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Do you know what was LENIH and what it has become now?

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Dedicated to Dr. Alberto López García on the occasion of his sixty–fifth birthday

Abstract

In this paper, the beginnings of the Laboratory of Nuclear Spectroscopy and Hyperfine Interactions (LENIH) at the Department of Physics of the National University of La Plata and the evolution of the principal ideas involved and the main goals achieved are reviewed. Special attention is devoted to the relationships between the LENIH members and the international scientific community through the years, since they have been fundamental for the existence and development of the applications of hyperfine interactions in Solid State Physics at La Plata. A scheme of the socio-political situation in which the LENIH grew and could consolidate its actual position as well as the diversified research lines developed at present are also described.

Keywords: Hyperfine interactions; Solid state physics; Argentine university; Nuclear spectroscopy

1. Introduction

Do you know what was the Laboratory of Nuclear Spectroscopy and Hyperfine Interactions (LENIH) and what has become of it now? Perhaps, perhaps not. In both cases, we would like to share with you through this paper, the beginnings of the LENIH at the Department of Physics of the National University of La Plata (UNLP). The evolution of the principal ideas involved and the main goals will be reviewed. Special attention will be devoted to the relationships between the LENIH members and the international scientific community through the years. Such feature has been fundamental for the existence and development of the applications of Hyperfine Interactions (HI) as a tool for research in solid state physics at La Plata. At the beginning is a random walk in condensed matter physics and a progressive definition of a lab, now several well defined lines of research at full work. In parallel, we will present a scheme of the socio-political situation in which the LENIH grew and could consolidate its actual position: two dictatorships, a civil and a external war that took place during the first fifteen years, as well as some economical difficulties which were casting a shadow on our future since the very beginning. So, if we take a look at the actual research lines and the new projects in the field of HI that take place in La Plata, maybe we will be able to reward LENIH.

At a birthday it is natural to look back and to examine what has happened over the years. Our aim here is to show how LENIH has responded to the challenges of developing experimental physics in Argentina, as well as the dramatic politics of the last 35 years. Through this paper we will try to describe what was denominated as LENIH at some moment, and how it ramified in several research lines nowadays due to the diversification of the material characterisation techniques, and in spite of the scarceness of students of physics in La Plata. We shall not attempt to give a detailed historical account, but the description will certainly contain the essential aspects in order to understand why and how LENIH has arrived to the present situation.

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2. The beginning

The research on HI using nuclear spectroscopy techniques began in La Plata, as in other laboratories of the world, as a continuation of the experimental research in nuclear physics. The last one had been developed intensely after the second world war, with contributions of the government and, eventually, of the US armed forces, a situation that, no doubt, would be very questioned nowadays.

In 1957 Dr. H. Bosch was designated Professor of Experimental Nuclear Physics of the Physics Department of the Faculty of Physics and Mathematical Sciences of the UNLP. Starting from his "full time" work as professor he formed a group of nuclear physics in low energy gamma spectroscopy. He had graduated at Buenos Aires University and had arrived from USA, where he had developed post-doctoral activities at the Berkeley Institute in the area of experimental nuclear physics. He obtained the resources to mount the laboratory through the North American Air Force. Part of these funds were assigned to the creation of a laboratory for electronic engineers, with the purpose of giving technical support to the group of nuclear Physics, carrying out maintenance tasks and development for the groups dedicated to this type of spectroscopy. This was the beginning of the Electronic Laboratory at the Physics Department during 1958. At the beginning of 1968 a research and development group in topics linked with electronic instrumentation and automatic control started to consolidate, which was the origin of the current Laboratory of Electronic Industrial, Control and Instrumentation (LEICI) at the Faculty of Engineering in 1993.

In order to administer the mentioned funds, the Special Commission of Atomic Physics and Radioactive Isotopes (CEFAR) was created which from 1960 to 1965 organised basic courses of nuclear physics and their applications, directed toward agriculturists, veterinarians and physicians. The courses were carried out in the Laboratory of Radiochemistry, which at that time was part of the Department of Physics.

In 1960, the Physics Department received the visit of Prof. Linqvist, from the Uppsala University (Sweden). During this visit an agreement between the universities was generated, thanks to which the Ph.D. students of physics of the UNLP could carry out experimental work of their theses in nuclear physics in Uppsala, the UNLP awarding the Ph.D. in physics. The program, called Seminar of Uppsala, lasted one year and was created with the purpose of receiving scientific youths from developing countries. The first to receive his Ph.D. was R. Othaz who brought a spectrometer donated by the Uppsala University. It belongs at present to the Museum of Physics of our Department (Fig. 1). One of the last ones who benefited from this program was A. López-García (1965) (Fig. 2). At that time the time differential Perturbed angular correlation (TDPAC) technique was being applied in several countries. López García worked with this technique under the direction of Prof. Linqvist and his thesis work was devoted to the study of the thermal dependence of the hyperfine fields at the ^{111}Cd probe, in Fe and Ni [1].

Fig. 1. The electron-gamma equipment brought by R. Othaz in 1964 from Upsalla University.

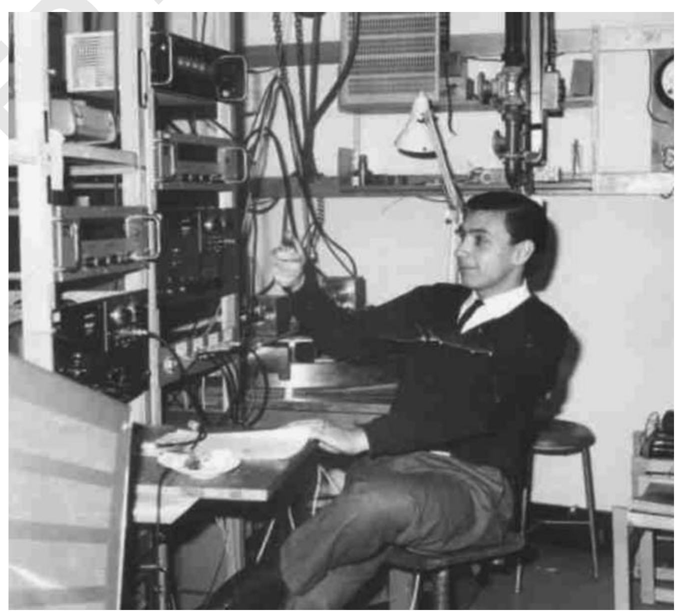

Fig. 2. A.R. López García at Upsalla University in 1966.

3. Hard times

Although many years elapsed during which the political situation of our country was very delicate, the year 1966

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was especially unfortunate for the Argentine University. At that time the destruction of education and of research in the University began: the night of July 29, 1966, defined a critical point in the contemporary history of the Argentine University, and particularly of the University of Buenos Aires (UBA). The so-called "Noche de los Bastones Largos" (Night of the Long Sticks), a denomination inspirited in the "Night of the Long Knives" that belongs to a sad part of the German history, abruptly changed the life of the academic community. The police actions of July 29, 1966 at the UBA, were the beginning of a long night of hunting for witches, intolerance and violence that would cause serious damage to scientific development and to higher education institutions in the country for almost two decades. The story of such night had started a month before, on June 28, when the civilian government of Arturo Illia was deposed by a military *coup d'etat*. On July 28, the new military regime cancelled the autonomy of the universities and their rights to self-governance. In the Faculty of Exact and Natural Sciences, professors and students began to discuss the situation, trying to define possible actions against the military decision. The policy and the military irrupted on the Faculty, and began to attack students, professors and researchers with a high level of violence, injuring several men and women, and putting many of them in jail. Among the victims of the beatings were prestigious scientists and it did not matter if the people where in a meeting analysing the opposition or merely giving lectures or attending them. The military had lost the respect for the University and knew that most of the society would not be worried for it. The vice-dean of the Faculty, Dr. Sadosky, would say years later: "We believed that we were doing transcendental things that the society appreciated and discovered our isolation in the worst way" and added: "Seeing what came later, with murders and missing people, we felt that we had been fortunate that night. The fact had transcendence because an USA mathematician (Prof. Warren Ambrose from the MIT) was among the attacked persons." This prompted the New York Times to publish a note on the incident, which gave international notoriety to the situation [2].

In spite of these facts, our Physics Department benefited because well recognised theoretical physicists were incorporated to the scientific staff. After resigning to the UBA and to his position at the Directory of the National Council of Research and Technology (CONICET), J.J. Giambiagi was incorporated to the Physics Department, and soon later came, among others, Dr. C. G. Bollini. This gave a great push to the scientific activity at La Plata [3].

At the beginning of 1966, López-García began the construction of a TDPAC equipment just with parts of spectrographs that were in the Physics Department. It included, among other things, two detectors of NaI(Tl) with photomultiplier tubes with a few dynodes and not very appropriate for timing spectroscopy.

In September 1966, M.C. Caracoche obtained her Ph.D., with a thesis work consisting in the calculations of nuclear cross-sections for (d,2n) [4].

In the course of 1967, A.G. Bibiloni, as student of physics, began to carry out a research under the directorship of Dr. López García.

In April of 1968 the Faculty of Exact Sciences was created, substituting the once denominated Faculty of Chemistry and Pharmacy. At the same time, the Faculty of Physics and Mathematical Sciences changed to the Faculty of Engineering. This included the transfer of the Departments of Physics and of Mathematics from the Faculty of Physics and Mathematical Sciences to the new Faculty of Exact Sciences.

In this year, the first TDPAC equipment, made in USA, was purchased with a grant of CONICET. This allowed the beginning (1973) of the experimental study of hyperfine fields at La Plata. However, the first publication related with HI dates from 1971 and consisted in calculations on internal electric and magnetic effects on the differential angular correlation [5]. The research in nuclear physics still continued. In 1971, R. C. Mercader obtained his Ph.D., with studies on excitations functions for the production of ^{90}Nb and ^{88}Y by irradiation of Zr with deuterons [6].

In those years, López García traveled to Germany, with a grant of CONICET, to work under the directorship of Prof. E. Bodenstedt, at the Institut für Strahlen und Kernphysik (ISKP) of the University of Bonn. With that visit (1970–1972), the long and productive co-operation between the ISKP and our Department began, situation that will be described later. Thus originated relationship resulted fundamental for the beginning of HI research at La Plata and the role played by Prof. Bodenstedt is invaluable, because he really worked as a professor outside his own country. He is considered a godfather of the LENIH. During one of his visits, (the first one, 1973), the first measurement using the TDPAC technique at La Plata, The half-life of the 379.3 keV state of ^{169}Tm, was carried out [7].

In 1973, R.C. Mercader visited the Brazilian Centre of Physical Research of Rio de Janeiro, (CBPF), Brazil in order to begin his studies in Mössbauer spectroscopy. He went there with an award for three months of the Organization of American States (OAS). There he worked under the directorship of Dr. Jacq Danon. With this trip the incorporation of the Mössbauer spectroscopy as a complementary technique at La Plata began. This appeared as an antecedent of the interaction between the CBPF and our laboratory.

In that year the military dictatorship was interrupted and our country returned to democracy. Gral. Perón was elected President but the violence to which the ceasing of the dictatorship had given place, did not diminish but increased. With the death of Gral. Perón some months later, hard times for the University arrived. To the fear of the repressive actions of irregular groups connected with the government it is necessary to add the absence of

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resources for education and investigation. For the experimental physics at La Plata, the shortage of funds made necessary the use of personal resources (we used a little box called "piccola cajeta" to have some cash). The University was closed for several months. In order to complete the load of liquid nitrogen required by the detector of Ge(Li) which had been received, it was necessary to request permission to enter to the Laboratory the Federal Police. Such difficulties explain the short life of the detector. A year later, in 1974, the so-called Ivanissevich–Ottalagano mission (the former was the Minister of Education, and the later the Rector of UBA imposed by the government of Isabel Perón) continued the dismantle of the universities. For those times the attacks to universities included burning books, persecuting students and faculty members, and the beginning of the era of 'killing' the opposition [8]

4. Getting worse

The situation continued worsening and the military dictatorship of March 24 (1976) and the worst age, the Military Process, arrived (the military nominated this intervention as "the Process of National Reorganisation"), with the disappearance of students and colleagues and the knowledge of the tortures and the executions suffered by them. The city of La Plata, due to its great University and the existence of a considerable worker population, was one of the cities more knocked by the military process. The following years were the worst of the dictatorship. We faced day-to-day death. The "Night of the Pencils", when many students of the secondary schools disappeared, took place in La Plata [9]. Anyway, in spite of being worried about the security of some of us who refuse to go out of the country, we continued working and while carrying out experiments with the collaboration of the National Atomic Energy Commission (CNEA), we used transit by the gate of the Superior School of Mechanics of the Navy (ESMA), which it was "vox populi" that was one of more important detention centres of the process. Later, the magnitude of the repression and the dramatic details of the crimes perpetrated there would be known [10].

As human beings must do, we continued working, in spite of the climate of fear and uncertainty. So, with resources of the OAS, J. A. Martínez carried out a stay at the Institute of Physics of Porto Alegre (Brazil) and then presented his doctoral thesis at the UNLP using the experimental results obtained in $CaHfO_3$ [11]. This work generated the first line of investigation of La Plata's group (hyperfine characterization of hafnium compounds), giving place to the first experimental thesis totally carried out at La Plata, which consisted in the study of the electric quadrupole interactions at ^{181}Ta impurities in hafnium pyrovanadate and hafnium pyrophosphate compounds [12]. With this work, L.A. Mendoza Zélis obtained his Ph D. degree. Later he went to Porto Alegre and participated in investigations on the HI of ^{111}Cd in Heusler alloys [13]. A.F. Pasquevich did the same one year later [14].

In the year 1977 the first Mössbauer spectrometer arrived to the Department of Physics. The equipment was donated by the Kernforschungszentrum Karlsruhe after an application of R.C. Mercader and the help of E. Bodenstedt. Later, from the same source, an evaporation chamber and a TDPAC equipment arrived, along with a metal roller and a hydraulic press.

The year 1978 was particularly prominent in events: the Tandar Project (initiated in 1976), the Argentinean tandem accelerator of 20 MeV for heavy ions, begun to be constructed. Argentina won the football world championship. And the possibility of a war with Chile, because of border problems, raised. The military government played a role in all these things. Meanwhile the disappearances of people continued.

In the year 1979 the second visit of the Prof. Bodenstedt took place. He brought two samples of noble metals implanted with ^{181}Hf. The idea was to study the annealing recovery stages of the implantation damage by means of TDPAC. The doctoral theses of A.F. Pasquevich and F.H. Sánchez were based on the experiments carried out then.

Simultaneously with TDPAC studies using ^{181}Hf as probe, the group tried to use other nuclei. This attitude began in 1977, in collaboration with the group IALE of the CNEA. They implanted ^{140}Xe in Ni with a mass separator and the γ–γ cascade in ^{140}Ce was used for TDPAC experiments. The ^{140}Ce isotope is a stable product of the disintegration chain of the ^{140}Xe, a fission product of the ^{235}U [15]. Later on, with the help of G. García Bermúdez and M. Behar of the CNEA, we began to use the well-known nuclear reaction

$$^{109}Ag(\alpha, 2n)^{111}In$$

The idea was to produce the ^{111}In isotope probe and use it in experiments that did not require its separation from the Ag metallic target. We began with the investigation of the interaction between defects and impurities in metals of cubic structure. In those times, several laboratories abroad were working in similar topics [16–19].

During an annealing performed to remove radiation damage in a Ag sample doped with ^{111}In, the quartz tube that contained the sample broke and the oxidation of the impurities took place accidentally. In this way we entered the world of internal oxidation [20]. The prize was the first division of the group. We divided as "oxidization" and "ionic groups" The oxidization continued with the investigation of the internal oxidation processes, the ionics continued working on the characterisation of Hf compounds, and additionally a third group configured around Mössbauer spectroscopy.

The oxidization group worked with the internal oxidation of In as impurity in Ag and they supplemented the study with the HI of ^{111}In in In_2O_3. The semiconductor character of this oxide constituted a favourable characteristic to relate the host electronic states with the magnitude of the "after effects" following the radioactive decay of the probe [21,22]. The work of these years was carried out in

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competition first and in collaboration later, with the group of K.P. Lieb of Göttingen. The topic concerning the HI of ^{111}In in oxides have current validity, as demonstrated by the contribution of M. Uhrmacher to this conference. Coming from her doctoral stage at the Institut de Physique Nucléaire (IPN) d'Orsay, France, C.P. Massolo incorporated to the oxidization group and remained working in the field of HI in oxides, and also in experimental nuclear physics at Orsay, until her early disappearance in 1993. The "oxidization continued with the study of diverse oxides and semiconductors.

The ionics group took profit of the appartion of the fast CsF-scintillators and gradually became specialised in zirconium-based ceramics. At the moment this is a line that gives place to several collaborations between members of the group and other laboratories in the world.

In 1980 the first measurement using the Mössbauer spectroscopy took place [23], opening a long collaboration with other researchers of the faculty for the characterisation of compounds synthesised by the chemists. In 1984, Sánchez carried out a complementary study of internal oxidation in dilute alloys of Sn in Ag with MS, taking advantage of the sensibility of MS to the local charge density and the symmetry of its distribution to characterize the Sn–O complexes that were obtained at different temperatures [24].

5. Gateway to democracy

In 1983 the dictatorship finished, leaving after it even more blood: the search of prestige had led militaries to intend the recovery of the Malvinas Islands, and they involved the country in a war where corruption and inefficiency of the military were mainly responsible for the defeat and deaths of Argentine youth.

In the decade of the 1980s, several members of the group carried out long stays in foreign research centres. In 1980 A. López García was on sabbatical leave at Rutgers University working with N. Koller and P. Raghavan in transient magnetic fields, nuclear half lives, magnetic dipole and electric quadrupole moments of excited states [25–27].

A.F. Pasquevich went to work with the pupils of E. Bodenstedt in Bonn and there, with R. Vianden, carried out pioneer works in the investigation of HI in semiconductors [28–30]. Other members of the group specialised in other techniques and topics. L. Mendoza Zélis worked with the group of H. Bernas on the preparation and characterisation of metastable systems with ionic beams [31–33]. F.H. Sánchez continued using MS, and working with Joe Budnick at Connecticut in USA, he was devoted to the study of magnetic metastable alloys (crystalline and amorphous) of the type Fe–X ($X = B$, C, Al, Si) [34,35]. Also, they worked on material modifications by ion beams [36]. These studies marked the direction of his investigations for many years. J.A. Martínez worked with T. Venkatesan at Bell Communications Research, New Jersey, USA, on ion beam interaction studies on High T_c superconductor thin films. J. Desimoni developed research with Agnès Traverse and Harry Bernas at the Centre de Spectrométrie Nucléaire et Spectrométrie de Masse (CSNSM), France, on ion beam mixing of metallic and semiconductors films and ion beam induced epitaxial crystallization of buried iron silicides [37–39].

In those years, several members of the group worked with accelerators of ions. This had to do with a project elaborated by López García for installing an ion accelerator at La Plata, project that finally did not prosper. This activity around ion implantation as a way of preparing metastables systems conducted the study of this type of systems originating by melt spinning and ball milling, less expensive techniques than ion implantation.

6. Current activities

From the end of the 1990s, the youngest generation made good use of the synchrotron radiation, available at Orsay (LURE) [40,41], Berkeley [42,43], Stanford (SSRL) [44,45] and Campinhas (LNLS) [46,47]. At the same time, electronic structure ab initio calculations of the EFG at impurities in doped binary oxides were introduced at the lab and developed for the first time by L. Errico, G. Fabricius and M. Rentería [48–50]. Several investigation lines around magnetism appeared in the last decade. The incorporation of a susceptometer to the LENIH was very important. R .C. Mercader created recently a laboratory for the study of magnetism, in some sense carrying out the first "official" separation of the LENIH. Independently, F.H. Sánchez developed research lines in magnetism. L. Mendoza Zélis incorporated the study of magnetic properties to his research in metastables systems. A.F. Pasquevich, working in collaboration with M. Forker, participated in systematic PAC studies of intermetallic compounds formed by transition elements and rare earths. More recently, theoretical ab initio and experimental studies of the novel dilute magnetic semiconductors (DMS) oxides, appealing for spintronic technology, have been developed with success at La Plata, in close collaboration with M. Weissmann (CNEA) and S. Duhalde (FI, UBA) [51–53]. In this way, four groups of the LENIH participate at the moment in the National Net of Magnetism and Magnetic Materials.

The following research lines, some of them with a clear overlapping, are the current ones at our Lab:

6.1. Research group of study of perovskites and aurivillius oxides

A. López García, is working on this subject since 1990. Nowadays, the group is formed by R. Alonso, M. Taylor and M. Falabella. The aim of this group is the study of perovskites and of aurivillius, some with ferroelectric characteristics, in order to determine the macroscopic, microscopic and nanoscopic properties' dependence on composition and temperature: calorimetric measurements, impedance as a function of frequency, crystalline and electronic structure, effects of impurities and defects, phase transitions, hyperfine electric field gradients, kind of cation–oxygen bonds, etc. New materials such as $Sr_{1-x}Ba_xHfO_3$, $BaTi_{1-x}Hf_xO_3$, $Ca_{1-x}Sr_xHfO_3$, $SrTi_{1-x}Hf_xO_3$, $SrTi_{1-x}Hf_xO_3$, $CaTi_{1-x}Hf_xO_3$, etc. with $0<x<1$ and $Bi_4Sr_{n-3}Hf_xTi_{n-x}O_{3n+3}$ and $n = 3$, 4 and $x = 0.1$, 0.2 are synthesised in order to determine those properties. At the same time simple calculations based on point charge model and on first-principles theory to interpret the experimental results are performed.

6.2. Research group on ceramic materials

The group is made up of the following permanent researchers: M.C. Caracoche, J.A. Martínez, A. Rodríguez, P. Rivas and M. Taylor. A.F. Pasquevich and J. Desimoni have also participated in some works. Ongoing collaborations with groups in Argentina and abroad at Italy, France and Germany, are being held.

Zirconia (ZrO_2) and zirconia–based ceramic materials constitute a vast ensemble of compounds that can be efficiently investigated using the TDPAC technique. In fact, by neutron irradiating the material under study, the naturally existing ^{180}Hf impurities in Zr become the nuclear probes that inform about the nanoconfigurations around Zr^{4+} ions, their thermal changes and thermally activated defect movements.

The knowledge that enhanced structural and electrical properties of zirconia are characteristic of the high temperature (higher than 1000 C) tetragonal and cubic phases has encouraged material science researchers to produce these structures as metastable phases at moderate temperatures and to widen their thermal stability as much as possible. The adding to zirconia of some aliovalent oxides and the reduction in the particle size are two very important factors to be taken into account in order to achieve this goal. In this sense, the search of both, efficient preparation methods and adequate doping oxide, is relevant to the objectives of the investigation.

The investigation consists in producing stabilised tetragonal and cubic zirconia–based ceramics (powders, films, compacts, glass ceramics) and characterising the resulting materials and their thermal transformations using PAC and ME (in compounds containing Fe) techniques. A PAS equipment will be active soon at the Laboratory in order to associate hyperfine changes with the defect structure in the samples under study. Results are often complemented with those drawn from bulk techniques such as XRD, TG-DTA and Raman Spectroscopy.

6.3. Research group of alloys and oxides

After the request from Dr. R. C. Mercader, the University has established recently the Laboratory of Applications of the Mössbauer Effect and Magnetism. This Laboratory intends to train its members and expose the Ph.D. students, who are developing basic research, to topics related to the scientific and technological needs of the society. The Laboratory researchers are: J. Desimoni, S.J. Stewart, S.M. Cotes, R.A. Borzi, J. Martínez, and M. Mizrahi.

The current basic lines of research are: nanostructured iron oxide particles, phase transformations in alloys, magnetic properties of spinels, magneto-resistive compounds, shape-memory alloys, and heterogeneous supported precursors and catalysts. Some of the interdisciplinary subjects studied are the following: metallurgy, clays, soils and iron-bearing minerals, loessic soils and paleosols in Argentina, archaeology artifacts and samples relevant to environmental science.

6.4. Physics of impurities in condensed matter

Under this title we concentrated the actual lines of research that originated for the old oxidisation group. Activities can be divided in three research lines, two directed by A.G. Bibiloni and one directed by A.F. Pasquevich:

During a long period, A.G. Bibiloni and P. Massolo worked on semiconductor oxides (in close collaboration with A.F. Pasquevich). In 1987, M. Rentería started working with them, being the first Ph.D. student of a group that grew up in a few years. In 1990, it was formed by 3 researchers and 4 doctoral students. The latter were motivated by their advisors to carry out, before their Ph.D. theses, formative short and long term stays in European laboratories, strengthening the fruitful collaborations with groups of Göttingen, Madrid, and Orsay. In spite of the sudden decease of Massolo in June 1993, the group continued the constant consolidation of two research lines, given rise nowadays to two groups. The first one, coordinated by M. Rentería, is concentrated in the study of structural and electronic properties of impurities in oxides, using nanoscopic techniques and ab initio calculations. A.G. Bibiloni, L.A. Errico, G. Darriba, and E.L. Muñoz are working in this group. Main fields of interest are:

(a) Doped oxides: study of structural and electronic properties of doped semiconductors via the EFG characterization and modeling at impurity sites in binary oxides [48–50,54–57].
(b) DMS appealing for spintronics: study of structural, electronic, and magnetic properties in magnetic and nonmagnetic impurity-doped oxide semiconductors, searching for ferromagnetism above room temperature [51–53].
(c) Surfaces and nanoclusters: includes studies of surface reconstruction of pristine, defect, and doped metals and oxides, and embedded clusters in oxides [58].
(d) Nuclear quadrupole moments (NQM): determination of NQM of probe isotopes with applications in atomic, molecular and condensed matter physics, combining ab

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initio calculations and experimental quadrupole interactions [59].

A.G. Bibiloni dedicated part of his time to the application of hyperfine techniques to catalysis problems [60]. This activity generated a group, which now is coordinated by F.G. Requejo, devoted to the application of synchrotron radiation techniques to nanostructured systems. In this group J. Ramallo López, L. Giovanetti, S. Figueroa and L. Andrini are working. The main fields of research in this group are surface science [43] and nanoscience [47]. The first topic includes interfaces studies under thermodynamic equilibrium (catalysis and environmental science) and the second one is mainly devoted to the study of highly ordered nanosystems (mesoporous materials, nanotubes) and nanoparticles (capped, supported and occluded ones) and their application to catalysis and magnetism.

After 1986, A.F. Pasquevich decided to keep a proper research line. It was based on the use of PAC technique as a tool of research on solid state physics. He worked in collaboration with other groups in LENIH and with groups of Göttingen, Bonn, Lisbon, Leuven, Sao Paulo, Rio de Janeiro, Buenos Aires and Bariloche. Nowadays, the group includes M. Fernández van Raap and A.M. Rodríguez, both mainly sharing other LENIH projects. The group studies diverse topics such as magnetism in thin oxide films, magnetism in intermetallic compounds, hydrogen in intermetallic compounds, hafnium–oxygen system and Phase transitions in solids.

6.5. *New metastable nanoscale systems with technological applications*

L.A. Mendoza Zélis studies the nitration and hidration of Hf, Zr, and compounds and alloys ZrFe produced by mechanically activated solid gas reaction. Complex magnetic structures and materials for hydrogen storage are also explored topics. L. Damonte uses, inside this project, the technique of positron annihilation. Other techniques used are TDPAC and Ms. Other members of the group are M. Meyer and L. Baum.

6.6. *New nano- and microstructured magnetic materials of technological interest*

F.H. Sánchez and his group explore original alternative routes for the preparation of magnetic nanocomposites. Other members of the group are: M.B. Fernández van Raap, C.E. Rodríguez Torres, A.F. Cabrera, P. Mendoza and G.A. Pasquevich.

Recent work has involved hydrogen-assisted development of submicrometric rare earth transition metal hard magnetic alloys, mechanosynthesis of nanostructured transition metal soft magnetic alloys, behaviour of mechanically coupled magnetic microcomposites (amorphous microwires and ribbons), silica-based nanocomposite aerogels, and DMS oxide nanofilms.

Aims of the group are:

To characterise structural and magnetically diverse materials, using own facilities or those available through collaborations with other domestic or foreign centres.

To study the nanoestructure experimentally, the intra - and inter-phase local interactions and their effects on the macroscopic states of the nanostructure systems.

To determine the dynamics of the magnetic interactions in nanostructured systems with different degrees of magnetic dilution.

To develop experimentally and to formalise theoretically the Mössbauer technique of thermal, isothermal, and magnetic scanning as a quantitative scientific method for the study of phase transitions, reactions in solid state physics, and magnetic dynamic response at specific sites.

7. Collaborations

The collaboration with other investigators was fundamental for the development of the LENIH and its arrival to the current position. There is no space, in this communication, to state all the collaborations, so we will mention only those associated with the hyperfine techniques. The biggest and the best interaction was with the ISKP that gave place to the implementation of methodologies and technologies. The grants of the Kernforschung Zentrum of Karlsruhe, the DAAD, the Alexander von Humboldt Foundation and of Antorchas Foundation, allowed us to obtain equipment and to adopt the developments of Bonn, as well as to make possible the exchange of visitors of the research centres. These interactions were very positive for the formation of our students. The donations of some Laboratories of the University of Bonn (Van der Graaff of Prof. Kopinski (1996) and PAC and Mössbauer Labs. of Prof. Forker (2005)) were particularly positive in this aspect: although the equipment was used, it has novel and very useful aspects for the improvement of the investigation in the LENIH. In this context the work in collaboration with M. Forker and R. Vianden are worth mentioning, as well as the possibility to use the implanter of Bonn, first mediated by K. Freitag and at the moment by P. Eversheim.

The interaction with the group of K.P. Lieb, in Göttingen, with different supporting, in particular that of the Volkswagenwerk Foundation, gave place to a very fruitful collaboration.

The interaction with the groups of Henrique and Elisa Saitovitch in the CBPF (Rio de Janeiro, Brazil) is also prominent. The same occurs with the group of HI of R. Saxena at the IPEN (Sao Paulo, Brazil).

The collaboration with Helena Petrilli (Sao Paulo) and Stephan Cottenier (Leuven), in connection with ab initio calculations of HI has also been very positive.

The collaboration with Professors J. Soares of Lisbon and M. Rots of Leuven should be mentioned as well.

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8. Conclusion

We have surveyed many features in the life of LENIH. We have shown how the Laboratory grew up from the old nuclear spectrometry to high-quality research in Solid State Physics, in spite of the political turbulence and violence, which was a common denominator during many years of its life. We make a positive evaluation of these 35 years and say: it was a nice walk!

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