Physics (I.F.B.).

The construction of the machine is in charge of Lic. J.J.Obiedo, a 1958 graduate of the I.F.B., an electronics engineer and two technicians. The group had advice and important support from Dr. Ricardo Platzeck.

Besides the budget of the Centro Atómico Bariloche (C.A.B.), the Linac has received a grant from U.S.A.I.D. for the purchase of two klystrons, driver, microwave measuring devices and otherequipment nececsary for completing the construction of the machine.

The Linac was designed according to the characteristics of Mark II of the Stanford University, that is:

a) a uniform wave-guide of constant impedance, 12 ft.long, working in the /2 mode.

b) the rf is injected in pulses of 2 microseconds duration and 12 MW peak power.

c) electrons are injected in pulses of 1 microsecond at 75 kV and 100 mA peak current.

d) the repetition frequency may be varied up to 100 pulses per second.

Having finished the construction and assembling of the Linac, at this time the wave-guide is being processed in order to be able to inject the maximum peak power. The way in which the wave-guide was built, does not permit baking;

hence, some time must be spent before breakdown problems can be solved.

During the initial stages of the Linac construction the group had technical support from Stanford University. Dr. Greg A. Leow, suggested improvements and changes in the design. In the final stages there has been close contact with the Linac group at General Atomic, San Diego, California.

From June 15th to July 18th, 1966, Lic. Olcese made a short visit to General Atomic in order to get acquainted with the working characteristics and handling of a similar machine.

Linacs with these characteristics, are of exceptional value for the investigation of many problems of neutron physics using the time-of-flight method of measurement. This Linac will be capable of providing a very high instantaneous neutron intensity with a spectrum similar to the fission spectrum and with repetition pulse characteristics.

A research project in this field is being prepared, the performance of which is planned in collaboration with General Atomic. This program will be in charge of Dr. M.M.Antônez, a graduate of the I.F.B., who is at present, doing research at General Atomic.

There is also interest to use the machine for research in radiation damage (Metal Physics Group) and for production of isotopes by photo-neutron induced processes (Nuclear Physics Group).

ELECTROMECHANICS DIVISION

The Electromechanics Division consists of all the work-shops in the Centro Atómico Bariloche (C.A.B.), such as

1) A modern mechanics work-shop equipped with a rather complete set of machines and tools as well as the necessary raw materials.
2) a blacksmith's shop
3) a carpentry
4) an electrical repair shop
5) a printing and photostatic copies work shop
6) a glass blower's shop in which the most varied glass apparatus are made, ranging from dewars for work at liquid He temperatures, to diffusion vaccum pumps.