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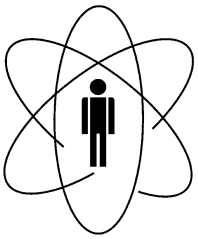

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The Beginnings of the Study of Magnetism in Brazil

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BRASIL UM PAÍS DE TODOS GOVERNO FEDERAL

The Beginnings of the Study of Magnetism in Brazil[1]

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Abstract

The studies of Condensed Matter were initiated at the National Institute of Technology in Rio de Janeiro in the 1930s, through the initiative of a German physicist, Bernhard Gross. In the 1960s, the first studies of Magnetism were made, in Rio, Porto Alegre and São Paulo. Initially, most of the studies used hyperfine interactions. Among the pioneers were Jacques Danon in Rio and John D. Rogers at Porto Alegre. The later development of the area of Magnetism was stimulated by Schools organized every other year, beginning in 1998. Other milestones were the organization in Recife of the International Conference on Magnetism (ICM) in 2000 and the inauguration of the synchrotron light source (LNLS) in Campinas in 1997.

As it occurred in many Latin American countries, scientific research had a late start in Brazil. Research in Physics in a modern sense began in Brazil with the German physicist Bernhard Gross in Rio de Janeiro and foreign scientists that were invited to work at the University of São Paulo, in 1934. Among them the Ukrainian Gleb Wataghin, who had worked at the University of Turin, in Italy, and started the study of cosmic rays in São Paulo. Wataghin was destined to have a very important role in the development of physics in Brazil, by training and stimulating the first generation of physicists graduated in the country, among them Marcelo Damy Santos, Paulus A. Pompéia, and Mario Schenberg.

The studies of Condensed Matter were initiated in the National Institute of Technology in Rio de Janeiro in the 1930s, through the initiative of Bernhard Gross. He started to work with electrets in the 1940s[1,2] and his work was continued by his pupil Joaquim Costa Ribeiro, who

[1] Text based on invited talk given at the Bicentennial Symposium, in the conference Frontiers of Condensed Matter V (FSM2010), Buenos Aires, December 7, 2010.

discovered the thermodielectric (Costa Ribeiro) effect[3]; in the 1950s, an ex-student of Costa Ribeiro, Sergio Mascarenhas founded Condensed Matter research in São Carlos and continued this work, extending the research to bioelectrets.

The first geomagnetic studies in Brazil occurred still in the XVII century, when Pierre Couplet des Tartreaux, in 1698, measured the magnetic declination in João Pessoa, in the Northeast[4]; in 1699 the astronomer Edmond Halley determined the magnetic declination of Rio de Janeiro[5]. The first geomagnetic charts of Brazil were prepared in 1880 by Jan Van Rickjervosel, a Dutchman brought by the Emperor Pedro II for this purpose.[6]

During World War II, in view of the several submarine attacks to Brazilian ships along the coast, the Navy asked Marcelo Damy Santos, of the University of São Paulo, to develop a Sonar system. This was accomplished using the magnetostrictive property of metallic Ni to generate the sound pulses; this was probably the first applied magnetism investigation performed in Brazil.

At the same university, the theoretical physicist Mario Schenberg stimulated the development of investigation on Condensed Matter Physics, convinced that a technological revolution would issue from the development of this area. Other physicists were opposed to this view, believing that Nuclear Physics was more promising as a source of new technologies[7].

In 1951 the Austrian physicist Guido Beck came for the first time to Brazil, where he worked with many young Brazilian researchers, in several areas, including Condensed Matter Physics. He lived for many years in Argentina; he was very influential in Physics research in both countries.

In the 1960s the first studies of Magnetism were made, in Rio, Porto Alegre and São Paulo. Many members of the first generation of investigators on Magnetism were originally nuclear chemists or nuclear physicists, who employed nuclear techniques to study hyperfine interactions. The chemist Jacques Danon started his Mössbauer Spectroscopy studies at CBPF in Rio in 1961, shortly after the 1957 discovery by the German physicist and later Nobel Laureate Rudolf Mössbauer of the effect and spectroscopy that carry his name. The first publication of the group using this spectroscopy, with Neila Costa and Roberto M.X. Araújo, came out in 1962, on iron complexes[8]. The technique was applied to Magnetism by George Bemski, who was at CBPF at the time, publishing with Ximenes A. da Silva a paper in 1964 on FePd.[9]

The American physicist John D. Rogers started at Porto Alegre a laboratory to use Perturbed Angular Correlations to study solids; the first results, obtained with Fernando C. Zawislak, Delmar E. Brandão and Flavio P. Livi were published in 1963[10].

In São Paulo the first Magnetism laboratory was installed with the participation of Nei Oliveira Junior and C. Quadros. Adrian M. de Graaf, a Dutch theoretician that had studied with Walter Baltensperger in Switzerland, initiated the work in his area in São Paulo; one of his students was Affonso A. Gomes, who afterwards obtained his PhD with Jacques Friedel in Paris. Baltensperger supervised the first MSc dissertation on Condensed Matter Physics in Brazil, in 1965, of the Argentinian physicist Jorge S. Helman, and De Graaf the first dissertation on Magnetism, of the Peruvian physicist Ernesto L. Carranza[11], also at CBPF, on the same year; both dissertations described theoretical work.

Affonso A. Gomes returned to Brazil at the end of the 1960s, working at CBPF, in Rio. Centered on the magnetism of metals and alloys, he was responsible for the formation of a second generation of theoreticians, among them José G.P. Ramos, Ximenes A. da Silva, Múcio A. Continentino, Amos Troper, Paulo M. Bisch, Laércio C. Lopes.

In the beginning of the 1970s, in Recife, Sergio M. Rezende created the basis of the new Department of Physics at the University of Pernambuco, which developed activities in magnetism, optics, and theory. The studies of the magnetism group were then centered on dynamical effects. At the same time Alberto P. Guimarães started experimental studies of the magnetism of metallic systems at CBPF; Sonia Cunha initiated at CBPF a laboratory devoted to the measurement of resistivity and magnetization of magnetic metallic systems. In the group lead by Jacques Danon, Rosa Scorzelli, Izabel Azevedo and Elisa B. Saitovitch used Mössbauer Spectroscopy to study different properties of materials, including hyperfine interactions.

In the same period Fernando de Souza Barros returned to Brazil, after having worked at the Carnegie-Mellon University on magnetic materials, mostly using Mössbauer Spectroscopy; he then installed several laboratories to allow the initiation of experimental activities at the Federal University of Rio de Janeiro (UFRJ).

In the same decade, with the support of the Government, three Brazilian physicists that were active at the Bell Laboratories returned to Brazil: Sergio Porto, Rogerio Cerqueira Leite, and José Ripper, beginning the installation at the new University of Campinas (Unicamp) of many well-equipped laboratories. In this decade in Campinas were active Mario Foglio, Carlos Rettori and Gaston E. Barberis.

At the same time, in Porto Alegre, Delmar E. Brandão turned his interest to magnetic and resistivity measurements of metallic systems, among them Heusler alloys. In São Paulo (USP) the group working on magnetism expanded, with the participation of Hercílio R. Rechenberg, Carlos C. Becerra, Frank P. Missell, and on the theoretical side, Sonia Frota Pessoa.

Frank P. Missell would later open a line of applied magnetism, studying permanent magnet materials. In the same decade Enrique Anda, a theoretical physicist working on magnetism moved to the Federal University in Niteroi (UFF); Carlos M. Chaves, at the Catholic University in Rio (PUC-RJ), turned his research interest to magnetism.

In the 1970s, an active community of theoreticians working on problems of Statistical Mechanics grew in Brazil, including many related to magnetism. Among these one may point Silvio S. Salinas (USP, São Paulo), Mauricio Coutinho (UFPE, Recife), Ivon Fittipaldi (UFPE, Recife), Jairo de Almeida (UFPE, Recife), Marco Moura (UFPE, Recife), Claudio Scherer (URGS, Porto Alegre), Roberto Lobo (USP, São Carlos). In the following decade other important contributions came from Constantino Tsallis (CBPF, Rio de Janeiro), Cesar Sá Barreto (UFMG, Belo Horizonte). Lindberg Gonçalves initiated his work on magnetism on the 1970s, in Rio (PUC-RJ), and after his PhD, turned to problems of statistical mechanics (UFC, Fortaleza).

Presently there are many groups active in the area of Magnetism; the number of groups created in Brazil in the last five decades is show in Fig. 1, based on data from the Directory of Research Groups, CNPq. The increase in the number of scientific papers published on Magnetism by Brazilian groups is equally expressive, as shown in Fig. 2, with data obtained from the Web of Science.

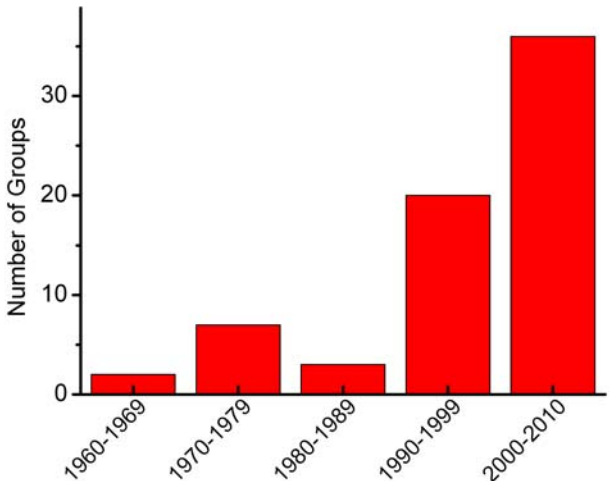

FIG. 1: Number of Physics groups in Brazil that have some activity in Magnetism vs. year of creation of the group; note that the groups can have any number of members. Total number of groups is 68, out of 637 Physics groups (CNPq Directory of Research Groups, 2008 edition).

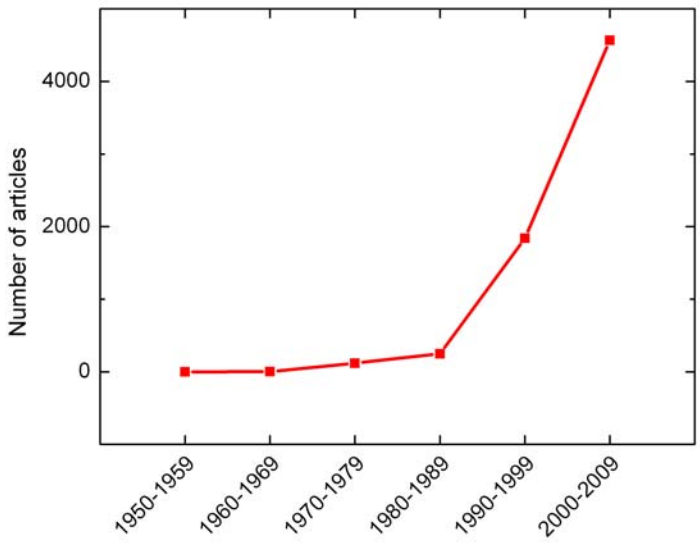

FIG. 2: Number of articles on Magnetism from the Web of Science. Search made with the subject magneti*, refined with Physics, using as address Brazil or Brasil. It appears that the data base is very incomplete in the earlier periods.

One scientific publication on magnetism with Brazilian participation that reached high visibility was the paper[12] published by Baibich and co-authors in 1988 describing work conducted by a team of researchers directed by Albert Fert, who shared for this work the 2007 Nobel Prize in Physics with Peter Grünberg; Mario Baibich is a researcher at the Federal University of Rio Grande do Sul, at Porto Alegre. As it is well known, this paper demonstrated the Giant Magnetic Resistance (GMR), an effect with very important practical applications, which has in fact opened the way to the development of Spintronics, the Electronics using the electron spin.

As a result of the development of magnetism in Brazil, several books on the subject have been published by Brazilian authors, both locally and abroad[13].

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Brazil: Institutional Background

In the 1970s, during the period of the military dictatorship in Brazil (1964-1985), FINEP (Financing Agency for Studies and Projects), the agency created in 1967, was made responsible from 1971 for the application of the FNDCT, the fund for Science and Technology. This fund was used to install laboratories in many universities, changing the scale of the experimental research in all areas of Physics, including in Magnetism. This fund was reduced in the 1980s and 1990s, and started to be recomposed in the beginning of the 2000s. It has increased tenfold in the period 2000-2009, reaching about 1.4B US dollars (in PP=equivalent purchasing power)[14]. The total investment in research in 2007 was 14.7B US$.[15]

It should me mentioned that a characteristic of the science funding in Brazil is the important role played by the funding agencies of the states, with annual investment equivalent to about 30% of the total spending in S&T. The most important state agency is FAPESP, of the state of São Paulo.

The graduate studies were institutionalized in Brazil in the beginning of the 1960s, although some institutions awarded doctor´s degrees before that date, specifically the University of São Paulo and Universidade do Brasil (now University of Rio de Janeiro, UFRJ).

The Brazilian Physical Society (SBF) was created in 1966. Its annual Condensed Matter Physics meetings started in 1977 with a little more than 100 physicists, and now attract some 1500 participants. Also important to strengthen the Magnetism community were the Magnetism Schools, organized on 1998, 1999, 2001, 2003, 2005, 2007 and 2009. Other milestones were the International Conference on Magnetism (ICM) organized in Recife in 2000, and the inauguration of the synchrotron light source (LNLS) in Campinas in 1997. The Latin American Workshop for Magnetism and Magnetic Materials (LAW3M) was held twice in Brazil, in 1998 (São Paulo) and 2007 (Rio de Janeiro); the XIV International Workshop on Rare-Earth Magnets and Their Applications was also held in São Paulo in 1996.

The Brazilian Materials Society (SBMAT) was created in 1998, and has since, in its meetings, included research conducted in Brazil on Magnetism.

The scientific output of the Brazilian scientific community is still very small in global terms, but it has grown rapidly in the last decades. The number of indexed scientific papers increased from a fraction corresponding to 0.44% of the world production in 1981 to about 2.7% in 2008[16].

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