ALBA BEAMLINE PROPOSAL

POLUX A SOFT X-RAY BEAMLINE FOR POLARIZATION-DEPENDENT SPECTROSCOPIES AND MICROSCOPIES AT ALBA

A proposal prepared for the SAC meeting February 2005

POLUX

A soft x-ray beamline for polarization-dependent spectroscopies at ALBA

Prepared by the working group nr. 2 «Hard condensed matter: electronic properties»

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1. SUMMARY

A beamline providing soft x-rays with variable polarisation in the energy range 80 – 2000 eV is proposed. It will be optimised for X-ray photoelectron spectroscopy and microscopy measurements of the morphology, chemical, charge and magnetic states of artificial materials and nanostructures.

The proposed beamline splits into two separate branches after the monochromator, to allocate *a)* a 10T magnet with UHV environment for x-ray magnetic circular and linear dichroism (XMCD-XMLD), followed by a multi-circle UHV diffractometer for soft x-ray resonant magnetic scattering (XRMS), and *b)* a x-ray photoemission and low energy electron microscope (XPEEM). For all the end stations, the possibility of realizing sub-nanosecond time-resolution experiments by using the inherent pulsed time structure of synchrotron radiation with a pump-probe scheme will be exploited.

The proposed energy range includes important absorption edges, such as the K edge of light elements (including C, N, and O), the $L_{2,3}$ edges of as the 3*d* transition metals, the $M_{4,5}$ and $N_{4,5}$ edges of the rare earths, and $N_{4,5}$ edges of the actinides.

The beamline will provide a versatile and competitive instrument to those scientists in the national and international research communities performing experiments on electronic states, binding properties, and/or magnetic properties of materials requiring element-specific, space-resolved, and/or time-resolved information.

2. INTRODUCTION

During last years, research in magnetism and magnetic materials is experiencing a continuous renaissance that has been enabled by developments in different areas on basic and materials physics, chemistry and technology. Nowadays, magnetic materials are a significant ingredient of most of the scientific and technological developments. Every device used in our everyday life has been ameliorated thanks to research performed on magnetic materials science and development during the last two decades, including advances like rare-earth-transition metal permanent magnets, giant magnetorresistive materials, invar alloys, or exchange-biased magnetic multilayers, among many others. The huge increase of the information storage capacity (while reducing size and weight) of modern personal computers is just the paradigmatic example. Today, hand-held devices with as much as 60 Gb of magnetic memory are available at affordable prices, allowing the mixed manipulation of information, communication, computing power, positioning technologies, etc, altogether and always on-line. These developments are demanding already for new tools, in order to perform up-to-dated research in applied magnetism. In parallel, fundamental magnetism, i.e., the understanding of the properties (statics and dynamics) of a magnetic material based on the structure and interactions at both the atomic and microstructural level has been the trigger of new science and technologies during the last decades.

Indeed, magnetism and magnetic materials is a very broad physical scientific discipline, ranging from theoretical physics to motor design, with active and emerging links to chemistry, engineering, materials science, mathematics and numerical calculation research, biology, or medicine, just to name a few. Therefore, it is not easy to identify the most challenging trends of magnetic research. However, when this effort has been confronted globally, within the whole of materials sciences and technologies, the areas of magnetic research which are pointed out as major outstanding questions and issues in magnetism coincide in many points with those which are being already, and will be boosted in the future decades by the availability of third-generation synchrotron radiation facilities. As an example, the Condensed-Matter and Materials Physics panel of the American National Research Council's Board on Physics and Astronomy published a general picture of the status of the materials physics in 1999[1]. This work points out as major issues in magnetism for the next decade four large areas:

- nanostructured magnetic elements
- spin-polarized transport and magnetoelectronics
- advanced synthesis and processing of new magnetic materials
- new techniques and probes which would have an impact on the previous issues.

In particular, the following "outstanding questions in magnetism" are identified within the four "main areas":

1. The nature of domain structure and its influence on magnetic switching behavior;
2. The dynamics and switching times in nanostructured magnetic elements;
3. The nature of the interaction of spin-polarized currents with nanostructured magnetic elements, both in equilibrium and out of it;
4. The influence of temperature and its competition with magnetic anisotropy energy, both in the context of stability against thermally induced switching and in the context of structural change at elevated temperature;
5. The role and the impact of quantum coherence and macroscopic quantum tunneling in nano-sized structures consisting of a cluster of atomic spins;

6. The development of advanced synthesis and processing techniques to fabricate, among others, 100% spin-polarized current materials and other magnetoelectronic elements, layered structures, magnetic nanostructures in 3 and lower dimensions, etc.
7. The development of magnetic materials and elements to produce magnetic random-access memories (MRAMS) to be implemented in future microelectronic chip technology.
8. The continuous scaling of the density for magnetic storage, implying strong research programs in both storage and sensing/writing elements.

Although it were not included as key issues of modern magnetism of materials, 5 years later we can add at least two more items, more or less related but not explicitly included in the previous ones:

9. The applicability of nanostructured magnetic materials in health-sciences and biological-sciences[2,3,4]: hyperthermia for treatment of tumors and other diseases, bio-magnetic vectorized macromolecules, etc.
10. The origin of high-temperature magnetism in recently discovered semiconducting ferromagnets as Co:ZnO, Mn:ZnO[5], Cu:ZnO[6], or thin films of undoped HfO_2[7], etc.

Obviously, the answers to these questions would have a technological impact and are necessary to boost the magnetic research and industry in strategic areas of a society based on information and knowledge. For the well informed reader, it is evident that due to its unique features, **synchrotron radiation** will be an invaluable tool in the research needed to advance in everyone of the above issues. Even more, it is important to note that in many of those issues, synchrotron radiation based techniques, and in particular, **polarization dependent spectroscopies and microscopies** are able to get information which hardly can be obtained by any other direct experimental means. Polarisation dependent SR techniques offer unique features to tackle the issues listed above and others which will appear in the future decades: atomic-selectivity, shell and bond selectivity, versatility on the polarization selection, versatility on the bulk or surface sensitivity at demand, versatility on the detection method (transmitted photons, secondary photons, photoelectrons…), ability to apply imaging techniques with mesoscopic and nanoscopic resolution (direct "optical" microscopy, photoelectron microscopy, scanning sample microscopies), separation of the orbital and spin magnetic moments (by using sum rules or directly by magnetic diffraction), time structure on the subnanosecond regime, use of the coherence of the synchrotron light, etc.

Evidently, not only magnetism will benefit the synergy between the nano-revolution and synchrotron radiation. The ability to manufacture and probe artificial systems at the nanometre length scale will address fundamental questions such as behaviour at the quantum/classical boundary and macroscopic quantum effects. During the last decades it has been shown that the "artificial" composition and structure of these systems as well as their low dimensionality give rise to a large number of interesting novel properties. Engineered molecules are common-place in biochemistry, and the same idea can be brought to bear on solids and electronic materials. Electronic properties of semiconductor devices have been controlled by heterostructures, quantum wells and superlattices. From the application point of view, these novel properties are already been used in advanced sensors, catalysts, high density visual displays, memory storage devices and environmental control.

The instrument whose implementation at the first stage of ALBA is proposed in this document **is a soft x-ray beamline dedicated to polarization dependent spectroscopies and microscopy** (**POLUX**), offering a set of techniques providing physical information which, in general, can not be obtained by any other experimental ways.

[1] Condensed-Matter & Materials Physics: Research for Tomorrow's Technology, National Research, National Academy Press 1999

[2] C. N. Ramchand et al., Indian J Pure Appl Phys 39:683 (2001).

[3] M. Safarikova and I. Safarik, Magn Electr 10, 223 (2001).

[4] I. Safarikova and M. Safarik, In *Scientific and Clinical Applications of Magnetic Carriers* (Edited by: Hafeli U, et al.). New York: Plenum Press 1997, 323-340.

[5] Parmanand and Sharma, Nature Materials 2, 673 (2003)

[6] K. V. Rao et al., 49th annual Magnetism and Magnetic Materials Conference, Jacksonville (FL), November 2004

[7] M. Coey et al., 49th annual Magnetism and Magnetic Materials Conference, Jacksonville (FL), November 2004

3. JUSTIFICATION OF THE PROPOSAL

3.1 HISTORICAL CONSIDERATIONS

The use of the polarization properties of synchrotron radiation for studies on the magnetic properties of materials has its historical roots in the calculation by Erskine and Stern of the x-ray circular magnetic dichroism (XMCD) at the $M_{4,5}$ edges of Ni, published 30 years ago[1], which was followed, 10 years later, by a calculation by Thole and coworkers, on the magnetic linear dichroism (XMLD) at the $M_{4,5}$ edges of rare earth magnets.[2] In the meanwhile, x-ray magnetic scattering, both resonant and non-resonant had been discovered (by de Bergevin and Brunel with a home-laboratory source[3]), demonstrated as a useful technique (in second generation SR sources[4]) and theoretically worked-out [5,6]. Let us note that we have restricted the following "brief historical review" to polarization-dependent studies on absorption, indeed excluding pure magnetic diffraction of x-rays, today greatly developed as a mature technique thanks to 3rd generation sources, too.

It was in the late eighties, when second generation synchrotrons allowed to observe the predicted magnetic dichroic effects: as soon as one year after the prediction, G. van der Laan and coworkers observed the XMLD at the $M_{4,5}$ of Tb in a terbium-iron garnet[7]. XMCD was shown by G. Schütz soon after in the K absorption edge of iron[8], although the XMCD signal in the K-edge is harder to measure and to understand than that at the $L_{2,3}$ edges. Early in the nineties, the fundamental steps were taken to develop XMCD as a unique technique in magnetism of materials:

- XMCD at the $L_{2,3}$ edges of Fe, Ni and Co were measured by C. T. Chen and coworkers in 1990[9], finding a signal as high as 20% of the measured XAS, easy to observe and quantify, showing that its use as a new magnetometry is possible.
- The so-called *sum rules* were derived by T. Thole, P. Carra and coworkers [10], allowing (in principle) to separate orbital and spin moments in the initial states from XMCD signal measured in a pair of well resolved $j=l\pm s$ absorption edges. Its experimental confirmation only needed to wait till 1995, and it was performed by C. T. Chen et al.[11].
- J. Stöhr and coworkers [12] did show that XMCD contrast allows to perform element-specific microscopy with high resolution and unique properties. After that seminal work, several magnetic microscopic techniques have been developed using synchrotron radiation, allowing to study ferro- as well as antiferromagnets, interfaces, buried layers, etc.

In 1994 ESRF opened their first beamlines to users, including two beamlines dedicated to XMCD from the very beginning and other one dedicated to magnetic diffraction shortly after. The American (APS) and Japanese (Spring8) third generation high-energy synchrotrons opened later in the decade. Although the main magnetic dichroic effects were already demonstrated, thanks to those three, and other third-generation synchrotron radiation sources, not only large signals as those observed at the $L_{2,3}$ edges of Fe, Ni and Co can today be studied, but also XMCD from tiny induced magnetic moments (in O, Cu, S, etc.) and also other very small dichroic signals, as the K-edge XMCD from transition metals, etc. Even more, as the absorption events are always present when the incident energy is tuned to a given absorption edge, MCD is also present in the photoemission, in the anomalous diffraction, in the x-ray inelastic scattering, in the x-ray reflectivity, in the x-ray small-angle scattering, etc., in such a way that synchrotron radiation, and specially polarization-dependent techniques are nowadays a well established set of experimental tools in advanced magnetism.

3.2 THE SYNERGY OF THE PRESENT MOMENT

Several key factors of both, the synchrotron radiation polarization-dependent techniques and the whole issue of modern magnetism of materials which were already pointed out in the introduction, allow to expect a fruitful synergy between these two fields in the next decades:

- 3rd-generation synchrotron radiation sources provide the researches with beamlines yielding a stable and huge amount of photons per second, per energy bandwidth and per solid angle, allowing tiny signals, as those generated by nanoscopic amounts of matter, to be probed. The "*nano* revolution" which is taking place in science and technology, based on structures on the 1 to 100 nanometer length scale, makes every modern science to converge toward the same principles and tools. As a result, progress in nanoscience will have very far-reaching impact. It is hard to overestimate the impact of the recently developed ability to measure, manipulate and organize matter on the nanoscale, not only on modern science but in modern society. Synchrotron radiation facilities, due to its ability to probe very small amounts of "active sample" can characterize and measure nanosized materials, being one of the key scientific tools on nanoscience, on which magnetic materials obviously play a leading role. For this reason, synchrotron radiation based magnetometry is a must for next-future cutting-edge science.

- Modern magnetic materials are in general, composed of several magnetic elements (exchange-biased elements, magnetic reading recording elements, magnetic memory elements, magnetocaloric, magnetorresistive, magnetostrictive, etc…) and the element specificity and atomic shell selectivity offered by polarization-dependent x-ray techniques offer unique capabilities of characterization. Moreover, the relationship between orbital moments and anisotropy already demonstrated by sum rules in a range of sizes from bulk to nanoscopic magnets will be a key factor in future research in magnetism of materials, both basic and applied.

- One of the channels of deexcitation of an absorbing atom is emission of secondary photoelectrons. This channel allows to implement a revolutionary imaging technique: X-ray Photoemission Electron Microscopy (XPEEM), which is an electron microscopy performed on the emitted electrons after a x-ray absorption event. By its own nature, XPEEM is an element-specific microscopy. Moreover, if XMCD (or XMLD) instead of just normal absorption is measured, the differential XPEEM image combines the element and magnetic specificity of XMCD with the strength of electron microscopy[13], with huge magnifications, achieving today resolutions of the order of tens of nanometers and atomic depth resolution (the sampling depth is determined by the cascading process of the scattered Auger electrons created after core excitation, what can be cleverly used[14]). Moreover, in energy filtered XPEEM, an electron analyser after the imaging column selects an energy window, permitting to obtain laterally resolved spectroscopic information by collecting a series of images at different kinetic energies.
Third-generation XPEEM stations (aberration-corrected) are being developed at ALS (USA), Diamond (UK) and Soleil (France). This would be our start-point in the development of the ALBA microscope. A combined spectroscopic XPEEM - LEEM (low-energy electron microscope) instrument would offer the elemental, chemical and magnetic specificity of XPEEM combined with the structural and morphological capabilities of LEEM/LEED with high spatial and temporal resolution: an extremely versatile and powerful instrument for the study of complex systems and processes.

- A complementary way to obtain information on the structure and magnetism at the nanoscopic level is soft x-ray resonant magnetic scattering (XRMS)[15]. This is a *photon-in photon-out* technique, and strong or time dependent magnetic fields can be applied on the

sample without interfering the detection. In general XRMS is a very versatile element-specific magnetometry, at the price of a relatively more complex data treatment and experimental sample environment. It is inherently sensitive to structural properties, but shares with XMCD the atomic and electronic shell selectivity, as it is a resonant x-ray absorption spectroscopy. Several different modes of measurement can be implemented: a very flexible geometric arrangement, while using circular or linear polarization allows to probe ferro- as well as antiferromagnetic systems. Disorder can be studied by analyzing specular and off-specular images, or by using coherent or incoherent incoming radiation (see below), etc.

- Added to what has been cited above, synchrotron radiation is generated in accumulation rings by relativistic bunches of charged particles when they pass through insertion devices or bending magnets. Therefore, x-rays are delivered with a unique time structure: x-ray pulses last tens of picoseconds (around 40 ps) and it repeats in an interval of the order of nanoseconds (it may vary strongly depending on the injection mode). The high brilliance of third generation sources allow to measure XMCD and XRMS in stroboscopic mode (so-called *pump-probe*) and to obtain the dynamics of the magnetization with picosecond time resolution. This technique may be also combined with XPEEM to have *micro to nanoscopic imaging information* of the dynamics of the magnetization in the *nanosecond and sub-nanosecond time-regime*.[16]

The impact of sub-nanosecond XMCD, XRMS and XPEEM is hardly overestimated. It is well known how quickly the size of hard disks is growing. Magnetic disks are today 1000 times denser than 10 years ago (from 10 Mb to about 10 Gb per cm^2), and magnetic storage density doubles every year. During this 10 years, the data rate has increased from 50 megahertz to 1 gigahertz and consequently, we need new tools to study magnetic materials in smaller areas and over shorter times. Moreover, a key parameter for the operation of future technologies based on *spin electronic* devices is the switching of the magnetization in a magnetic nanostructure between two stable magnetic configurations. The corresponding frequency of this switching has to be of the order of GHz, which corresponds to the internal precession frequency of the magnetization. Thus all aspects of the magnetization dynamics need to be considered in order to develop, characterize and optimize the devices. Time-resolved XMCD, XPEEM and scattering will be key techniques in this applied research area [17,18,19].

- A different approach to the study of dynamics with synchrotron radiation is coherent x-ray scattering. This is a fast evolving technique, with inherent information on space and time structure (magnetic or non-magnetic) of disordered systems. It represents the evolution of a well-developed technique on the laser regime, which has become available to the x-ray range with the 3rd generation sources. A disordered system introduces a random shift on the phase of the incident light, resulting on a strongly modulated or "speckle" pattern when illuminated by a coherent radiation. Information on the dynamics of the disordered system can be obtained by the time-correlation analysis of a single speckle, while the Fourier transform of the measured pattern gives space-correlation information. Relevant magnetic information can be directly obtained from speckles of magnetic origin[20], but again, the technique can be extended to differential mode in order to obtain improved magnetic information.

3.3 THE COMMUNITY

The Spanish community of users and potential users of POLUX has two main components. First, there is a number of groups of the CSIC and Spanish universities with a variable degree of experience in the use of Synchrotron Radiation which are working in areas fitting the scientific offer made by POLUX (both on magnetic materials and other issues as well). Most of the research groups with experience in polarization dependent spectroscopy with synchrotron radiation have

been involved in the preparation of the scientific case which is included later in this document. They are listed in a table in Annex IV, including their affiliation and the actual manpower.
Moreover, the "traditional" Spanish community working on magnetism is probably the largest one of the Spanish condensed-matter physics, and one of the largest of the whole Spanish physics community. The weight of magnetism-related issues in the Solid-State Group of the Spanish Physical Society is usually a very large percentage of the whole. Indeed, magnetism is one of the not many scientific areas in which the volume of the Spanish community (and not only the average quality) is comparable to that of the large countries of the European Union. To give a recent figure, the last International Conference on Magnetism, held in Rome in August 2003, received 112 participants from Spain, the fourth largest European representation, after Germany (211) and the host country Italy (151), comparable in size to the French (121) or the American delegations (126). To compare those figures with some other countries which already have installed or are building beamlines comparable to POLUX in their own third generation synchrotrons sources, the Swiss delegation at ICM'03 was 24 people, the British were 80, and the Swedish, 32.

Although the Spanish magnetic research has been traditionally based on "basic" magnetism, a decided trend to develop research on nanomagnetism is growing during the last decade. The Spanish nanoscience/nanotechnology community is already a very active one, and it is becoming increasingly co-ordinated with the Ministerio de Educación y Ciencia support of individual programmes and networks. In several areas it holds a world-leading position. Specific experimental tools must be developed to address the basic understanding of the relationship between structure and physical properties in these artificial materials, as a first step towards the development of devices with custom-chosen properties. New facilities are hence needed to support the Spanish research programme and encourage future technological advance. This is the basis of the research proposed here to develop a polarized soft x-ray beamline at ALBA synchrotron to be dedicated to spectroscopy, scattering and microscopy experiments on artificial systems. These techniques can be employed when information about electronic states, binding properties, element-resolved, space-resolved, and/or time-resolved properties is required. *Therefore, the approval of the POLUX beamline would represent a step forward on the development of the Spanish nanoscience*.

Moreover, our hope is to attract to POLUX not only the Spanish, but also the international scientific community, as it is a goal of the whole ALBA project. XRMS, and very specially XPEEM microscope will positively contribute to this flux towards ALBA, as the microscopy user community is growing at very high rate, due to both, the novelty of these kind of instruments and the increasing number of research groups producing nanosized samples.

ALBA will probably be the last 3rd generation synchrotron to be built in Europe. At the moment in which the first beamlines in ALBA will be developed, the other European third-generation synchrotrons will be already in operation, with relatively similar capabilities and scientific objectives (see Annex III). It is clear that ALBA proposals must try to turn this fact into an advantage, offering cutting-edge measuring techniques at the same time that giving service to the particular Spanish and European scientific communities.

The proposed design makes this project unique among the similar beamlines of this genre available on Europe. Among the beamlines already in operation, scattering experiments were not usually offered, and this is being corrected practically in every beamline in construction or approved. However, the number of big magnets for low-temperature XMCD remains low, as the bigger efforts are mainly focused towards scattering and microscopy. This is shown in Annex III, where we present a comparison of the characteristics of the variable-polarisation beamlines, both in operation and approved. Moreover, none of the Spanish synchrotron CRG beamlines (neither at LURE-SOLEIL nor at ESRF) allows to perform the kind of experiments envisaged here. Polarisation-dependent

studies are necessarily performed under international beamtime, competing with very well organised and experienced users communities. Our only "own" (full-right) synchrotron beamline with similar characteristics to POLUX is ID08 at ESRF, where Spain has "in principle" a 4% participation. But the acceptance rate of the proposals at the ID08 beamline is very low, varying from 1/3rd to 1/5th of the beam time applications, depending on the total volume received. Thus, the competition for the ID08 beamtime is really hard, making very difficult to create a community of *often-users* for magnetism-related synchrotron studies, even, as it is the case, having the critical mass of research groups to do it.

The main group of the Spanish community of users and potential users for POLUX (i.e. the Spanish community working on nanoscience and magnetic materials) is a large and very active one, and giving them service is a commitment and a necessity. Within Europe, different beamlines (at ESRF, Elettra, Bessy II, SLS and Maxlab) allow to perform some of the experiments proposed for POLUX. However, the combination of a wide energy range (especially extended towards the low energies) together with sample environment conditions, as low-temperature and high field when possible, and the possibility to perform time-dependent experiments in every end station is not available at the moment.

Therefore, we are convinced that the implementation of POLUX would contribute to make of ALBA both a succesful Spanish synchrotron and a really internationational light-source placed in Spain.

1 Erskine and Stern, Phys. Rev. B 12, 5016 (1975).
2 T. Thole et al., Phys. Rev. Lett. 55 2086 (1985).
3 F. de Bergevin and M. Brunel, Phys. Lett. A **39**, 141 (1972).
4 D. Gibbs, D. E. Moncton, K. L. D'Amico, J. Bohr, and B. H. Grier, Phys. Rev. Lett. **55**, 234 (1985).
5 M. Blume, J. Appl. Phys. **57**, 3615 (1985).
6 M. Blume and D. Gibbs, Phys. Rev. B **37**, 1779 (1988).
7 G. van der Laan et al., Phys. Rev. B 34 6529 (1986).
8 G. Schütz et al., Phys. Rev. Lett. 58 737 (1987).
9 C. T. Chen et al., Phys. Rev. B. 42 7262 (1990).
10 T. Thole et al., Phys. Rev. Lett 68, 1943 (1992); and P. Carra et al., *ibid* 70, 694 (1993).
11 C. Chen et al., Phys. Rev. Lett 75, 152 (1995).
12 J. Stöhr et al., Science 259, 658 (1993).
13 F. Nolting, A. Scholl, J. Stohr, et al., Nature 405, 767 (2000).
14 H. Ohldag et al., Phys. Rev. Lett. 86, 2878 (2001) and *ibid*, 87, 247201 (2001).
15 J.-M. Tonnerre, L. Sève, D. Raoux et al. PRL 75, 740 (1995).
16 S.-B. Choe, Y. Acremann, A. Scholl, A. Bauer, A. Doran, J. Stohr, and H. A. Padmore, *Science* 304, 420 (2004).
17 W. Kuch, J. Vogel, J. Camarero, K. Fukumoto, Y. Pennec, S. Pizzini, M. Bonfim, and J. Kirschner, Appl. Phys. Lett. 85, 440 (2004).
18 Y. Pennec, J. Camarero, J. C. Toussaint, S. Pizzini, M. Bonfim, F. Petroff, W. Kuch, F. Offi, K. Fukumoto, F. Nguyen Van Dau, and J. Vogel, Phys. Rev. B 69, 180402(R) (2004).
19 J.Vogel, W.Kuch, J.Camarero, K.Fukumoto, M.Bonfim, Y.Pennec, S.Pizzini, A.Fontaine, and J.Kirschner, BESSY Highlights 2003, 28 (2004).
20 Jorge Miguel, Ph. D. Thesis, U. van Amsterdam, in preparation.

4. SCIENTIFIC CASE

The scientific case of the present proposal is based on the actual and future needs of the spanish community of synchrotron radiation users grouped in the "Hard Condensed Matter: electronic properties" workgroup. This community is mainly active on magnetism and related areas, although other communities may beneffit of the implementation of POLUX, as a beamline offering soft x-ray spectroscopy and microscopy is an extremely versatile experimental tool, whose scope is much wider than magnetic properties of nanosystems.

The scientific case is organized as follows: Three wide-scope scientific areas are identified; NANOMAGNETISM, BULK MAGNETISM, and NON-MAGNETIC-STUDIES.

Within "Nanomagnetism", 3 large areas have been detailed, with examples on each one of those. "Bulk-magnetism" and "Non-magnetic studies" are too broad issues to be exhaustive, and only some paradigmatic examples of the kind of science POLUX would allow to perform have been indicated. Consequently, the "index" of the scientific case is the following:

4.1. NANOMAGNETISM

4.1.1. THIN FILMS AND SUPERLATTICES . SURFACE AND INTERFACE EFFECTS

- 4.1.1.1. Proximity effects: Induced Moments and Origin of Anisotropies
- 4.1.1.1. Thin Films of Amorphous Binary Alloys
- 4.1.1.3. Exchange spring magnets
- 4.1.1.4 Rare Earths Thin Films
- 4.1.1.5. Magnetoresistive oxides and nanomagnetic aggregates.
- 4.1.1.6. Nanocrystalline Magnetic Nitrides
- 4.1.1.7. Magnetism at buried interfaces. Exchange bias.
- 4.1.1.8. Surface Molecular Magnetism
- 4.1.1.9. Magnetic spectroscopy from small areas.
- 4.1.1.10. Dimensional effects on critical fluctuations of surfaces and thin films.

4.1.2. NANOSTRUCTURES, NANOPARTICLES AND AGGREGATES

- 4.1.2.1. Core-Shell structured Magnetic Particles.
- 4.1.2.2. Nanogranular Films.
- 4.1.2.3. Size-effects on spin and orbital moments of particles.
- 4.1.2.4. Magnetic nanostructured systems
- 4.1.2.5. Antidots
- 4.1.2.6. Quantum Computing Systems
- 4.1.2.7. Spatially-resolved magnetization dynamics in nanomagnets

4.1.3. SINGLE-MOLECULE MAGNETS AND SINGLECRISTALLINE NANOMAGNETS

- 4.1.3.1. Single-molecule magnets
- 4.1.3.2. Soft x-ray spectromicroscopy of single nanocrystals

4.2. BULK PROPERTIES AND APPLICATIONS OF MAGNETIC MATERIALS

- 4.2.1. Magnetism in intermetallic alloys
- 4.2.2. Amorphous ferromagnets

4.2.3. Complex Magnetism of Mixed-Valence Manganites
4.2.4. Orbital moments through magnetic phase transitions
4.2.5. Molecular Magnetism

4.3. NON-MAGNETIC APPLICATIONS

4.3.1 Tuning surface reactivity via electron quantum confinement.
4.3.2. Polymers and Biological Samples

The dynamism of the above mentioned scientific research areas during last years as well as the expected technological benefits from magnetic studies are strong guarantees of the success of a beamline like POLUX that could provide immediate results in applied and fundamental science.

4.1. NANOMAGNETISM

Magnetic nanostructures have generated an intense (and growing) research activity in the last years since they have very exciting potential applications in many strategic areas, both basic and applied, with an enormous potential impact in society, as magnetic recording, sensors & actuators, spintronics, biomedical applications or quantum effects which may lead in future to quantum computation[1,2]. The novel properties of nanostructures emerge as the sample size becomes comparable to or smaller than certain characteristic length scale of the system, such as spin diffusion length, carrier mean free path, magnetic domain wall width, exchange length etc. As a consequence, new magnetic phenomena appear, as quantum confinement, altered thermodynamics, exchange coupling between different magnetic phases[3], induced magnetic moments[4], etc., just to name a few. **Polarization dependent x-ray spectroscopies and microscopies** are of very high interest to study the cited magnetic phenomena since they incorporates magnetic selectivity on the atomic species, can provide information on spin and orbital magnetic moment, while nanometric-range spatial resolution and sub-nanosecond time resolution can be achieved. Therefore, the areas of nanomagnetism in which the POLUX beamline could contribute to the development of the Spanish and European nanoscience and nanotechnology cover the whole of the subject. The proposed beamline is a unique tool for the study of magnetic nanoscopic systems since it includes x-ray magnetic circular dichroism (XMCD) spectroscopy, photoemission microscopy (PEEM), and x-ray resonant magnetic scattering (XRMS).

4.1.1. THIN FILMS AND SUPERLATTICES

The element specificity and the ability of XMCD to determine quantitatively the orbital and spin magnetic moment can be used to characterize the microscopic magnetism in every magnetic system, and in particular it has been widely used to study magnetic film properties.

Magnetic surfaces and interfaces present very interesting properties, whose delicate control is necessary to properly tailor technologic units, in areas where the control of the physical parameters will be critical to allow spintronics to hit it off with the technological arena. Spintronics is a new branch of electronics in which electron spin in addition to charge, is manipulated to yield a desired outcome. All spintronic devices act according to the simple scheme: (1) information is stored (written) into spins as a particular spin orientation (up or down), (2) the spins, being attached to mobile electrons, carry the information along a wire, and (3) the information is read at a terminal. Spin orientation of conduction electrons survives for a relatively long time (nanoseconds, compared to tens of femtoseconds during which electron momentum decays), which makes spintronic devices particularly attractive for memory storage and magnetic sensors applications, and, potentially for quantum computing where electron spin would represent a bit (called qubit) of information. Polarization-dependent spectroscopies and

microscopies in the soft x-ray range are hence particularly well suited for cutting-edge studies in the field of surfaces and interfaces of magnetic materials; in particular in nanostructured systems, thin films, superlattices, etc. Indeed, very interesting experiments like temperature-dependent measurements of spin and orbital moments of epilayers grown in-situ; combined XMCD/XMLD studies to probe anisotropy in ultrathin films and nanoclusters, studies of interface coupling, exchange biasing using element specific vector magnetometry; measurement of surface-element specific spin and orbital interface moments; or studies on perpendicular anisotropy using combined XMCD/XMLD would be important issues which could be tackled in the proposed beamline POLUX.

The combination of thin film deposition with lithography favors a large variety of structures and geometries, expanding the number of possible systems and magnetic effects to study. The combination of XMCD spectroscopy and photoemission microscopy (PEEM) allows the visualization of the magnetization process in the films modified by the lithographed nanostructures with chemical sensitivity, what distinguish this microscopy from others microscopies which are sensitive only to the sample magnetization.

XRMS performed in reflectivity geometry would give useful information concerning the magnetization reversal process and the magnetization profiles in magnetic multilayers[5]. The study with this technique of multilayers showing antiferromagnetic coupling would yield an estimate of the strength of the interactions involved. In the case of arrays of nanostructures in the plane, prepared by nanolithography or by self-organizing methods, as well as multilayers having stripe band domains induced by perpendicular anisotropy, XRMS measurements would lead to a better knowledge of the domain distribution and its evolution under the applied magnetic field so that the relationship between domain structure and geometric parameters of the nanostrutured array can be understood[6].

Time resolved measurements are specially interesting for samples obtained by nanolithography. The nanostructures can be prepared so that the configuration of magnetic domains and the magnetization reversal processes can be controlled. The study of these reversal processes under fast switching of the magnetic field, in the order of nanoseconds, is of scientific and technological importance[7].

Consequently, there is a growing demand for synchrotron beamtime for beamline that allow such studies in this expanding subject. Bellow, we describe some scientific cases:

4.1.1.1. PROXIMITY EFFECTS: INDUCED MOMENTS AND ORIGIN OF ANISOTROPIES

XMCD allows to study the magnetic environments and the degree of mixture of the elements of complex structures, such as supperlattices and alloys, looking at the ratio μ_s/μ_o, which is characteristic of each kind of chemical environment[8], or measuring possible induced magnetic moments in non-magnetic elements.

Induced magnetic moments have been already found in several non magnetic materials in contact with ferromagnetic ones. It was observed first in Cu[9], and more recently in C[10] and Ge. In this sense, the combination of XMCD and XRMS is extremely useful. XRMS obtained at the absorption edge of the magnetic species is sensitive to chemical and magnetic heterogeneities. Moreover, this allows to know the possible coupling between the microstructure of the films and their magnetization. Correlation distances of the order of 10 nm can be obtained with this technique, surpassing the resolution of conventional microscopies[5,11].

XMCD can be also used to elucidate if the origin of the magnetic anisotropy of thin films is related to pair atom orientation, measuring the projection of the orbital moment in the three directions of the space, or if it is the result of chemical heterogeneities. Additionaly, other important experiment that can take advantage of the element and magnetic sensitivity of XMCD

and XRMS is the study of the modification of the magnetic anisotropy of the films by externally applied magnetic fields or by mechanical strain, either during thin film deposition or thin film heating.

4.1.1.2 THIN FILMS OF AMORPHOUS BINARY ALLOYS

There is a high current interest in the magnetism of amorphous binary alloys of the kind Transition Metal-Metalloid, like Fe-Si and Co-Si, or Transition Metal-Rare Earth, like GdCo, GdFe and YCo [12] . The magnetization, the magnetic anisotropy energy and the coercivity are the fundamental characteristics of these thin films, and XMCD, XRMS and XPEEM are very useful tools to understand of the microscopic physical factors that determine them, as outlined above. This knowledge help us to also search ways to alter their magnetic properties, for instance, changing the parameters of thin film deposition, preparing multilayers or fabricating nanostructures using electron lithography. The most important steps to understand the magnetism in amorphous alloys are to determine the chemical environments of the magnetic atoms, to investigate their possible segregation and to characterize the microstructure of the films.

4.1.1.3. EXCHANGE SPRING MAGNETS

Exchange-spring-coupled magnets ("spring" magnets) are heterostructures that consist of hard ferromagnetic (i.e. permanent magnet) and soft ferromagnetic (i.e. Fe or Py) layers[13]. The two layers are expected to align parallel to each other at the interface and thus are predicted to be forgiving of interfacial spin frustration. These systems are of potential importance for ultra-strong permanent magnets and for spintronics. In these systems, the magnetization reversal process is assumed to occur via the development of exchange springs in the soft material before the magnetization of the hard one is reversed. The key issue is to limit the spatial extent of the soft ferromagnet below its magnetic domain wall thickness. The soft magnet is then expected to have its magnetization pinned to that of the hard magnet. The detailed mechanism remains unclear and it gets more complex depending on the microstructure, the composition, and other factors. To unravel the mechanisms of magnetization reversal one needs to know the behavior of both hard and soft layers separately, which can be done uniquely with X-ray polarization-dependent studies (mainly XMCD and XMLD). Typical examples of exchange-spring magnets are rare-earth superlattices (more generally, materials with high magnetocrystalline anisotropy) composed of alternating layers of a hard ferri/ferro-magnet and of a soft ferromagnet[14,15]. Novel approaches will include coupling between hard nanostructured magnets and soft continuous layers. Novel magnetic properties may emerge depending on the thickness, size and period of the nanostructures.

4.1.1.4 RARE-EARTH THIN FILMS

Magnetic materials containing Rare-Earth ions (RE) are often employed in technologically relevant systems, for example to achieve high coercive fields in magnetic layers (e.g. in spring magnets) or large perpendicular magnetic anisotropies. In the RE's, dipole-allowed transitions from the 4d ($N_{4,5}$ edges, at typical photon energies of 150 eV) or 3d levels ($M_{4,5}$ edges, at photon energies around 1200 eV) into the empty, localized 4f shell show very strong intensities in the soft x-ray range. In contrast to the $L_{2,3}$ edges of TM, the atomic character of the 4f levels leads to strong correlations and to a rich multiplet structure with a strong dichroich component.

As an example of the power of the x-ray resonant magnetic scattering (XRMS), we can cite some recent studies[16] of the interlayer exchange coupling of RE films through nonmagnetic spacer layers at the example of Gd/Y/Tb epitaxial structures grown on W(110). The two magnetic layers, Gd and Tb have different coercivities. Therefore, the possibility of studying their respective magnetizations by means of an element specific technique as the MO Kerr effect in the x-ray range (XMOKE) by tuning the photon energy to the M_5 threshold is essential

in order to study the coupling through the Y layer. In particular, valuable information on the temperature dependence of the coupling through the measurement of the shifts of the hysteresis curves of the magnetically softer material (Gd) has been recently obtained.

4.1.1.5. MAGNETORESISTIVE OXIDES AND NANOMAGNETIC AGGREGATES.

Collosal magnetoresistive of perovskite-like oxides is a subject with a high technological interest on sectors like magnetic writing, sensors and data storage. The ability to prepare these kind of materials as thin-film and heterostructures, which has been acquired after a systematic project during the last years, adds a technological plus to their bulk properties. The structural, magnetic and electronic characterization is needed to understand the mechanisms and identifying the parameters governing the properties which would drive to applications. One can expect to improve the properties by controlling the composition and microstructural key parameters. Within this framework, the electronic structure and measurement of the magnetic properties with element- specificity is central to optimize the magnetorresistive properties. In particular, the future activity will be focused, among others, on two families of oxides: pyroclores[17] and perovskites of the type $CaCu_3Mn_4O_{12}$.[18] These families have been already studied by using photoemission and XANES in order to get information on the electronic structure and valence states of the different ions present in the system and its influence on the magnetorresistance of the films, depending on doping, oxygen stiochiometry, and preparation conditions.

4.1.1.6. NANOCRYSTALLINE MAGNETIC NITRIDES

Soft magnetic thin films with high saturation magnetization are crucial for achieving large write fields and high switching speeds in magnetic write heads, and have been enabling technology for the hard disk drive industry. Materials like Fe-N and Fe-X-N (X=Ti, Ta, Zr, Co,...) have been shown to reach $4\pi M_s$ values of around 20KOe, as well as low coercitivity and high permeability at very high frequencies. In fact, these materials have been proposed for use in write heads as soft underlayers for perpendicular media and to increase the inductance of elements used at GHz frequencies[19]. Those properties are closely related to the nanocrystalline character of these materials, typically < 20nm. When the size of the nanocrystals is smaller than the ferromagnetic exchange length, there is a coupling by exchange interactions and appears an overall magnetic anisotropy[20].

Even though some magnetic nitrides have been extensively studied from the structural and magnetic point of view, XMCD studies are necessary to determine spin and orbital magnetic moments, to understand the behaviour of the iron atoms in these systems and to explore the character of the 3d electrons. Furthermore, the possibility of obtaining element contrast in XMCD makes this technique an invaluable tool to determine the influence of the nitrogen and the third X element in the formation of the bimetallic nitride alloy and to discern between the magnetism associated to Fe and X if it is present.

The dynamics of the magnetization is of increasing industrial interest as the operating speeds of magnetic devices become swifter. In fact, time-resolved inductive techniques and frequency-resolved permeability measurements are usually performed to study the switching characteristics of this kind of materials[21]. However, the possibility of performing time resolved studies with nanosecond or ever picosecond resolution using the pulsed structure of the synchrotron radiation accompanied with element contrast would be helpful to understand the switching behaviour in these nanocrystalline materials.

4.1.1.7. MAGNETISM AT BURIED INTERFACES. EXCHANGE BIAS.

Spintronic devices are normally based in a stack of different magnetic and non-magnetic materials. For instance, spin valves (and magnetic tunnel junctions MTJ) are complex

multilayer structures in which a soft free layer is separated by a metallic (insulator) spacer from a hard magnetic layer which is pinned by an antiferromagnetic layer. Therefore, a complete understanding of the magnetic properties of these complex systems requires the ability to probe the magnetization of the *individual* layers as well as their mutual interaction. This investigation is possible with polarised synchrotron based techniques, due to their element-specificity and magnetic sensitivity.

Spin valves and MJTs are devices whose resistance changes depending upon whether the magnetisation of an unpinned Ferromagnet (the sensor) is parallel or antiparallel to the magnetisation of a pinned reference layer. Spin valves in recording heads and MJTs in magnetic random access memories are based on the so-called *exchange bias* phenomenon: exchange coupling between antiferromagentic (AF) / ferromagnetic (F) systems, i.e. exchange bias, anchors the F magnetization to the AF, serving as a mean to establish a magnetic reference in the ferromagnetic layer. Exchange bias is a proximity effect that usually, manifests itself as a horizontal shift of the hysteresis loop of the F along the magnetic field axis direction and the enhanced coercivity observed below the Néel temperature of the AF.

Exchange bias is being extensively studied both due to its key role in spin valves and tunneling magnetoresistance devices[22,23,24] and due to its interesting basic properties[25],[26]. Despite extensive research in the field, understanding the microscopic mechanisms has proven to be a challenging task and many theories have been put forward to explain the observed phenomena[25].

Studies have indicated that exchange bias could have its origin in the frozen uncompensated spins located in the AF close to the F-AF interface, therefore, it depends critically on the morphological and magnetic structure at the interface. Moreover, it has been theoretically proposed that interface domains in the AF or F may play an important role in exchange bias[25]. Nevertheless, the studies of the magnetic AF or F interface structure are rather scarce[27,28,29,30,31]. This lack of interface or depth dependence studies is mainly due to the reduced number of techniques which allow the study of magnetic buried interfaces, e.g. magnetic dichroism based techniques (e.g. x-ray photoemission electron microscopy (XPEEM)).

Based on the element selectivity of dichroism, by tuning to different K or L edges of diverse materials, the magnetic properties of both sides of the interface AF and F can be separately studied. It has been demonstrated that using x-ray magnetic circular dichroism (XMCD) depth dependent studies of the F part of the bilayer can be undertaken. Investigation of the domains in the F and the AF, using circularly and linearly polarized XPEEM, have been undertaken. Finally, using XMCD and circularly polarized XPEEM, induced ferromagnetic effects in the AF have also been studied. However, although great progress has been achieved in understand the AF/F interface coupling thanks to dichroism based studies, many open questions still remain to fully understand it. For example, the knowledge of linear dichroism in complex metallic AF, i.e. the ones usually used in devices, is still rather limited. Hence, this hinders the further advances in the field, such as the role of antiferromagnetic domains in inducing high order anisotropies in the system or the role of defects in the AF in enhancing the loop shifts. Moreover, there are many other fields in magnetism where the study of buried interfaces and depth dependent information would be essential, such as spring magnets[32].

Other approach would be to undertake a detailed study of the interface magnetism of the F and AF and its relationship with the surface roughness, trying to determining the spatial distribution of the uncompensated spins. Since specular reflectivity is related to the Fourier transform of the variation of the density along the depth of the sample, resonant x-ray scattering in reflection geometry can also be an important tool to determine the depth-dependent element-specific magnetic and charge density profiles and hence the location of the uncompensated spins. It would be complementary to the XPEEM studies, to perform resonant soft x-ray scattering studies on exchange biased samples, as functions of temperature, magnetic field and momentum transfer. For example, in Al/Co/FeF_2/MgF_2, by tuning the circularly polarised incident beam

energy to either the Co or the Fe L_3 edge, the reflectivity from the sample may be measured in an element selective way for both positive and negative helicity of the incident beam[33]. The specular reflectivity can be analysed in the Distorted Wave Born Approximation (DWBA), in order to *quantitatively* determine the charge and magnetic density profiles as function of depth of the sample. Besides, off-specular measurements in the same conditions may also shed some light on the domain structure in Co and Fe at the interface.

4.1.1.8. SURFACE MOLECULAR MAGNETISM

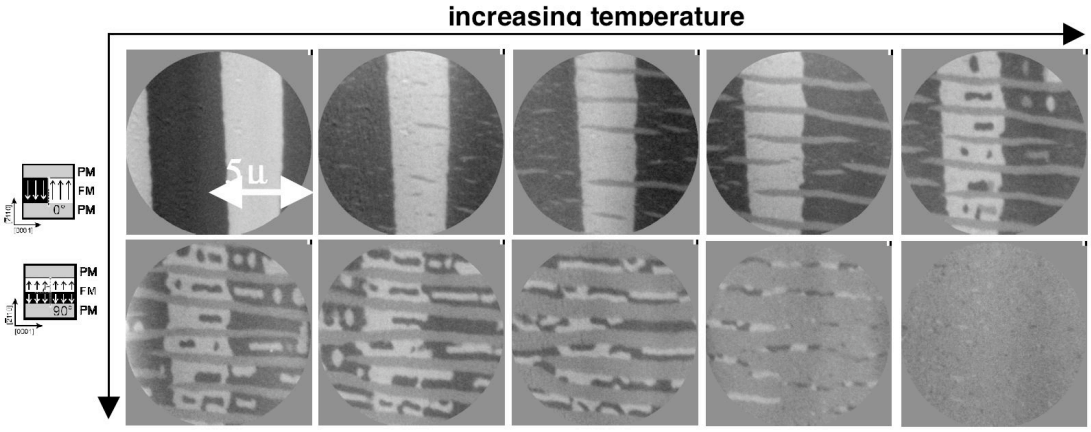
In the last decade, the synthesis of purely organic magnetic materials has become a major topic of interest[34],[35]. Since the discovery of the first organic ferromagnet in 1991, a number of other organic radicals exhibiting ferromagnet order at low temperature have been found[36]. Recently, high spin molecular magnets (e.g. Mn_{12}, Fe_8) and molecule-based magnets of the Prussian blue family have become the object of studies through synchrotron light[37]. Specifically, research area related to quantum size effects (with regard to macroscopic quantum tunnelling, quantum coherence, and quantum computing), and the tailoring of long range magnetic order in these systems are presently expanding. The issue of synthesizing magnetic assemblies through inter-molecular interactions strong enough to keep magnetic ordering at room temperature is a challenge. The new route we propose to achieve this goal is to explore long range magnetic ordering through self-assembly of magnetic molecules at surfaces. Recent advances in crystal engineering have led to the formation of molecular compounds that exhibit both ferromagnetism and metallic conductivity. The combination of this type of supramolecular chemistry opens promising routes towards the 2D synthesis of novel magnetic structures.

However, the magnetic studies of this kind of compounds require both large magnetic fields and extremely low temperatures in the range of a few Kelvin. Therefore, XMCD measurements with high field magnet coupled to low temperature facility are clearly the ideal tool to investigate the magnetic response of such auto-organized systems.

4.1.1.9. MAGNETIC SPECTROSCOPY FROM SMALL AREAS .

The combination of the magnetic imaging capabilities of XPEEM with the spectroscopic nature of XMCD and XMLD implies that local dichroic spectra at any position of the sample can be analyzed from a set of images taken at different incident energies. The size of the spot to be analized depends on the photon flux, but in principle, it can be reduced to the resolution limit. This enables to overcome the "qualitative" character of many imaging techniques, as spectroscopy and imaging are performed and recorded at the same time.

As an example, we show a study of the striped phase transition in epitaxial MnAs films on GaAs: understanding the change of magnetic order with temperature in a closely coupled two-phase system. XMCD-PEEM images resolve the secondary electrons resulting from the photoionization of the Mn L_3 level where LEEM images give the structural information. The phase transition near room temperature from the paramagnetic orthorhombic β phase above 40ºC to the ferromagnetic hexagonal α phase below 40ºC is rather complex due to the epitaxial strain that leads to the coexistence of the two phases over a temperature range of nearly 30ºC. At every temperature, each small spot of a given "gray value" may be analyzed separately, in a similar way as the "combinatorial chemistry" operates. Indeed, The XPEEM to be installed at POLUX would be able to study XAS and polarization dependent spectroscopies in combinatorial chemistry samples (example by *E. Bauer* and coworkers at the SPELEEM instrument, Nanospectroscopy beamline, ELETTRA, Trieste (Italy).



4.1.1.10 DIMENSIONAL EFFECTS ON CRITICAL FLUCTUATIONS OF SURFACES AND THIN FILMS

Reduction of the size of magnetic systems down to nanometer scales leads to the appearance of new phenomena with direct implications for magnetic information storage techniques. Especially important are the changes in the thermodynamical behaviour of the magnetization with dimensionality. Knowledge of the critical exponents of the thermodynamical parameters near magnetic phase transitions gives information on the universality class of the transitions, which determines the characteristic scaling behaviour of the system. One of these parameters, the magnetic correlation length, has been extensively studied in bulk materials with neutron critical scattering[38], which however can not be applied to surfaces and thin films.

By making use of X-ray Intensity Fluctuation Spectroscopy (*XIFS*), a new X-ray technique with which the magnetic correlation length can be measured in surfaces, thin films and multilayers, we also expect to study the dynamics of the magnetization of cluster and particulate systems with super-paramagnetic behaviour. XIFS is a new tool for the study of fluctuations in hard and soft condensed matter systems. Pioneering experiments[39] have demonstrated that *XIFS* can probe time scales between 100 s and 1 µs over a transferred momentum range between q=10^{-3} and q=1 $Å^{-1}$. *XIFS* is unique in its capability to probe relatively slow and large scale phenomena, and can be adapted to the study of magnetic fluctuations by exploiting the anomalous magnetic contrast of X rays tuned to particular "magnetic" X-ray absorption edges. The surface sensitivity is obtained by working in reflection geometry.

In brief, the principle of *Magnetic XIFS* is as follows: at these "magnetic" X-ray absorption edges, a core electron resonates with the unoccupied spin-polarized valence states, leading to strong magneto-optical effects. The refractive index becomes strongly dependent on the size and direction of the magnetization. A polarized X-ray beam, tuned to such a resonance, and incident on a magnetic domain pattern, will be scattered by the domain pattern. Due to the small ratio of the wavelength to the typical domain size, the typical scattering angle lies in the range of 0.1-20^{o}.

If the X-ray beam is made coherent, the small-angle scattering breaks up into a *magnetic speckle* pattern. Intense speckle patterns indeed have been measured, as described in ref. 40. As shown there, such speckle patterns are the Fourier Transform of the magnetic correlation function, which contains all statistical information of the domain pattern. Temporal fluctuations in this correlation function cause fluctuations in the speckle intensities. Measurement of the time-autocorrelation of the fluctuating intensity at a particular q transfer will give the correlation time of magnetic fluctuations with a correlation length that corresponds to that q. In homogenous systems, this amounts to measuring the dispersion relation of the magnetic fluctuations at very low frequencies.

We envisage applying this technique to two types of systems, critical phase transitions and magnetic nanocluster systems. In the first case, the information obtained is the magnetic correlation length, and, from its temperature dependence, its critical exponent ν. Such an experiment is the X-ray equivalent of critical neutron scattering[21]. In reflection geometry, it is possible to change the probing depth of soft X-ray scattering by changing the angle of incidence, which should allow us to follow the transition from 3D bulk behavior to 2D behavior near the surface[41].

Prime candidates for such experiments are single crystal surfaces of Fe, Co and Ni and rare earths such as Gd. The latter case is particularly interesting, since no neutron data exist on this important magnetic element. Important practical considerations are that the Gd M_5 edge has the largest magnetic cross section and has the critical point near room temperature.

Continuing to even smaller dimensionality leads to the appearance of superparamagnetism. Here the magnetic correlation length is determined by the particle size, and the only option to study thermodynamic fluctuations and order-disorder transitions lies in the time domain, and we expect *MXIFS* to be particularly useful.

4.1.2. NANOSTRUCTURES, NANOPARTICLES AND AGGREGATES

The great development of synthesis methods and deposition techniques experienced in the last decades has allowed the preparation of new magnetic materials with morphologies in the nanoscale range[42]. This extensive research, based on the discovery of a large deal of new phenomenology, is focused in the future implementation of different type of device[43,44]. In particular, among these nanostructures it is interesting to mention nanogranular and nanocrystalline systems, exhibiting properties from the giant coercivity observed in Fe nanoparticles[45], size and dimensional effects on spin and orbital moments probed at low temperatures; orbital moment doubling; complex spin configurations (F+AF), induced magnetic moment in Pd and Pt nanoparticles[46], the collective magnetic relaxation in systems with strong exchange coupling[47], to the very recent observation of permanent magnetism in chemisorbed organic molecules in surfaces of Au nanoparticles and films[48].

This case is very interesting showing the need to build the POLUX facility in ALBA. The outstanding discovery of these *magnetic gold particles* by Crespo and coworkers was obviously a result to comfront to XMCD, as this *is the technique of choice* to adscribe unambiguously the observed magnetism to gold, ruling out any contamination by magnetic impurities or other spurious effect. However, the experience on synchrotron radiation of the magnetism community is rather low, in extreme contrast with the neutron scattering case, due to historical reasons. Moreover, the access to soft x-ray XMCD beamtime in Europe is very difficult, specially for non-habitual user groups. The final result of this situation was, shortly afterwards, the confirmation by XMCD of the magnetic gold particles by a japanese group[49] (after performing XMCD experiments in one of their own national synchrotron facilities).

4.1.2.1. CORE-SHELL STRUCTURED MAGNETIC PARTICLES.

The *magnetic nanoparticles* are among the nanostructured materials that present huge interest since they offer attractive possibilities in biomedicine[50] and in magnetic recording[51], among many other applications. Most of these systems present two magnetic phases in a core/shell structure. The core (2-10nm) can be crystalline ferromagnet (Fe, Co, Ni) or amorphous ferromagnet (FeCoNiB) and the shell (2-3nm) can be a diamagnetic (Au, Ag, Pt, Cu) or an antiferromagnet (Fe-Co oxide). XMCD experiments will allow study the magnetic behavior of both phases, the core and the shell. Different magnetic aspects could be explored: a) the induced magnetic moment on the diamagnetic shell (Ag, Au, Cu), b) the interface effect on the

magnetic anisotropy, c) the influence of particle size on the orbital and spin magnetic moment, d) exchange coupling between ferro and antiferro magnetic phases.

4.1.2.2. NANOGRANULAR FILMS.

The nanogranular films composed of magnetic nanoparticles (Fe, Co) embedded in a nonmagnetic metallic matrix (Au, Ag, Cu) present giant magnetoresistance: a huge decrease of the electrical resistance when a magnetic field is applied and present great relevance in the spintronic field[52,53,54]. The magnetic and magnetotransport properties of the nanogranular films are strongly influenced by particle size and interfase. The influence of the interface increases its relevance as the cluster size diminishes which corresponds with a high surface to volume ratio, i.e, in a cluster size of 3 nm the number of atoms at the interface is at least 60% of the total atoms in the cluster. In this case, the influence of the interface on the magnetic behavior is determinant. X-ray magnetic circular dichroism will provide us direct information of the effect of the interface on the magnetic and magnetotransport response.

4.1.2.3. SIZE-EFFECTS ON SPIN AND ORBITAL MOMENTS OF PARTICLES.

Although ferromagnetism in the transition metals is probably the most studied property of bulk matter, several basic questions remain unanswered. Particularly interesting is the question of how the quenching of the orbital magnetic moment evolves from the atom to the bulk through the nanoscopic regime. XMCD has been recently revealed as the tool of choice for this kind of studies[55] as it allows to separately determine the spin and orbital magnetic moments.

The magnetic anisotropy of nanometer-sized metallic clusters determines the stability of their magnetic moments against thermal fluctuations. Therefore, this magnitude plays a crucial role for applications, since, in fact, it limits the minimum size that a particle must have to store information. A few experimental studies convincingly show that the anisotropy constant K of nanoparticles becomes larger than in bulk and that it strongly depends on size and dimension[54] The magnetic relaxation and anisotropy K of Co self-organized nanospheres which form layers of particles giving rise to a hcp superstructure. The particles can be prepared ranging from less than 40 atoms to 4500 atoms, prepared by sputtering on amorphous alumina[56]. We found that K is inversely proportional to the cluster diameter, i.e., approximately proportional to the relative fraction of surface atoms. According to Bruno's model[57], this surface anisotropy can be attributed to the presence of non-quenched orbital moments m_L at the surface of the clusters.

However, these experiments do not solve the question of whether the anisotropy is dominated by the reduction of particle's size or by the electronic interaction between the magnetic atoms and the metallic substrate. Moreover, it has been shown that an additional increase of K and m_L is found when the clusters are capped by a thin (1.5 nm) layer of Cu. In analogy with theoretical[58] and experimental[59] results obtained for monolayers of Co, we attribute this effect to the hybridization of the surface d orbitals with the conduction band of the matrix, which modifies the energies and occupation numbers of the former. First-principles calculations predict indeed that covering with Au leads to a larger K than covering with Cu[57]. The use of Pt would add a new and interesting ingredient, as Co atoms induce a spin polarization in a neighbouring Pt layer[58]. Therefore, because of the strong spin-orbit interaction of this 5d metal, we expect the increase of K and the m_L to be also larger. If properly understood, this phenomenon could open a new method to *tailor* the anisotropy of metallic nanoparticles by simply choosing the appropriate electronic properties of the capping layer.

4.1.2.4. MAGNETIC NANOSTRUCTURED: SURFACES, INTERFACES AND GRAIN BOUNDARIES - LINK BETWEEN PROPERTIES AND LOCAL ELECTRONIC STRUCTURE MODIFICATION

It is proposed the exploration of particulate systems in surfaces, layered nanostructures, and chemisorbed species on surfaces of

i) local magnetic moments and thermal dependence (for biomedical applications: Fe_3O_4, γ-Fe_2O_3, thiol-capped Au nanoparticles, for magnetic recording: FePt), and

ii) analysis of the orbital component of the magnetic moment and its correlation to the surface/interface magnetocrystalline anisotropy. In nanocrystalline systems, it is proposed the local analysis of the hysteresis and relaxation processes in the grains and their boundaries (Fe-based soft magnetic materials, and hard magnetic materials based on rare-earth / transition metal intermetallic composites, to study the mechanisms of intergranular exchange).

The application of X-ray Magnetic Circular Dichroism (XMCD), which provides element and chemical sensitivity, spin and orbital magnetic moment selectivity and therefore analyze the contribution to the magnetization of a particular element, will help investigate the origin of this very rich phenomenology, the unusual induced magnetic behaviour in nanoparticles, the interplay between size / surface effects, and structure and electronic properties, present in the magnetic nanostructured systems. Likewise, the functionality of this beamline in terms of photon energy range, which covers the absorption edges of interest, flux and energy resolution, light polarisation, and endstation equipped with high magnetic field and low temperature facilites, it makes it as a good candidate to observe subtle magnetic effects.

4.1.2.5. ANTIDOTS

One interesting magnetic nanostructure is based in magnetic thin films with periodic arrays of nonmagnetic inclusions usually referred as antidots. Around the antidots, stable domain configuration is formed which is a result of the interplay of the intrinsic uniaxial anisotropy of the magnetic thin film and the demagnetizing fields associated with the antidots which tend to align the magnetization parallel to the intrinsic hard axis of the magnetic films that can be used to store bits of information. The antidots introduce shape anisotropies which allow the nucleation and movement of domain walls, and therefore, a control over the net-in-plane anisotropy and associated properties such as magnetoresistance[60].

X-ray photoemission microscopy is a powerful technique for the study and observation of the configuration of magnetic domains in this kind of magnetic nanostructures[61]. The main advantages over others techniques being its nonintrusive character and the achievement of direct imaging of the orientation of the magnetization. The dynamic properties are of fundamental importance to evaluate the time scale of the magnetization reversal process which governs the writing time in magnetic storage devices based on these magnetic nanostructures. Studies on switching dynamics on the nanosecond time scale by time resolved spin polarized photoemission have been peformed on iron nanoclusters[62] revealing that nanosecond resolution is necessary to explore the switching in magnetic nanostructures.

4.1.2.6. QUANTUM COMPUTING SYSTEMS

A nanostructured system can be patterned from thin films of amorphous alloys, for example, in such a way that they behave as quantum dots. They can record charge with a well defined spin state, so that the dots will be the equivalent to quantum bits (qubit in quantum computing[63]). The quality of this qubit depends on the time that is able to maintain the coherence. This time can be of the order of nanoseconds, so that time resolved up to picosecond range would be useful in order to study the details of the processes of decoherence and switch of the spin[64].

Chemical sensitivity of time-resolved XMCD would give valuable information to understand the spin relaxation processes of the excited qubit.

4.1.2.7. SPATIALLY-RESOLVED MAGNETIZATION DYNAMICS IN NANOMAGNETS

Understanding the complex phenomena involved in ultrafast magnetic reversal is vital for the improvement of the information media related technology, both for recording and random-access media, and poses a great challenge in the nanoscopic scale physics community.

Recent studies on precessional switching[65] have pushed the known limits down to hundredths of picoseconds, with clear applications in the recording media industry. At the same time, the non-volatility of the magnetization direction and the requested readout signal-to-noise ratio exert extreme conditions on the grain size of the material, currently in the 20 nm range.

Furthermore, ultrafast optical techniques have made possible to follow the coupling between the electronic, spin and lattice systems in the femtosecond regime[66], disentangling the basic relaxation channels in a magnetic system. At slower time scales, the reversal process is consecutively governed by nucleation and domain-wall propagation, which are understood in the frame of Fatuzzo's theory[67].

Pump-probe techniques are common in the study of ultrafast switching. Three basic excitations, pulsed heat[68] (produced by a laser pulse), spin-selective excitation[69] and magnetic field (normally via a strip line[70] or a single micro-coil[71]) are used to bring energy to the system, whereas different probes, namely anything with magnetic contrast, witness the response of the system. The probes can be divided in three groups: inductive, magnetoresistive, and magneto-optic. Among the last group we can enroll the scanning and spatially-resolved ones, like scanning Kerr magnetometry (t-MOKE)[72] and its combination with second-harmonic generation (SHG)[73]. Lately time-resolved element-specific X-ray techniques have been explored XMCD[74], spin-resolved photoemission[75], and photoemission electron microscopy (PEEM)[76] make use of the time structure of the synchrotron sources. They provide a temporal and lateral resolution of about 100 ps and 20 nm, being limited to the study of nucleation and domain wall propagation.

Since these imaging techniques are stroboscopic, they rely on the fact that at a given delay time between the pump and the probe, the magnetic state will be very similar over millions of pulses collected in every image. This is only the case when the nucleation and domain wall propagation processes are produced in the same places, i.e. dictated by defects in the film structure. In order to overcome this limitation, here we propose to develop an alternative technique at the POLUX goniometer: time-resolved X-ray resonant magnetic scattering (t–XRMS).

Soft X-ray resonant magnetic scattering has already been extensively used to study the collective behaviour of magnetic domains under applied field of very different systems: thin films[77], multilayers[78], recording media[79], exchange-bias systems[80], etc. Combining SXRMS with very powerful micro-coils synchronised with the Synchrotron clock, we can witness the nucleation of reversed domains and their further evolution in time[81]. The scattering approach presents a clear advantage over microscopy: the topology of the nucleated domains can be different at each pulse, allowing studies in pinning centers-free samples.

4.1.3. SINGLE-MOLECULE MAGNETS AND SINGLECRISTALLINE NANOMAGNETS

4.1.3.1. SINGLE-MOLECULE MAGNETS

Molecular crystals made of large magnetic molecules, such as Mn_{12} [82], have attracted a great deal of scientific interest in the last few years. These molecular clusters have a net spin $S = 10$ at

sufficiently low temperatures and are therefore intermediate between paramagnetic ions and bulk magnets. Furthermore, the magnetization of $Mn_{12}O_{12}$ becomes hysteretic below approximately T=3K [83]. This property makes these materials potential candidates for information storage at the molecular scale. Hysteresis is caused by the superparamagnetic blocking of the molecular spins along the direction (z) favoured by the uniaxial magnetic anisotropy. The anisotropy is related to the strong Jahn-Teller distortion of the oxygen octahedron surrounding the eight Mn^{3+} ions located in the outer ring of the molecular core. These molecules are also the first mesoscopic materials for which quantum tunnelling of the magnetic moment has been convincingly observed[84].

Their unusual properties make these materials very promising for applications in both high-density recording and quantum computation. However, this requires that the molecules can be processed by e.g. depositing them onto metallic surfaces or inside nanoporous materials or by connecting them to other compounds (paramagnetic spins, optically active molecules, etc) that enable adressing a single molecule. In the last few years, some Chemistry groups, in Valencia, Barcelona, Florence, among other places have carried out a strong research along these directions [85,86]. The investigation of the magnetic properties of these processed materials faces however two main difficulties. The magnetic signal is usually too low for conventional magnetometers and it is difficult to disentangle the response of the molecules from that of other magnetic components that might be present in the sample. For these two reasons, XMCD experiments can be of enormous interest in this field, since this technique has shown to be capable of measuring the response of minute amounts of a magnetic material and it is element specific.

4.1.3.2. SOFT X-RAY SPECTROMICROSCOPY OF SINGLE NANOCRYSTALS

Magnetic properties of a crystal change when characteristic lengths such as domain size, domain wall width and exchange length fall below certain scales. Many scaling laws have been hypothesized, only a few are verified[87]. The experiments on this topic are usually limited to ensembles of particles and therefore to an average of the properties of these particles with respect to their size and shape distribution, chemical composition, etc. This limitation can be overcome by investigating the properties of the *single* nanocrystals individually, which will allow to truly correlate scaling laws of material properties with changes in size[88]. From X-ray absorption spectroscopy (XAS), detailed information about the electronic structure can be obtained in addition to the chemical composition, structural properties and magnetic properties (see e.g. refs. 89).The combination of spatial and spectral resolution, as well as the unique sensitivity of polarization-dependent x-ray spectromicroscopy, makes PEEM a unique tool in the study of magnetic properties of *single* nanocrystals[90]. With this method, information on the electronic properties, magnetism, solid-state metastability, and on the local crystallographic structure (such as phase composition and degree of order) can be obtained from the individual particles. This ambitious project aims not only for a beamline offering high spectral resolution and flux, but also the fast switching of the circular polarizations would significantly increase the signal-to-background ratio of the measurements. Next-generation *single* nanocrystal experiments would include time-resolved magnetic reversal and kinetics of structural phase transitions of such *single* particles.

4.2. BULK PROPERTIES AND APPLICATIONS OF MAGNETIC MATERIALS

4.2.1. MAGNETISM IN INTERMETALLIC ALLOYS

Transition metal (TM) intermetallics are known to exhibit remarkable functional magnetic properties, from ultrasoft FeNi alloys to hard magnetic materials, such as $SmCo_5$[91]. Other types of intermetallic alloys often exhibit other unique magnetic properties. For example, the magnetic properties of TM – non-magnetic (TM-NM) intermetallic alloys depend very strongly

on the degree of ordering or the lattice parameter[92,93,94]. For example, many TM-NM alloys are known to go from paramagnetic to ferromagnetic at room temperature with increasing disorder[108]. Some of these properties stem, in part, from (i) the electron transfer between the elements and the concomitant induced moments in the NM ions and (ii) the local environment of the TM ions. For example nearest neighbors, e.g. a TM ion surrounded by 4 or more TM ions tends to behave ferromagnetically, while if the TM is surrounded by less than 4 TM ions it acts paramagnetically[95]. Synchrotron radiation has been used to study intermetallic alloys composed of TM and rare earths (Sm, Y, Pr) or actinides (Ce, U)[96,97]. However, despite the obvious possibilities of x-ray absorption and dichroism, being able to tune to the resonant edges of each of the components of the alloy, in unveiling the correlation between magnetism and local environment in TM-NM alloys, synchrotron radiation has been seldom utilized for this purpose[98]. Nevertheless, recent XMCD studies on FeAl have demonstrated a clear correlation between magnetism and atomic arrangement in this system[99].

4.2.2. AMORPHOUS FERROMAGNETS

It has been very well demonstrated the crucial role played by XAS techniques in undertanding the relation between local structure and magnetic properties in disordered metallic alloys. A direct magnetic probe as the XMCD spectroscopy capable to check separately the magnetism of different magnetogenic elements presented in the alloy has become a unique and fundamental tool in any basic magnetic study.
.In particular, in our case the chance to perform XMCD experiments both in the K and L edges of different magnetogenic 3d transition elements would be essential to dilucidate many of the aspects involved in the magnetism of these alloys, as shown indeed in a very direct way by previous experiences in the Fe K-edge of binary amorphous ribbons[100,101].
The knowlege of the ferromagnetic nature (weak or strong) of the Fe is determinant in order to understand the magnetic behaviou of Fe based amorphous ferromagnet. X-ray magnetic circular dichroism at the Fe K-edge gives direct insigh on the ferromagnetic character of the sample.

4.2.3. COMPLEX MAGNETISM OF MIXED-VALENCE MANGANITES

The observation of complex magnetic behavior in perovskite oxides has been trend in the last decade. One of the most intriguing effects is the observation of negative magnetization (NM, opposed to the magnetic field) after a field cooling (FC) process in manganites. NM was described more than four decades ago in some spinel ferrites[102] and more recently in other complex ferrimagnetic systems as molecular magnets[103], "fanned" amorphous alloys[104], or irradiated garnets[105]. In the last years, NM has been found in non-stoichiometric $NdMnO_{3+d}$ [106], and $Nd_{1-x}Ca_xMnO_3$[107], among several other manganites[108]. All of these systems are complex ferri- or canted antiferromagnetic systems with at least two magnetic sublattices and some degree of disorder (structural or chemical). In most of cases, if the magnetic field used in the FC process is below a certain maximum value the magnetization is parallel to Ha below TN, but upon cooling, M(T) increases, reaches maximum and then diminishes to zero (bottom panel, H = 1 kOe). Instead of the expected behavior of ferrimagnets presenting a compensation point, a negative net magnetization is developed below an "inversion" temperature in a metastable situation. In manganites, negative magnetization has been related with canted antiferro – ferro phase separation and negative exchange bias between the net moment of the two phases. XMCD experiments may rule-out the simple competition between the Nd and Mn sublattices as the origin of negative magnetization in $NdMnO_3$: the compensation takes place between two different phases instead of between two ferrimagnetically coupled sublattices. This is a new kind of magnetic compensation, not identified as such until now. We plan to study if the numerous examples of negatively magnetized manganites recently found[108] belong to this new kind.

4.2.4 ORBITAL MOMENTS THROUGH MAGNETIC PHASE TRANSITIONS

One of the most important parameters in magnetism and in magnetic materials applications is the magnetic anisotropy energy (MAE) that allows to stabilize the magnetic moments against random fluctuations over time. Magnetic anisotropy is fundamental, for instance, to storage the information in a hard disk or to design a permanent magnet. The dependence of MAE on crystal symmetry have been largely studied: where as the exchange interaction is isotropic, the orbital magnetization, via the spin-orbit coupling, connects the spin magnetization to the atomic structure giving rise to MAE. In 1989, P. Bruno theoretically related the origin of the magneto-crystalline anisotropy in metallic compound to the magnitude and anisotropy of the orbital moment[56]. In the last nineties, application of the sum rules to the XMCD spectra at the $L_{2,3}$ edges in transition metals (mainly Fe, Co, Ni) has allowed to determine the orbital magnetic moment of these elements.

XMCD and sum rules have been widely used during last years to study the effect of dimensionality in the orbital moment (and consequently in the MAE) of transition metals. It has been reported how the orbital moments is increase, with respect to the bulk values) in surfaces[109], clusters[110,111], , monoatomic chains or even single atoms[54], whereas it remains almost quenched in molecular magnets[112,113]

In 2000, we observed , for the first time, a strong increase of a metallic orbital moment in a magnetic phase transition. We demonstrated that the orbital moment of iron in $Nd_2Fe_{14}B$ suffer an strong instability in the spin reorientation transition that this compound show at around 135 K. This work opened a new way (together with dimensionality effects) to study modifications in the quenching of the orbital moments in transition metals: the *thermodynamic effects*. We have gone deeper in this topic, demonstrating how the orbital moment of cobalt in $ErCo_2$ [114] show a sharp jump in the Curie temperature, clearly related to the one observed in the anisotropic magnetostriction. Our final objective is to study the behaviour of the orbital moment of transition metals in the Curie temperature in different conditions: first or second order phase transitions, ferri-, or ferromagnetic ordering, coupling with different rare earths,…

The final objective of this scientific case is to understand the role played by the orbital magnetic moment of transition metals in the ordering process, the effects of the critical phenomena in its quenching, and its relation to the magnetoelastic properties like magnetostriction.

4.2.5. MOLECULAR MAGNETISM

The available incident energies of the proposed POLUX beamline range from 80 to 2000 eV. This is a rather extended energy range, when compared with other available soft x-ray beamlines. The goal is to cover, not only the $L_{2,3}$ absorption edges of 3d transition metals and $M_{4,5}$ ones of the rare-earths but also the carbon, oxygen and nitrogen K edges, as well as sulfur $L_{2,3}$ edges, for example. A scientific highlight of this energy range would be the possibility to study the magnetism of organic magnets, a new and very interesting family of magnetic materials including magnetic carbon nano-foam[115], graphite (both natural[116] or treated[117]), nanotubes[118], C_{60} polymers[119], magnetic C_{60}-radical complexes as TDAE-C_{60} [120], as well as a long list of organic radicals[121], etc.

4.3. NON-MAGNETIC APPLICATIONS

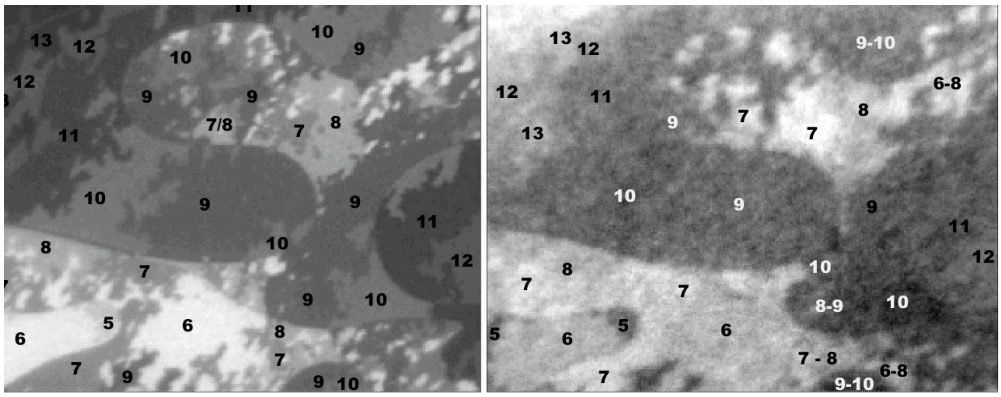
The specifications of the synchrotron light in the proposed beamline are not only very attractive for the scientific community interested in magnetism but also to the scientists dedicated to other research areas, not only among condensed matter physics, but also organic molecules and polymers, biologist included.

A non-exhaustive list of scientific areas of possible application of the POLUX beamline include:

- Growth mode and structure of thin films and aggregates.
- Segregation, wetting and alloying.
- Band structure inhomogenities.
- Electron emission properties of wide band gap semiconductors.[122]
- High temperature superconductors (superconducting domains).[123]
- Real time studies of dynamical processes like surface diffusion, mass transport on surfaces: Electromigration, thermal migration relevant for microelectronics.[124]
- Surface chemistry: pattern formation in chemical reactions on surfaces, bistable systems, bimetallic catalysts, etc.[125]
- Polymer films (possibly covered by thin protective conductive layers, thanks to the photon energy tunability XPEEM can get quite bulk sensitive, and also working with secondary electron yield gives sampling depth of several nm).[126] See case **4.3.2**.
- Nanocrystalline and nanocomposite electrocatalysts.
- Real time studies of corrosion, oxidation, surface damage by ion bombardment, laser beam, and other inhomogeneous processes relevant in a broad range of technologies
- Tribology, surface coatings, wear.[127]
- Semiconductor, metal and metal/semiconductor nanostructures.[128]
- Edge effects, selective adsorption, reactivity of nanostructures.[129] See case **4.3.1**.
- Self-organization on the nm scale.[130]
- Organic/inorganic interfaces.[131] See case **4.3.2**.
- Studies of chiral molecules with circularly polarized light. In general, experiments on organic materials will be limited by radiation damage, thus fast imaging is a clear advantage. See case **4.3.2**.

4.3.1. SURFACE REACTIVITY: TUNING SURFACE REACTIVITY VIA ELECTRON QUANTUM CONFINEMENT.

Comparing the initial oxidation rate of atomically flat ultrathin magnesium films of different atomic thickness. XPEEM permits to demonstrate the existence of thickness dependent quantum-well states in the Mg valence band and to probe simultaneously the oxidation of Mg micro-regions of different thickness, excluding any side effects due to variations in the O_2 exposure or temperature. Pronounced thickness-dependent variations in the oxidation rate are observed for well ordered films of up to fifteen atomic layers. Quantitative comparison reveals direct correlation between the surface reactivity and the periodic changes in the density of electronic states induced by quantum-well states crossing the Fermi level.



6x5 mm^2 images of a Mg film in an advanced growth stage. **(a)** 1.3 eV LEEM image: the indicated number of atomic layers corresponding to the micro-regions was determined following the reflectivity changes during film growth at 120 ˚C with deposition rate of 0.1

atomic layer/min. **(b)** XPEEM image of the same Mg film after exposure to 9 L of O_2 at 50 ˚C, where the contrast corresponds to the extent of local Mg oxidation. The image is obtained by measuring the Mg 2p intensity of oxidised Mg (I_{ox}).[132] (SPELEEM instrument, Nanospectroscopy beamline, ELETTRA, Trieste)

4.3.2. POLYMERS AND BIOLOGICAL SAMPLES

The POLUX energy range covers photon energies from 50 eV to 2 keV that includes the K-edges of C, N and O, i.e., the most important components of polymers and biological molecules. Covalent bonding, ubiquitous in these molecules, is very directional, and therefore, very sensitive to the polarization of the incoming light. This fact has been used for decades to determine the spatial orientation of polymers and organic molecules[133]. The corresponding K-edges usually have p* resonances from conjugated bonds which are very narrow in energy and whose binding energy is very dependent of the kind of bonding and the specie bonded, making them a very efficient signature to distinguish a molecule from another. Current research of polymers uses successfully the polarization and chemical sensitivity of these resonances in combination with microscopy techniques like photoemission microscopy (PEEM) and x-ray transmission microscopy (XTM)[134], to study fundamental problems like polymer segregation in polymer blends[135], glass transition temperature[136] and polymer orientation under different process[137]. For instance, X-PEEM with tunable soft X-rays has the sensitivity to locate and detect adsorbed proteins at the submonolayer level, while simultaneously detecting the spatial distribution of phases, and protein distribution relative to the phases, at the surface of an underlying microphase separated polymer substrate[138]. The same ability of resonant small angle scattering (XRMS) to detect magnetic and chemical heterogeneities in magnetic materials can be used in polymer films. Research in nanotechnology involves the study of the behaviour of polymers like in self-organized polymer segregation and in colloidal solution of nanocrystals which are two of the proposed methods to obtain ordered nanostructures. Polymer blends are also ubiquitous in common objects, from car tires to baby diapers. Semiconductor polymers are considered to be the main components of microlectronic circuits for dairy live in the future. Finally, magnetism and organic chemistry are getting closer fields with the relatively recent development of organic magnets[139] and the discover of magnetic carbon[140]. The importance of polymer science has brought the Canadian Light Source and the Advanced Light Source synchrotrons, similar to the projected Spanish synchrotron ALBA, to share the research time of elliptical undulator beamlines between magnetism and polymer science.

Note:

- *Some parts of the present scientific case (in particular that concerning groups 5, 8 and 10 of Annex IV on magnetic nanoparticles, amorpohous ferromagnets, etc) has been also presented with the proposal for a hard X-ray spectroscopy beamline for ALBA. Depending on the scientific subject (i.e. the element and the egde to study), hard or soft X-ray will be needed. It is clear that many of the scientific ideas here presented would be complemented or even only fully completed with the complementary use of a hard x-ray polarization-dependent spectroscopy beamline.*

References

1 See for example H. S. Nalwa, en *Magnetic Nanostructures*, editado por H. S. Nalwa. Ed. American Scientific Publishers, New York (2002)

2 R. C. O'Handley, en *Modern Magnetic Materials: Principles and Applications,* editado por R. C. O'Handley. Ed. John Wiley & Sons, New York (2000)

3 J. Nogués y I. K. Schuller, J. Magn. Magn. Mater. 192, 203 (1999).

4 P. Crespo et al, Phys. Rev. Lett. 93 (2004) 087204.

5 J.-M. Tonnerre, L. Sève, D. Raoux et al. PRL 75, 740 (1995)

6 H. A. Dürr et al., Science 284, 2166 (1999)

[7] M.Bonfim, G.Ghiringhelli, F. Montaigne, S. Pizzini, N. B. Brookes, F. Petroff, J. Vogel, J. Camarero, A. Fontaine, Phys. Rev. Lett. 86, 3646 (2001)
[8] J. B. Kortright, Sang-Koon Kim, and H. Ohldag. Phys. Rev. B 61, 64 (2000).
[9] M. G. Samant et al. Phys. Rev. Lett. 72 (1994) 1112
[10] H.-Ch. Mertins, S. Valencia , W. Gudat, P. M. Oppeneer, O. Zaharko, and H. Grimmer. Europhys. Lett., 66, 743 (2004)
[11] J. B. Kortright, Sang-Koon Kim, G. P. Denbeaux, G. Zeltzer, K. Takano, and E. E. Fullerton. Phys. Rev. B 64 (2001) 092401
[12] M. L. Fdez-Gubieda, I. Orue, P. Gorria, A. García-Arribas, J. M. Barandiarán, R. Lopez, S. Pizzini, A. Fontaine, J. Magn. Magn. Mater., 196/197 (1999), 204; M. L. Fdez-Gubieda, A. García-Arribas, J. M. Barandiarán, R. López Antón, I. Orue, P. Gorria, S. Pizzini, A. Fontaine, Phys. Rev. B, 62 (2000), 5746; M. L. Fdez-Gubieda, I. Orue, P. Gorria, S. Pizzini, A. Fontaine, J. Synchrotron Radiat., 8 (2001), 443.
[13] E. E. Fullerton, J. S. Jiang, M. Grimsditch, C.H. Sowers, S. D. Bader, Phys. Rev. B 58, 12193 (1998).
[14] G J Bowden, J M L Beaujour, S Gordeev, P A J de Groot, B D Rainford, and M Sawicki, J. Phys.: Condens. Matter 12 9335 (2000).
[15] K. Dumesnil, M. Dutheil, C. Dufour, Ph. Mangin, *Phys. Rev. B* 62, 1136 (2000).
[16] J.E. Prieto, F. Heigl, O. Krupin, G. Kaindl, and K. Starke, *Phys. Rev. B* **68**, 134453 (2003); O. Krupin, J.E. Prieto, S. Gorovikov, K. Starke, and G. Kaindl, *Thin Solid Films* **428**, 98 (2003); K. Starke, F. Heigl, J.E. Prieto, O. Krupin, and G. Kaindl, *Nucl. Instrum. Methods B*, **199**, 313 (2003); J.E. Prieto, F. Heigl, O. Krupin, G. Kaindl, and K. Starke, *Phys. Rev. B* **66**, 172408 (2002); *"X-ray Magneto-Optics"*, K. Starke, F. Heigl, J.E. Prieto, O. Krupin, A. Vollmer, G. Reichardt, F. Senf, R. Follath, N.B. Brookes, and G. Kaindl, in *Advances in Solid State Physics*, Volume 41, pp. 161-170. Editor: Bernhard Kramer, Springer-Verlag Berlin Heidelberg (2001)
[17] J. Sánchez.Benítez, A. de Andrés, C. Prieto,J. Ávila, L. Martín-Carrón, J.L. Martínez, J.A. Alonso, M.J. Martínez-Lope and M.T. Casais, Appl. Phys. Lett. 84, 4209 (2004)
[18] J. Sánchez-Benítez, C. Prieto, A. de Andrés, , J.A. Alonso, M.J. Martínez-Lope, M.T. Casais, Phys. Rev. B. 70, 024419 (2004)
[19] K.H. Kim, H.W. Choi, J. Kim, S.R. Kim, S.H Han , IEEE Transactions on Magnetics 36(5)(2000) 2656
[20] N.G. Chechenin, A. van Veen, H. Schut, A.R. Chezan, D.O. Boerma, T. Vystavel and J.Th.M. De Hosson, J. Phys.: Condens. Matter 15 (2003) 7663
[21] C. Alexander, J. Rantschler, T.J. Silva and P. Kabos, Journal of Applied Physics 87(9)(2000) 6633
[22] B. Dieny, et al. Phys. Rev. B 43, 1297 (1991).
[23] J.S. Modera, et al. Philos. Mag. B 80, 195 (2000).
[24] J.M. Daughton, et al., J. Phys. D: Appl. Phys. 32, R169 (1999).
[25] J. Nogués and I.K. Schuller, J. Magn. Magn. Mater. 192, 203 (1999).
[26] V. Skumryev et al. Nature 423, 850 (2003).
[27] H. Ohldag et al. Phys. Rev. Lett. 87, 247201 (2001)
[28] C. Sánchez-Hanke and C.C. Kao, J. Magn. Magn. Mater. 226-230, 1803 (2001).
[29] F. Nolting et al. Nature 405, 767 (2000).
[30] J. Camarero et al., Phys. Rev. B 67, 020413R (2003).
[31] J. Camarero et al., Phys. Rev. Lett. 91, 027201 (2003).
[32] E.E. Fullerton et al. J. Magn. Magn. Mater 200, 392 (1999).
[33] S. Roy, M. Dorn, S. K. Sinha, O. Petracic, Z. Li, X. Batlle, R. Morales, I. Roshchin, I. K. Schuller, J. B. Kortright, K. Chesnel, S. Park and M. R. Fitzsimmons, Oral contribution to the 49th Annual Conference on Magnetism and Magnetic Materials, Jacksonville (USA), November 2004.
[34] Magnetic properties of organic Materials, Ed. P.M. Lahti, M. Dekker, New York, 1999, and references therein
[35] J. Veciana, H. Iwamura, MRS Bulletin 2000, 25, 41 and references therein
[36] M. Tamura *et al*. Chem. Phys. Lett. 1991, 186, 401; A. Alberola *et al*. Chem. Int. Ed. 2003, 42, 4782; M.M. Matshushita *et al*. J. Am. Chem. Soc. 1997, 119, 4369; A.J. Banister *et al*. Angew. Chem. Int. Ed. 1996, 35, 2533; A. Caneschi *et al*. Adv. Matter. 1995, 7, 476; M.P. Allemand *et al*. Science 1991, 253, 301.
[37] R. Moroni, C.C. Moulin, G. Champion, M.A. Arrio, P. Sainctavit, M. Verdaguer, and D. Gatteschi, Phys. Rev. B 68, 064407 (2003); M. Verdaguer, T. Mallah, C. Hélary, F. L'Hermite, P. Sainctavit, M.A. Arrio, D. Babel, F. Baudelet, E. Dartyge, A. Fontaine, Phys. B, 1995, 208-209, 765.
[38] M. F. Collins, *Magnetic Critical Scattering*. Oxford series on Neutron scattering in condensed matter, ed. S.W. Lovesey and E.W.J. Mitchel. Vol. 4. 1989: Oxford University Press.

[39] S. Brauer *et al.*, Phys. Rev. Lett. 74, 2010 (1995). S. B. Dierker *et al.*, Phys. Rev. Lett. 75, 449 (1995). T. Thurn-Albrecht *et al.*, Phys. Rev. Lett. 77, 5437 (1996). S.G. J. Mochrie *et al.*, Phys. Rev. Lett. 78, 1275 (1997).

[40] J.F. Peters *et al.*, ERSF Newsletter 34, 15 (2000)

[41] H.A. Dürr, E. Dudzik, S.S. Dhesi, J.B. Goedkoop, G. van der Laan, M. Belakhovsky, C. Mocuta, A. Marty and Y. Samson, Science 248, 2166 (1999) , H.A. Durr, E. Dudzik, S.S. Dhesi, J.B. Goedkoop, G. van der Laan, M. Belakhovsky, C. Mocuta, A. Marty, Y. Samson, J. Synchrotron Radiation 7, 178 (2000)

[42] G.A. Prinz, Science 282 (1998) 1660.

[43] B. Dieny, V.S. Speriosu, S.S. Parkin, B.A. Gurney, D.R. Wilhoit, D. Mauri, Phys. Rev. B 43 (1991) 1297.

[44] M.N. Baibich, J.M. Broto, A. Fert, F. Nguyen van Dau, F. Petroff, P. Etienne, G. Creuzet, A. Friederich, Phys. Rev. Lett. 61 (1988) 2472.

[45] G. Xiao and C.L. Chien. Appl. Phys. Lett. 51 (1987) 1280.

[46] B. Sanpedro, P. Crespo, A. Hernando, R. Litrán, J. C. Sánchez López, C. López Cartes, A. Fernández, J. Ramírez, J. González Calbet, and M. Vallet. Phys. Rev. Lett. 91, (2003) 237203

[47] C. de Julián, M. Emura, F. Cebollada and J.M. González. Appl. Phys. Lett. 69 (1996) 4251.

[48] P. Crespo, R. Litrán, T. C. Rojas, M. Multigner, J. M. de la Fuente, J. C. Sánchez-López, M. A. García, A. Hernando, S. Penadés, and A. Fernández. Phys. Rev. Lett. 93 (2004) 87204.

[49] Y. Yamamoto PRL93 2004 116801

[50] J. Phys. D:Appl. Phys. 36, R167 (2003).

[51] V.F. Puntes, K.M. Krishnan, A.P. Alivisatos. Science, 291, 2115 (2001).

[52] M. N. Baibich et al Phys. Rev. Lett. 61 (1988) 2472

[53] Berkowitch et al Phys. Rev Lett, 68 (1992) 3745

[54] J.Q. Xiao et al, Phys. Rev. Lett. 68 (1992) 3749

[55] P. Gambardella et al., Nature 416, 301 (2002); Phys. Rev. Lett. 88, 047202 (2002); Science 300, 1130 (2003).

[56] F. Luis et al., Phys. Rev. Lett. 88, 217205 (2002), Phys. Rev. B 65, 094409 (2002)

[57] P. Bruno, Phys. Rev. B 39, R865 (1989); G. van der Laan, J. Phys. Cond. Matter 10, 3239 (1998)

[58] B. Ujfalussy, L. Szunyogh, P. Bruno and P. Weinberger, Phys. Rev. Lett. 77, 1805 (1996)

[59] N. Nakajima et al., Phys. Rev. Lett. 81, 5229 (1998).

[60] F.J. Castaño, K. Nielsh, C.A. Ross, J.W.A. Robinson and R. Krishnan, Applied Physics Letters 85(4)(004)2872

[61] L.J. Heyderman, F. Nolting and C. Quitmann, Applied Physics Letters 83(9)(2003) 1797

[62] C. Binns, F. Sirotti, H. Cruguel, S.H. Baker, P. Prieto, J.D. Bellier and S.C. Thorton, J. Phys.: Condens Matter 15(2003)4287

[63] D. P. DiVincenzo, "Quantum computation", Science 270, 255-261 (1995).

[64] G. Salis, et al., Nature 414, 619 (2001); B. Beschoten, et al., Phys. Rev. B 63, R121202 (2001)

[65] Tudosa, I., *et al*., Nature 428, 831 (2004); Schumacher, H.W. *et al*., Phys. Rev. Lett., 90 017201 (2003); Acremann, Y. *et al*., Science 290, 492 (2000); Gerrits, T. *et al*., Nature 418, 509 (2002).

[66] Beaurepaire, E. *et al*., Phys. Rev. Lett. 76, 4250 (1996); Hohlfeld, J. *et al*. Phys. Rev. Lett.78, 4861 (1997).

[67] E. Fatuzzo, Phys. Rev. 127, 1999 (1962).

[68] B. Koopmans *et al*., J. Phys.-Condens. Matter 15, S723 (2003).

[69] J.A. Gupta *et al*. Science 292, 2458 (2001).

[70] A.Y. Elezzabi *et al*., Appl. Phys. Lett. 68, 3546 (1996).

[71] K. Mackay *et al*. J. Appl. Phys. 87, 1996 (2000).

[72] W.K. Hiebert *et al*,. Phys. Rev. Lett.79, 1134 (1997); M.R. Freeman *et al*., J. Appl. Phys. 83, 6217 (1998).

[73] P. Kabos *et al*., J. Appl. Phys. 87, 5980 (2000).

[74] Bonfim, M., *et al*., Phys. Rev. Lett., 2001 86 3646-3649; Camarero, J., *et al*., Phys. Rev. B, 2003. 67

[75] Vaterlaus, A., *et al*., Phys. Rev. Lett., 1991. 67 3314-3317; Scholl, A., *et al*., Phys. Rev. Lett., 1997 79 5146-5149; Aeschlimann, M., *et al*., Phys. Rev. Lett., 1997 79 5158.

[76] Choe, S.B., *et al*., Science, 2004. 304 420-422; Pennec, Y., *et al*.,. Phys. Rev. B, 2004. 69; Vogel, J., *et al*., Appl. Phys. Lett., 2003. 82 2299-2301.

[77] J. M. Tonnerre *et al.*, Phys. Rev. Lett. 75, 740 (1995); J.M. Tonnerre, L. Sève, A. Barbara, F. Bartolomé, D. Raoux, V. Chakarian, C-C. Kao, H. Fisher, O. Fruchart, J. Applied Physics 83, 6293 (1998), H. A. Dürr *et al*., Science 284, 2166 (1999).

[78] A. Déchelette et al. Phys. Rev. B 60 6636 (1999), T.P.A. Hase *et al*., Appl. Phys. Lett. 79, 985 (2001)

[79] E.E. Fullerton *et al*., Nucl. Instrum. & Meth. Phys. Res. Sect. B 200, 202 (2003).
[80] O. Hellwig *et al*., Phys. Rev. B 65, 14 (2002).
[81] J. Miguel *et al*., In preparation.
[82] D. Gatteschi, et al. *Angew. Chem. Int. Ed. Engl*. **42**, 268 (2003).
[83] R. Sessoli, D. Gatteschi, A. Caneschi, and M. A. Novak, *Nature* (London) **365**, 141 (1993).
[84] J. R. Friedman, M. P. Sarachik, J. Tejada, and R. Ziolo, Phys. Rev. Lett. **76**, 3830 (1996); J. M. Hernández, X. X. Zhang, F. Luis, J. Bartolomé, J. Tejada, and R. Ziolo, Europhys. Lett. **35**, 301 (1996); L. Thomas, F. Lionti, R. Ballou, D. Gatteschi, R. Sessoli, and B. Barbara, Nature **383**, 145 (1996).
[85] D. Ruiz-Molina et al. *Adv. Mater*. **15**, 42 (2003).
[86] A. Cornia et al. *Angew. Chem. Int. Ed. Engl*. **42**, 1645 (2003)
[87] A. P. Alivisiatos Abstr. Pap. Am. Chem. Soc. 216 U337 (1998).
[88] S. Empedocles and M. Bawendi, Acc. Chem. Res. 32 389 (1999); H. J. Dai, E. W. Wong, and C. M. Lieber, Science 272 523 (1996).
[89] J. Lüning and .J. Rockenberger, Solid State Comm. 112 5 (1999); S.S. Dhesi, H. A. Dürr, E. Dudzik, G. van der Laan, and N.B. Brookes, Phys. Rev. B 61 6866 (2000).
[90] J. Rockenberger, F. Nolting, J. Lüning, J. Hu, and A.P. Alivisiatos, J. Chem. Phys. 116 6322 (2002).
[91] *Properties and Applications of Intermetallic Compounds, Volume 4, Magnetic, Electrical and Optical.* Eds. J.H. Westbrook, R.L. Fleischer (John Wiley & Sons, New York, 2000).
[92] X. Amils et al. Phys. Rev. B **63**, 052402 (2001); and IEEE Trans. Magn. **34**, 1129 (1998).
[93] G.F. Zhou and H. Bakker, Mater. Trans. JIM **36**, 329 (1995).
[94] J.C. Krause et al. Phys. Rev. B **61**, 6196 (2000).
[95] G.K. Wertheim, et al. Phys. Rev. Lett. **12**, 24 (1964).
[96] V.N. Antonov et al. Phys. Rev. B **68**, 214425 (2003).
[97] R.M. Galera et al. J. Synchr. Rad. **6**, 676 (1999).
[98] H. Maruyama et al., Physica B **209**, 787 (1995).
[99] J. Nogués et al. unpublished.
[100] M. L. Fdez-Gubieda, A. García-Arribas, J. M. Barandiarán, R. López Antón, I. Orue, P. Gorria, S. Pizzini, A. Fontaine, Phys. Rev. B, **62** (2000), 5746;
[101] M. L. Fdez-Gubieda, I. Orue, P. Gorria, S. Pizzini, A. Fontaine, J. Synchrotron Radiat., **8** (2001), 443
[102] N. Menyuk, K. Dwight, and D. G. Wickham, Phys. Rev. Lett. 4, 60 (1960).
[103] S. Ohkoshi, Y. Abe, A. Fujishima, and K. Hashimoto, Phys. Rev. Lett. 82, 1285 (1999).
[104] S. Pizzini, L. M. Garc´ıa, A. Fontaine, J. P. Rueff, J. Vogel, R. M. Galera, J. B. Goedkoop, N. B. Brookes, G. Krill, and J. P. Kappler, J. Electr. Spectr. 86, 165 (1997).
[105] Y. G. Chukalkin and V. R. Shtirts, Phys. Stat. Sol. A 173, 459 (1999).
[106] F. Bartolomé, J. Bartolomé, and J. Campo, Physica B 312, 769 (2002).
[107] I. O. Troyanchuk et al., J. Phys.: Condens. Matter 15, 8865 (2003).
[108] G. J. Snyder et al., Phys. Rev. B 55, 6453 (1997); I. O. Troyanchuk et al., J. Phys.: Condens. Matter 11, 8707 (1999); O. Pena et al., J. Mater. Chem. 12, 2480 (2002); O. Pena et al., Solid State Sciences 5, 1217 (2003); J. Hemberger et al., Phys. Rev. B 70, 024414 (2004).
[109] D. Weller et al., Phys. Rev. B 49, 12888–12896 (1994)
[110] K.W. Edmonds et al., Phys. Rev. B 60, 472–476 (1999);
[111] H. A. Dürr et al., Phys. Rev. B 59, R701 (1999)
[112] R. Moroni et al., Phys. Rev. B 68, 064407 (2003).
[113] P. Ghigna et al., Phys. Rev. B 64, 132413 (2001).
[114] F. Bartolomé et al.; J. Magn. Magn. Matter 272-276, 319 (2004)
[115] Giapintzakis et al, APS March meeting, and Science 304 42 (2004).
[116] Coey et al. Nature 420 156 (2002)
[117] P Esquinazi et al. Phys Rev. Lett. 91 227201 (2003)
[118] O Céspedes et al. J. Phys.: Condens. Matter 16 L155 (2004)
[119] T Makarova et al. Magnetic carbon Nature 413 716 (2001)
[120] K. Tanaka et al., Phys. Rev. B 47, 7554 (1993)
[121] Antorrena, G et al., . Chemical Communications. London, 15 (1999)
[122] R. J. Nemanich et al. App. Surf. Sci. 146, 287 (1999).
[123] D.D. Sarma, et al.; Phys. Rev. Lett.; 93, 097202, (2004).
[124] A. Barinov et al, CHEM. PHYS. CHEM. 3, 1019 (2002).
[125] A. Locatelli et al., Surf. Sci. 566, 1130 (2004).
[126] C. Morin et al. J. Elec. Spec. Rel. Phen. 121, 203 (2001)

[127] S. Anders et al, J. Vac. Sci. Tech. A 17, 2731 (1999) ; K.Y. Eun et al., ALS Abstract Compendium (2000).
[128] F. Ratto et al, Appl. Phys. Lett. 84, 4526 (2004).
[129] Aballe et al. Phys. Rev. Lett. 93, 196103(2004).
[130] F.-J. Meyer zu Heringdorf et al, Phys. Rev. Lett. 86, 5088 (2001).
[131] C. Morin et al. J. Elec. Spec. Rel. Phen. 137-40, 785 (2004) ; R. Fink et al., ALS Abstract Compendium (2001).
[132] L. Aballe, A. Barinov, et al., Phys. Rev. Lett. 93, 196103 (2004)
[133] J. Stöhr. NEXAFS Spectroscopy. Springer Series in Surface Sciences 25. Ed. Springer-Verlag (1992)
[134] A.P. Hitchcock, C. Morin, Y.M. Heng, R.M. Cornelius and J.L. Brash, J. Biomaterials Science, Polymer Ed. 13 (2002) 919-938
[135] C. Morin, H. Ikeura-Sekiguchi, T. Tyliszczak, R. Cornelius, J.L. Brash, A.P. Hitchcock A. Scholl, F. Nolting, G. Appel, A. D. Winesett, K. Kaznacheyev and H. Ade, X-ray Spectromicroscopy of immiscible polymer blends: polystyrene-poly(methyl methacrylate), J. Electron Spectroscopy121, 203 (2001).
[136] Y. Liu, M.G. Samant, J. Stöhr, H.R. Brown, T.P. Russell, A. Cossy-Favre, and J. Díaz, Macromolecules 30 (1997) 7768-7771
[137] A. Cossy-Favre, J. Díaz, Y. Liu, M.G. Samant, J. Stöhr, S. Anders, H.R. Brown and T.P. Rusell. Macromolecules 31 (1998) 4957-4962
[138] C. Morin, A. P. Hitchcock, R. M. Cornelius, J. L. Brash, A. Scholl, A. Doran, J. Electron Spectroscopy 137-140, 785 (2004).
[139] A. J. Epstein. MRS Bulletin 28, 492 (2003).
[140] P. Esquinazi et al. Phys. Rev. Lett. 91, 227201 (2003).

5. PROPOSED SET-UP OF THE POLUX BEAMLINE

A soft X-ray beamline to perform light polarisation dependent experiments in the 80-2000 eV photon energy range is proposed. This energy range covers the $L_{2,3}$ edges of 3d transition elements, the $M_{4,5}$ and $N_{4,5}$ edges of rare earths, the $N_{4,5}$ of actinides, and the K-edges of important ligands such as nitrogen and oxygen as well and other light elements (Na, Mg, Al, and Si).

High photon flux (>10^{12} photons/sec), high spectral resolution (E/ΔE > 8000), high energy-stability (essential for dichroism measurements) and fast scanning are the basic requirements.

Two separate branches on the same beam line after the monochromator are proposed to allow setting up several independent experimental stations. One related to the magnetic spectroscopy and magnetic scattering experiments and the other one dedicated to x-ray photoelectron microscopy (XPEEM) measurements. The requirements for the best instrumental performance of the two branches are: high coherence length and variable photon-beam size, respectively. In order to meet these requirements, we propose Variable Line Space (VLS) gratings solution for the monochromator and adaptive plane elliptical (bendable) mirrors for the re-focusing. The "index" of the beamline set-up is the following:

5.1. SOURCE

5.2 OPTICS

5.2.1. MONOCHROMATOR

5.2.2. MIRRORS

5.3 EXPERIMENTAL END STATIONS

5.3.1. SPECTROSCOPY AND SCATTERING BRANCH

5.3.1.1. HIGH MAGNETIC FIELDS AND LOW TEMPERATURE CHAMBER.

5.3.1.2. DIFFRACTOMETER FOR ANGLE SCATTERING EXPERIMENTS.

5.3.2. MICROSCOPY BRANCH

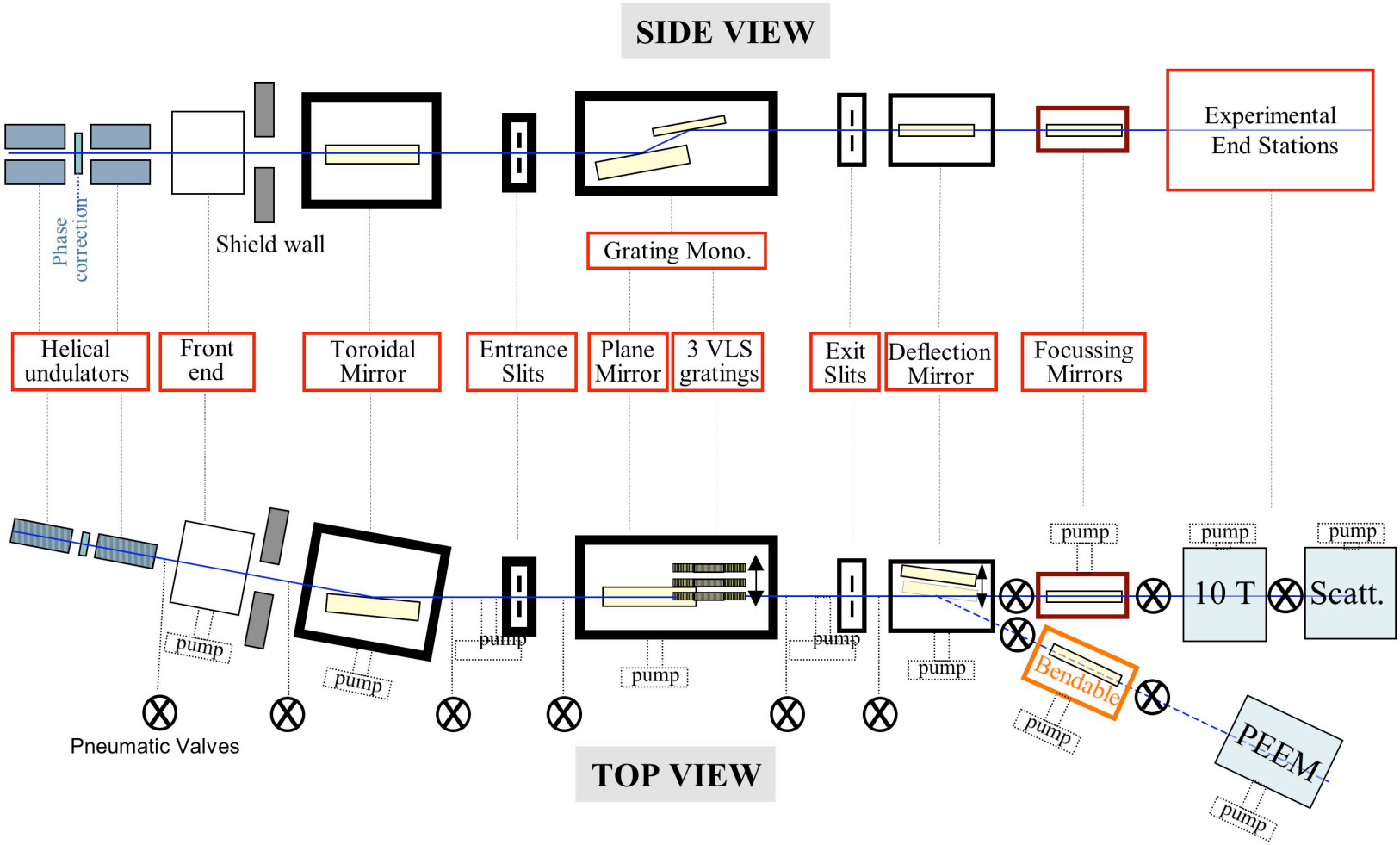
5.4 ESTIMATED BEAMLINE-COST

5.1 SOURCE

The definitive insertion device should be studied taking into account the final synchrotron machine characteristics. However, in principle, two APPLE II type (Advanced Planar Polarised Emitter) undulators coupled by a phase modulation electromagnet will be able to provide linear polarisation in all orientations, elliptical and both circular polarisations in the desired spectral range. This scheme is chosen just to have the best mechanical configuration. This design will provide full control over the photon polarisation. Two different control modes are proposed:

- Tuneable polarisation at 'reasonable' rates (< 1 min) by using both undulators.
- Fast (automatic) switching between left and right circular polarisation or vertical and horizontal linear polarisation for spectroscopy (difference spectra) and microscopy (difference imaging). This latter will only be implementable assuming the adopted source design takes up only 1/2 of the straight section and that funds are found to build the second half of the two undulator scheme required for fast polarisation switching.

The source should be placed in a 4.3 m straight length section of ALBA to get the high coherence length and flux and the small beam-size required.



Polarized Soft X-ray Beamline Layout

5.2 OPTICS

To preserve both (i) the coherence and (ii) the high brilliance of the source up to the sample the main requirements are:

(i) To use as few optical elements as possible. For instance, holography-based measurements require a coherence length that is longer than the optical path length differences encountered in the experiment.

(i) The surface roughness of all the optics will have to be very good to preserve the reflectivity at the highest energies; an rms roughness of 3 Å or less should be sufficient.

5.2.1 MONOCHROMATOR

The particular demands of high energy-stability, reproducibility and fast scanning can be meet by using a grating monochromator in which the line spacing is varied (VLS). With a plane VLS grating, one can cover a large energy range with a relatively small change in the resolving power. The correct choice of line spacing variation will minimize the change in focal length over the energy range and hence allows the exit slit to be fixed at a the mid-value for each scan range without (significantly) degrading the resolution with defocus at the ends of the scan range. In addition, the monochromator efficiency can be maximised by the use of low groove density gratings, while maintaining a resolving power in excess of 8000.

The desired energy range covers the $L_{2,3}$ edges of 3d transition elements as well as the $M_{4,5}$ and $N_{4,5}$ edges of rare earths. The access to the K-edges of important ligands such as nitrogen and oxygen as well as other light elements (sodium, magnesium, aluminium and silicon) will equally be possible. We propose to restrict full power operation to above 250 eV in order to keep optics specifications within currently feasibly fabrication and cooling technology. Three interchangeable gratings will be required to cover the required total energy range. The grating ranges will be optimised to combine energies of likely correlative interest onto a single grating. For instance:

- Grating #1, optimised for 80-600 eV. (*K* edges of C, N and O)
- Grating #2: optimised for 500-1100 eV (*L* edges of transition metals)
- Grating #3: optimised for 900-2000 eV (*M* edges of rare-earth metals)

5.2.2 MIRRORS

In the 4.3m straight length sections of Alba, the source has horizontal and vertical sizes around 151x50 μm^2 full widths at half maximum (FWHM) and horizontal and vertical angular divergence around 40x6 μrad^2 FWHM. The beam could be collimated by using a horizontal toroidal mirror and a plane mirror placed before the monochromator. The later is placed in front of the grating and is used to set the energy of the monochromator outgoing photons by changing the angle between the incident and diffracted beams. In this way, a large energy range with a relatively small change in the resolving power is achieved. By coupling the rotation of mirror and grating, the beam can always be diffracted in the desired direction.

After the exit slit a plane mirror should be inserted in order to deflect the light to the PEEM branch. The final demagnetization factors that must be reached for the two branches should be different. In the Spectroscopy and Scattering branch, the high photon beam coherence length need it to perform coherent x-ray scattering experiments can be managed by using a low demagnetization factor, i.e. small focusing factor. On the contrary, in the PEEM branch a high demagnetization factor must be employed to achieve very high spatial resolution (< 20 nm) and perform magnetic imaging

exploiting dichroism at that resolution. The refocusing sections for both branches must hence be different. To avoid additional optical elements, the Spectroscopy and Scattering branch should be aligned straight with the direction of the outgoing photons from the monochomator to get the highest coherence of the beam on the experimental end stations.

For the second branch, i.e. the PEEM branch, a *tuneable microsize photon-beam* with high photon flux is necessary in order to enhance the signal level as much as possible and to permit to acquire images with *different field-of-views* in reasonable times. Equally important as a small spot is the possibility to increase the spot size in order to match it to the field of view of the microscope. The solution was found by the Nanospectroscopy beamline at Elettra synchrotron in collaboration with the French factory S.E.S.O., and is based on bendable gold-coated Si mirrors[1]. By applying the correct force to a plane or spherical substrate, it is possible to deform it with the desired shape (in this case an ellipsoid). Since the deformation is controlled and reproducible, it is possible to obtain the desired shape and modify it according to the requirements. Finally, inhomogeneities of the beam due to random instabilities from the source (< 0.1 μm) can be solved by replacing the single Si block of the bendable mirrors by two Si blocks separated by a piezoelectric film[2].

5.3 EXPERIMENTAL END-STATIONS

Two separate branches operating alternatively on the same beam line after the monochromator are proposed. One related to the spectroscopy and scattering experiments and the other one dedicated to microscopy measurements. The latter can be operated without the photon beam as an independent laboratory and could encourage to the beamline scientific staff to perform its own research projects without using the x-ray beam. The different information that could be obtained in the experimental end-stations can be also found in ANNEX I.

5.3.1 SPECTROSCOPY AND SCATTERING BRANCH

Two independent experimental end stations are proposed. One will be dedicated to perform spectroscopy measurements with high magnetic fields (10 T) and low temperatures (4 K). The second one will be dedicated to perform spectroscopy and magnetic scattering measurements at moderate magnetic fields (< 1 T) in a 200-1000 K range of temperatures.

5.3.1.1. *High Magnetic Fields and Low Temperature Chamber*

We propose to build a 10 T magnet designed especially for soft x-ray XMCD and XMLD measurements. The magnetic field should be ramped up relatively fast (of the order of 0-10 Tesla in 2 minutes, and +5 to -5 Tesla in 1 minute). The sample must be vacuum-mounted onto a LHe variable temperature, 180 degrees rotable insert with a minimum temperature of 2K approx. The sample space should attain ultra-high vacuum conditions by cryo-pumping of the liquid helium can.

The low temperature 10 T superconducting magnet allows perform XMCD and XMLD experiments to many different aspects of new magnetic phenomena (nanomagnetism, interface spin polarization, isolated atoms on surfaces …). Also a large part of the projects of bulk magnetism should be realized in this low-temperature – high-field end station.

Both total electron yield and fluorescence detection must be available simultaneously, while transmission should be a possibility when requested.

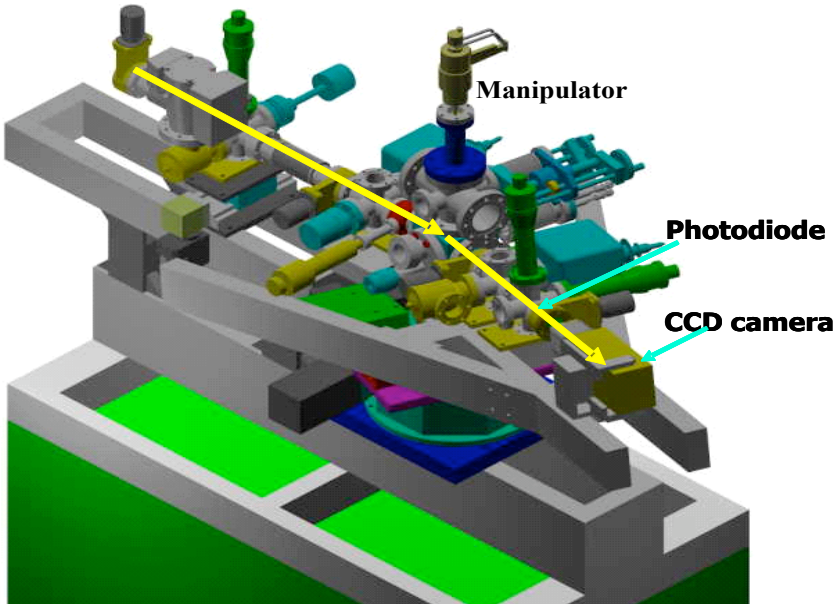
Although this kind of equipment is not standard commercial to this date, it is very probable that it will be part of the Oxford Instruments Superconductivity catalogue at the moment of the beamline development, and the adequacy of the commercial offer will have to be studied at that time.

A secondary UHV chamber allowing to load several samples at a time and to prepare sample surfaces should be available. The samples would be transferred into the magnet with a magnetic transfer rod. The preparation chamber has to be equipped with several preparation tools, such as cleaver for single crystals, a diamond file scraper for poly-crystalline samples and a sputter gun sample and heater stages (up to 300 K for annealing in gas atmospheres, up to 1000 K for single crystals), e-beam evaporators, etc.

5.3.1.2. *Diffractometer for angle scattering experiments*

Soft x-ray resonant reflectivity and XMOKE are therefore very useful techniques for the analysis of complex layered or nanostructured materials. They are complementary in several aspects to the standard x-ray magnetic circular dichroism (XMCD) in absorption spectroscopy. XMCD, for example, allows the quantification of the orbital and spin magnetic moments present in the sample. Due to the contribution of magneto-optical effects, this is problematic in soft x-ray XMRS. On the other hand, XMRS and XMOKE in the soft x-ray range allow the study of magnetization reversal processes.

We propose to build up a vacuum soft x-ray diffractometer similar to the system developed for Jeroen Goedkoop from University of Amsterdam (see Figure).



Soft x-ray diffractometer (courtesy of Prof. J. Goedkoop, University of Amsterdam).
Note that all the motions are outside of the vacuum.

The experimental requirements can be met by a UHV chamber and a detector in situ, which can be as simple as a Si diode mounted on a rotatable feed through with moderate angular precision to measure in both transmission and reflection (± 10º) geometries. The magnetic field inside can be

easily generated by external electromagnets up at moderate strengths (0.5 T). The limitation of maximum field is not a problem for soft magnetic materials, most of 3d-metal thin-film magnetism.

Moreover, spectra could also be simultaneously measured in drain current and fluorescence yield mode. This would be very important because will be an easy way to perform XMCD and XMLD experiments on particular systems that not require high magnetic fields and low temperature measurements. Moreover, it can offer an improved solution, in terms of data collection efficiency for spectroscopy measurements. Within the chamber, the external electromagnet system allows field-modulated XMCD measurements, so called as *flipping mode*. In normal electromagnets the field can be switched with moderate frequencies (0.1-20 Hz) without significant changes of their permeability properties. Modulating the field increases the sensitivity since it eliminates drifts in the beamline. To avoid offsets in the spectra generated by beamline drifts, fixing the helicity the absorption is measured at each energy value with the sample saturated in both directions. Finally, collecting the data for both light helicities in the same way, the average of the two spectra is highly reliable[3].

Magnetic field-dependent measurements in transmission and reflection geometry with the field applied perpendicular or parallel to the film surface could be performed. In this case, field dependence of the absorption intensity reproduces the magnetization hysteresis curve with element-selectivity. On the other hand, field dependent q-space resolved images can be also measured by using a beam stop for the transmitted beam and 2D detector. From the latter, valuable information on the magnetic domain structure during the reversal is obtained.

In a holographic experiment the phase information must be recorded via the interference of the wave scattered by the specimen (object wave) with a known reference wave (see ANNEX I). In in-line holography, a spherical wave is created by illumination of a sufficiently small pinhole. The sample is illuminated by the spherical wave and the interference between the undisturbed spherical wave and the wave scattered from the sample is observed. For this purpose, a small diameter (i.e. 2mm) pinhole must be located in front of the sample restricted the sample illumination to a volume smaller than the coherence volume of the x-ray beam at the sample position[4].

5.3.2 MICROSCOPY BRANCH

The Microscopy branch is proposed to perform photoemission microscopy PEEM experiments with high lateral resolution (< 20 nm). It can be dedicated as a chemically specific microscopy in earth and environmental science, in corrosion protection and in the field of biological surfaces.

A photoelectron emission microscope (PEEM) essentially consists of an imaging electrostatic electron lens system. The basic principle is as follows: the photoelectrons excited for the incoming photons are emitted from the surface and are imaged first onto a channel plate for intensification and finally onto a fluorescent screen for direct inspection or observation using a CCD camera. In contrast to a scanning electron microscope (SEM), the PEEM does not use a scanned probed beam, but the sample surface is uniformly illuminated. With respect to its parallel image acquisition, the basic principle of operation is similar to an optical microscope. However, since electrons are used for imaging the resolution is not longer diffraction-limited. By using soft X-rays, for instance, characteristic core-levels become accessible and permit “element specific” imaging. For polarized photon beams, magnetic circular or linear dichroism can be exploited in order to image “magnetic microstructures” with high lateral resolution.

Many commercial companies have developed PEEM instruments but we propose to use the Spectroscopic Photoemission and Low Energy Electron Microscope PEEM-LEEM from ELMITEC

(see ANNEX II). This instrument is an extremely versatile and powerful instrument for the study of complex systems and processes. An important advantage of this instrument with respect to simple PEEM systems is the availability of LEEM and LEED for obtaining structural information from the same sample with lateral resolution of 10 nm and with atomic depth resolution. Therefore, this microscope will allows to study at the same time the structural, electronic, chemical, and magnetic properties of matter, and it is particularly suited for the study of growth processes and thin films.

The possibility of performing illumination with low energy electrons and their associated techniques (LEEM, LEED, SPA-LEED, EELS) provides not only essential and complementary structural information on the samples, but permits both to carry out aligning of the microscope and preliminary experiments independently from the photon beam. This is extremely important for an end-station from a branch beamline working in shifts. Especially alignment is much easier and faster with the strong intensity from LEEM electrons.

An XPEEM end station is a complicated piece of equipment and will need of a highly dedicated personnel, providing strong user support. The experience at other synchrotrons shows that almost full-time presence of beamline personnel is required for most users. It is therefore important to stress that this beamline should have several highly motivated full-time beamline scientists.

PEEM-LEEM requirements

- The geometry of the PEEM-LEEM should be able to have the sample lie horizontally, so that focus broadening due to grazing incidence is in the vertical beam direction and a homogeneously illuminated large field of view is easier to realize.

- Feasibility to rotate the sample by ± 90 degrees. Keeping the polarization of the light, the simple experimental way to discern between magnetization components parallel and perpendicular to the surface plane is by rotating the sample 180º. Only the in-plane components will change the magnetic contrast. Additionally, domains and domains walls sensitivity can be achieved by rotating the sample.

- Broad temperature range accessibility. Ideally cooling with N or He and heating (electron bombardment) up to 2000C. Stable temperature would permit measuring at low temperatures (no drift).

- High speed measurements, energy resolution goal 0.1eV (currently 0.2 at SLS) If not implemented in the first phase, the possibility to have spherical aberration correction (and thus improved spatial resolution down to 5nm in XPEEM and even better in LEEM) should be left open. Similar instruments with aberration correction under construction are PEEM3 at ALS, SMART at BESSY. SOLEIL microscope is planned to have also aberration correction.

4.4 ESTIMATED BEAMLINE-COST

Source	
Insertion Devices (2 APPLE II undulators)+ Front End	400 k€
Total	**400 k€**
Beamline & Optics	
Mirrors and Mechanisms 1 Toroidal mirror 2 plane mirrors 2 Bendable (Si/piezoelectric/Si) mirrors	 80 k€ 100 k€ 170 k€
Monochromator system (3 VLS gratings)	100 k€
Other equipment (Slits + flight tubes + valves+ pumps + etc)	550 k€
Total	**1000 k€**
Experimental End Stations	
10 T He-cryostat system	600 k€
Scattering system (3 goniometers, pumps, manipulator, detectors…)	250 k€
SPLEEM (PEEM+LEEM microscope+energy filter+pump+…)	850 k€
Total	**1700 k€**
Other equipment (CCD camera)	**300 k€**
TOTAL	**3400 k€**

[1] J.J. Fermé, G. Dahan, *Bendable Mirrors* SPIE 1998 Proceedings, Vol. 3447, San Diego, USA

[2] Danielle Cocco, private communication

[3] J.Camarero, Y. Pennec, J. Vogel, S. Pizzini, M. Cartier, F. Fettar, F. Ernult, A. Tagliaferri, N. B. Brookes, and B. Dieny, Phys. Rev. B **67**, 020413R (2003). Using the flipping-mode the authors reached a XMCD sensitivity of about 0.01%.

[4] S. Eisebitt, J. Lüning, W. F. Schlotter, M. Lörgen, O. Hellwig, W. Eberhardt and J. Stöhr, Nature **432**, 885 (2004)

ANNEX I: OVERVIEW OF THE PROPOSED TECHNIQUES

In order to give an idea to future users about the different information that could be obtained in the beamline here proposed, we will briefly describe the different soft x-ray polarization dependent techniques pointed out along this proposal.

The basis of the research proposed is to develop a polarized soft x-ray beamline at the ALBA synchrotron to be dedicated to spectroscopy, scattering and microscopy experiments on artificial systems. These techniques can be employed when information about electronic states, binding properties, element-resolved, space-resolved, and/or time-resolved properties is required.

I.1 X-ray absorption spectroscopy

X-ray absorption spectroscopy XAS refers to the absorption structure close to an absorption edge, about the first 30 eV above the actual edge. This region usually shows the largest variations in the x-ray absorption coefficient and is often dominated by intense, narrow resonances. In XAS the x-ray energy is scanned and the absorbed x-ray intensity is measured. XAS spectra can be recorded in different ways: fluorescence (photons emitted), transmission (photons absorbed) and electron (secondary electrons) yield measurements.

The combination of x-ray synchrotron radiation (i) and tuneable polarity (ii) makes possible to get different information of the system:

i.1 **Elemental contrast** is achieved by tuning the incident x-ray wavelength through absorption edges of elements. X-ray absorption and the resulting photo electron emission intensity is strongly enhanced at absorption edges. Areas on the surface containing the corresponding element emit more photoelectrons and thus appear bright in the Photoemission Electron Microscopy PEEM image at a given absorption edge X-ray energy.

i.2 **Chemical contrast.** XAS spectra are very sensitive to the bonding environment of the absorbing atom.

i.3 T**opographical contrast** (PEEM) is due to distortion of the electric field around surface topological features. The field distribution distortions disturb the electron trajectories which produces image contrast.

ii.1 **Magnetic contrast.** XAS spectroscopy is its polarization dependence**,** linear as well as circularly polarized light, can be used to probe the anisotropy of charge and spin. Magnetic information can hence be obtained employing magnetic circular dichroism (**XMCD**) or magnetic linear dichroism (**XMLD**), for ferromagnetic or antiferromagnetic materials respectively, by taking advantage of the polarization of the synchrotron radiation. The combination with a PEEM microscope gives magnetic spatial resolution of several nanometers.

ii.2 The **orientation** of molecular orbits can be probed with linear polarized X-rays, since the absorption is stronger when the electrical vector of the light and the orientation of the molecular orbit are parallel than for a perpendicular orientation.

I.2 Dichroism Spectroscopy and Microscopy

In optics, the term "dichroism" refers to changes in the absorption of polarized light on passing through a material in two different directions. Since materials typically absorb one color of white light preferentially, the material appears with two different colors for the two light directions - it is di- (two-) chroic (colored). Today, the term dichroism is used more generally to reflect the dependence of photon absorption of a material on polarization. *The origin of the dichroism effect can be anisotropies in the charge or the spin in the material*. In the later case

we speak of magnetic dichroism. Circular polarised light gives information about magnetization along the beam direction

X-ray spectromicroscopes combine the advantages of x-ray spectroscopy and x-ray microscopy in a single device. The combination of photoelectron emission microscopy PEEM for imaging with dichroism experiments is so called XPEEM. XPEEM can be exploited as a chemically specific microscopy in earth and environmental science, in corrosion protection and in the field of biological surfaces. XPEEM will provide a means to directly link structure to function through nanoscale spectroscopic data.

I.3 Soft x-ray Resonant Magnetic Scattering

Many methods are used to characterize the magnetism of thin films and confined magnetic structures. Among these, magneto-optical methods (MO) are a default tool. One powerful feature of MO techniques is hey are not hampered by magnetic and electric fields. MO effects in the visible-light region are widely used in the analysis of magnetic materials and find important technological applications e.g., in the reading process of MO disks. With the use of ultra-fast lasers they combine femto-second time resolution, important for studies of the dynamics of magnetization processes, with a spatial resolution in the submicron range (but > 0.3 μm). Although the latter is good enough to resolve mesoscopic magnetic structure, the spatial resolution could be improved by going to shorter wavelengths.

MO techniques in the visible-light region involve optical transitions between delocalized valence states, which renders it extremely difficult to spectrally separate the magnetic contributions of different elements in compounds and in advanced layered or nanostructured materials. This can be a severe limitation in analyzing magnetic nanostructures or heteromagnetic systems for information storage.

Fortunately, the development in synchrotron radiation techniques over the past 15 years has been as breathtaking as the rapid pace in magnetism research. The advent of undulator devices has resulted in high-intensity x-ray beams with complete control of the wavelength and the polarization. The latter development was strongly stimulated by the discovery of large polarization and spin dependent magneto-optical effects at the core level x-ray absorption edges of magnetic elements. Element sensitivity is naturally achieved by employing optical transitions that involve core electrons.

Scattering experiments are mostly performed using hard x rays (> 2 keV), which have the combined advantage of high spatial resolution and large penetration power. However, in the soft x-ray range the resonant magnetic scattering cross-sections are much larger and although the soft x-ray wavelengths are too large for the determination of the unit cell structure, they are perfectly suited to resolve the micromagnetic structure of domains and the artificially structured devices and objects encountered in the field of nanomagnetism.

In fact, polarization dependent soft x-ray resonant magnetic scattering (SXRMS) has been established as a new powerful tool for studying magnetic structures in surfaces and thin films on the nanometer length scale[1,2]. Magnetic scattering originates from deviations from uniform magnetization, and its maximum intensity is orders of magnitude stronger than the scattering at saturation. It is therefore extremely sensitive to the nucleation processes at the onset of magnetization reversal. In this context, at large field, the F is uniformly magnetized and there is no contribution to the scattering signal.

In the soft x-ray range the large resonant magnetic scattering cross sections are suited to resolve the magnetic structure of domains on length scales between 10 nm and 10 micron. Coherent x-ray interference techniques can, in principle, achieve a spatial resolution on the order of the

wavelength of the electromagnetic radiation. But the determination of non-periodic nanoscale structures by x-rays is difficult. Inversion of the measured diffuse x-ray intensity patterns suffers from the intrinsic loss of phase information. Very recently it has been shown that holography based method overcomes the central problem —the recovery of the phase information— with the use of a nanoscale reference aperture next to the sample that phases the recorded interference pattern[3].

I.4 Sub-nanosecond resolved experiments

For all the aforementioned experiments that can be performed in the proposed beamline there appears the possibility of realizing picosecond time-resolution experiments by using the inherent pulsed time structure of the synchrotron radiation Alba source with a pump-probe scheme[4]. Excitation pulses (the pump) are synchronized with the x-ray photon pulses (the probe) at the repetition frequency of the Alba source. For instance, the time-dependence of the magnetisation of the probed sample during and after the pulse can be studied by carrying out XMCD, XPEEM, or scattering measurements as a function of the delay between the pump and the probe. The ultimate time-resolution will be limited by the x-ray bunch width.

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1 H.A. Dürr, E. Dudzik, S.S. Dhesi, J. B. Goedkoop, G. van der Laan, M. Belakhovsky, C. Mocuta, A. Marty, and Y. Samson, *Science* **284**, 2166 (1999).

2 J. F. Peters, M. A. de Vries, J. Miguel, O. Toulemonde, and J. B. Goedkoop, ESRF Newsletter **34**, 15 (2000).

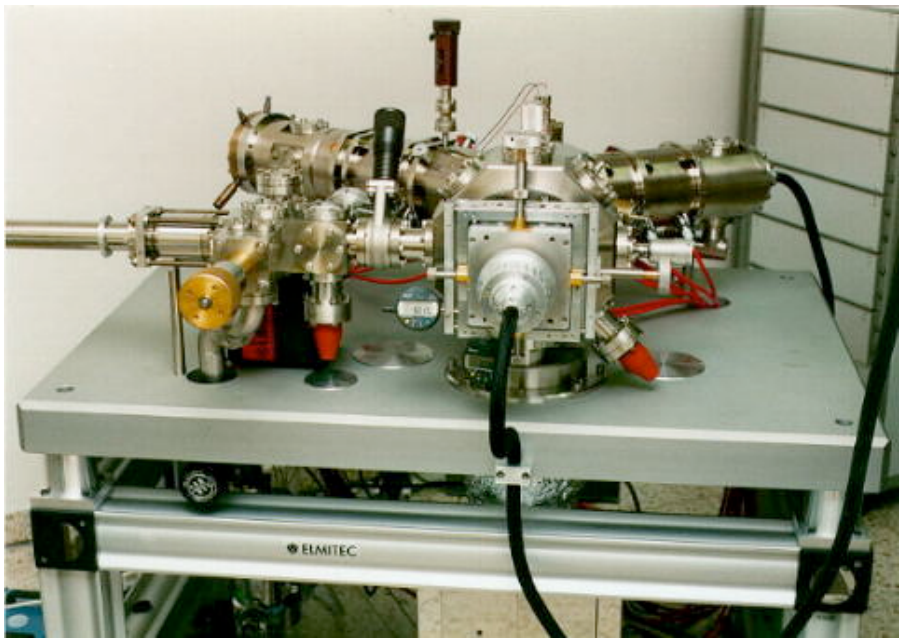
3 S. Eisebitt, J. Lüning, W. F. Schlotter, M. Lörgen, O. Hellwig, W. Eberhardt andJ. Stöhr, *Nature* **432**, 885 (2004)

4 M. Bonfim, G. Ghiringhelli, F. Montaigne, S. Pizzini, N. B. Brookes, F. Petroff, J. Vogel, J. Camarero, and A. Fontaine, Phys. Rev. Lett. **86**, 3646 (2001); J. Vogel, W. Kuch, M. Bonfim, J. Camarero, Y. Pennec, F. Offi, K. Fukumoto, J. Kirschner, A. Fontaine, and S. Pizzini, Appl. Phys. Lett. **82**, 2999 (2003); Jorge Miguel, private communication.

ANNEX II: PEEM-LEEM MICROSCOPY

A PEEM-LEEM microscope is an unique multi-method instrument, which combines microscopy and spectroscopy with high spatial and energy resolution, respectively, with LEED and energy-selected photoelectron angular distribution from selected small areas. With this instrument it is now possible to determine the structure and the morphology by LEEM/LEED/PED and the local chemical composition and chemical state by XPEEM/XPS on the same area of the surface on the10 nm-scale. This combination of imaging, diffraction and spectroscopy modes is presently possible only with this instrument. The spatial resolution allows the separation of particles with sizes smaller than 25 nm, and peak shifts of less than 0.2 eV can be measured.

The high brightness of third generation synchrotron radiation sources has opened the door to chemical and magnetic surface imaging with resolutions in the 10 nm range. A PEEM-LEEM instrument equipped with an energy filter was demonstrated to be a powerful instrument for spectromicroscopy (using linearly polarized light at the TGM5 undulator beamline at BESSY 1 in Berlin) and for imaging of magnetic domains (using circularly polarized light at the SX700-3 beamline at BESSY 1 in Berlin). In 2000 an improved new LEEM microscope was installed in a special beamline in ELLETRA called “Nanospectroscopy beamline”. It demonstrated not only the usefulness of the energy filter in XPEEM but also of the combination of XPEEM with LEEM and LEED. The instrument can be used alternately for XPEEM, LEEM, LEED, MEM and other imaging modes, depending upon the particular problem studied. The combination of these imaging, diffraction and spectroscopy modes allows a comprehensive characterization of the specimen. This is of particular importance when the chemical identification of structural features is necessary for the understanding of a surface or thin film process. Three other synchrotron radiation sources (in Switzerland, Japan and Australia) will soon be also equipped with PEEM-LEEM instruments.



Commercial PEEM-LEEM from Elmitec GmbH (http://www.elmitec.de)

II.1 System description

- Illumination system consisting of:
  - thermionic LaB_6 electron gun
  - magnetic condensor lenses
  - magnetic deflection coils
  - stigmator
  - illumination-aperture manipulator with 3 apertures
- Magnetic beam splitter
- Magnetic objective lens with deflectors and stigmator
- UHV specimen chamber with flanges for specimen transfer system, 7 2_" conflat flanges pointing directly forwards the sample surface for connection of a UV-short-arc-lamp (for PEEM), evaporators and other equipment, 7 further 2_" conflat flanges for viewports, gas inlet etc.
- Specimenmanipulator: 3 translations (±4 mm for X,Y and 25mm travel along manipulator axis) and 2 eucentric tilts ±4°, exchangeable sample cartridge with electron bombardment heating, W/Re-thermocouple .
- Sample temperature from room temperature up to 1500C°. Modification for cooling below room temperature is possible.
- Imaging system consisting of 5 magnetic lenses, 4 deflectors, 2 stigmators, 1 contrast aperture manipulator with three apertures and a chevron channel plate array with a fluorescent screen
- Video camera and monitor
- Sample preparation chamber, airlock, and a 24 inch magnetic transfer system
- Adjustable photo emission light source
- Power supplies, computer and control software for all electron optical elements (lenses, deflectors, stigmators).
- Ultra high vacuum system consisting of 3 ion getter pumps, 1 turbo-molecular pump, oil-free foreline pump, 2 Ti-sublimation pumps, bakeable valves and 3 UHV-ion-gauges, 1 thermocouple gauge, bakeout heaters and bakeout tent.
- One simple metal evaporator
- Mass Spectrometer, Ion sputtering gun in preparation chamber.
- Energy analyzer for spectroscopic imaging.

II.2 Specifications

- Imaging modes: bright- and darkfield-LEEM, mirror-microscopy, Thermionic- and Photo-emission Microscopy
- Resolution: < 5 nm in LEEM, < 15 nm in PEEM (The resolution in PEEM depends very much on the width of the energy distribution of the photoelectrons and the flux (XPEEM). For 0.1eV it can approach that of LEEM.)
- Transfer width in LEED > 50 nm, small area- and low angle-LEED
- Electron energy at the sample:-5 to 500 eV (mirror microscopy, LEEM, LEED)
- Field of view in LEEM: 2 - 40 µm, in PEEM: up to 100 µm
- Magnification: 400 - 20000
- Base pressure: $< 2 \times 10^{-10}$ Torr

II.3 PEEM-LEEM Imaging Methods

Low energy electron microscopy (LEEM) utilizes low energy, elastically backscattered electrons to image surfaces with high spatial and temporal resolution [Bauer]. Advantages of LEEM over other surface imaging techniques are: (a) real-time imaging capability, (b) several unique contrast mechanisms for image formation, (c) operation under extreme conditions. LEEM is a powerful tool for studying the dynamic and static properties of surfaces and thin films, including growth and decay, phase transitions, reactions, structure amd morphology, magnetism, and more
One basic instrumental feature of LEEM, the cathode lens, provides the possibility of combining LEEM with other surface imaging methods such as Mirror Electron Microscopy (MEM) and all forms of emission microscopy, foremost Photoelectron Microscopy (PEEM).

II.3.1 Secondary Electron Emission microscopy SEEM

MEM is very useful for non-crystalline or strongly charging specimens and for imaging of magnetic and electric fields in front of the specimen. In this case the energy of the incident electron beam is chosen to be at the low energy crossover of the secondary electron yield and the surface is imaged with secondary electrons. Due to their wide energy distribution and the chromatic aberration of the objective lens the resolution is not as good as in LEEM but the intensity is usually high. This allows again image acquisition at video rates. Contrast is determined by differences in secondary yield.

II.3.2 Mirror Electron Microscopy MEM

In MEM the specimen is more negative than the electron source so that the electrons are reflected in front of the surface. Contrast is determined by field distribution above the surface which depends upon the surface topography and the charge distribution on the surface. In the case of magnetic specimens also the magnetic field distribution above the surface can be imaged by proper illumination and imaging conditions. Its resolution is in principle comparable to that of LEEM but the field distribution above the surface causes a smearing of the contrast which effectively reduces the resolution somewhat. Otherwise, the operation conditions and application possibilities are the same as in LEEM. This includes in particular image acquisition at video rates.

II.3.3 Photoelectron Emission Microscopy PEEM

PEEM also does not require a crystalline specimen. It can be used to image not only the surface but also magnetic fields in front of it. For many applications laboratory light sources are sufficient. The increasing availability and brightness of synchrotron radiation has extended PEEM into the Soft X-ray range (XPEEM). XPEEM performed in PEEM-LEEM instrument allows chemical identification on the 10 nm scale with chemical shift sensitivity of a few tenths of an eV, provided the instrument is equipped with an imaging energy filter. Circular and linear polarized synchrotron light allows element-selective magnetic imaging, which makes use of circular and linear magnetic dichroism and has successfully been done in a PEEM-LEEM instrument. In this imaging method the photon-excited secondary electrons are used for imaging so that no energy filter is needed.

Related Bibliography:

History:
E.Bauer: S*urface electron microscopy: the first thirty years,* Surf. Sci 299/300, 102 (1994)

LEEM:
E. Bauer: *Low Energy Electron Microscopy*, Rep. Prog. Phys. 57 (1994) 895-938.

E. Bauer: *LEEM basics*, Surf. Rev. Lett. 5 (1998) 1275-1286.

T.Schmidt et al: *SPELEEM:combining LEEM and spectroscopic imaging*, Surf. Rev. Lett. 5 (1998) 1287.

E. Bauer and T. Schmidt: *Multi-Method High Resolution Surface Analysis with Slow Electrons, in:* High Resolution Imaging and Spectroscopy of Materials, ed. by F. Ernst and M. Ruehle (Springer, Berlin Heidelberg 2003) 363-390.

Raymond J. Phaneuf and Andreas K. Schmid *Low Energy Electron Microscopy: Imaging Surface Dynamics Physics Today, vol. 56, no. 3, March 2003*

XPEEM general:
E. Bauer: *Photoelectron spectromicroscopy: present and future*, J. Electron Spectrosc. Relat. Phenom. 114 – 116 (2001) 976 –987.

E. Bauer: *Photoelectron Microscopy*, J. Phys.: Condens. Matter 13 (2001) 11391 - 11405.

A. Locatelli, A. Bianco, D. Cocco, S. Cherifi, S. Heun, M. Marsi, M. Pasqualetto, and E. Bauer: *High lateral resolution spectroscopic imaging of surfaces: The undulator beamline "nanospectroscopy" at Elettra,* J. Phys. IV 104 (2003) 99 -102.

M. Klaeui, C. A. F. Vaz, J. A. C. Bland, T. L. Monchesky, J. Unguris, E. Bauer, S. Cherifi, S. Heun, A. Locatelli, L. J. Heyderman, and Z. Cui: *Direct observation of spin configurations and classification of switching processes in mesoscopic ferromagnetic rings,* Phys. Rev. B 68 (2003) 134426.

M. Bertolo, L. Gregoratti, S. Heun, B. Kaulich, and M. Kiskinova: *X-ray spectromicroscopy with synchrotron radiation: approaches and applications,i*n: Science, Technology and Education of Microscopy: an Overview, ed. A. Mendez-Vilas, Formatex, 2003.

E. Bauer, A. Pavlovska, S. Cherifi, S. Heun, A. Locatelli, R. Belkhou, J. A. C. Bland, M. Klaeui, C. A. F. Vaz, L. J. Heyderman, J. Shi, and W. C. Uhlig: *Micromagnetic studies with x-ray magnetic circular dichroism photo emission electron microscopy (XMCDPEEM),* Elettra Highlights 2002-2003, Sincrotrone Trieste (2003) 42 - 45.

O. Fruchart, M. Eleoui, J. Vogel, P. O. Jubert, A. Locatelli, and A. Ballestrazzi: *Nanometers-thick self-organized Fe stripes: bridging the gap between surfaces and magnetic materials,* Appl. Phys. Lett. 84 (2004) 1335 - 1337, also Virtual Journal of Nanoscale Science & Technology, Volume 9, Issue 8 (March 1, 2004).

ANNEX III. Beamlines dedicated to polarized dependent soft x-ray experiments.

Operative beamlines

BEAMLINE	Energy range	DE/E	Techniques	Status
ESRF (France) Dragon beamline, ID8 http://www.esrf.fr/UsersAndScience/Experiments/XASMS/ID08/	500-1500 eV	5000	XMCD XMLD (7 T, 4K) XRMS XPS	User operation since 1995
ALS (USA) 4.0.2 beamline http://www-als.lbl.gov/als/techspecs/bl4.0.2.html	90-1900 eV	7000	XMCD, XAS (6T, 2K) Advanced photoelectron spectrometer/diffractometer XPEEM	User operation
ALS (USA) 7.0.1 beamline http://www-als.lbl.gov/als/techspecs/bl7.0.1.html	100-800 eV	7000	Scanning Photoelectron microscope Soft x-ray fluoresce spectrometer	User operation
Spring-8 (Japan) Soft x-ray spectroscopy of solids BL25SU http://www.spring8.or.jp/e/facility-e.html	220-1900 eV		High resolution photoemission spectroscopy XPEEM XMCD (2T, 25K) XMLD (2T, 25K)	User operation since 1998
APS (USA) Soft X-ray Polarization Dependent Scattering and Spectroscopy, 4-ID-C https://beam.aps.anl.gov/pls/apsweb/beamline_display_pkg.display_beamline?i_beamline_id=4-ID-C	500-2800 eV	1000	XMCD XPS XRMS XPEEM	
BESSY II (Germany) UE56/PGM 1-2 http://www.bessy.de/users_info/02.beamlines/linespdf/ID_05_2.pdf	100-1200 eV	>6000	No end station facility	User operation since 2001
BESSY II (Germany) UE52-SGM http://www.bessy.de/users_info/02.beamlines/linespdf/ID_09_1.pdf	90-1500 eV		Microfocus, no end station facility	In operation since 2001

Operative beamlines (continued)

BEAMLINE	Energy range	DE/E	Techniques	Status
BESSY II (Germany) U125/1-ML http://www.physik.uni-bielefeld.de/experi/d4/pm/	90-99 eV 400-460 eV		XPEEM	CRG in operation
BESSY II (Germany) Smart project UE52-PGM	90-1500 eV		XPEEM, microfocus	
BESSY II (Germany) U41/1-TXM http://www.physik.uni-bielefeld.de/experi/d4/pm/	250-600 eV		Transmission X-ray Microscope	In operation
Elettra (Italy) Nanospectroscopy, BL 1.2 L http://www.elettra.trieste.it/experiments/beamlines/nano/index.html	10-1000 eV	5000	XPEEM, microfocus	User operation since 2001
Elettra (Italy) Beamline for Advanced DiCHroism (BACH) BL 8.2 http://www.elettra.trieste.it/experiments/beamlines/bach/index.html	35-1600 eV	5000	XMCD XMLD XAS Photoemission Spectroscopy X-ray fluorescecence	User operation since 2001
Elettra (Italy) APE-HE, BL 9.2 http://ape.tasc.infm.it/	35-1600 eV	5000	Photoemission Spectroscopy Advanced Photoelectric-effect Omicron 125 mm hemispherical analyzer 60 kV Mott detector	User operation since 2001
MaxLab (Sweden) D1011 (bending magnet) http://maxsun5.maxlab.lu.se/beamlines/bld1011/	30 - 1500 eV		XMCD Scienta analizer	User operation since 2002
SLS (Switzerland) Surface and Interface Spectroscopy beamline SIS UE212 http://sls.web.psi.ch/view.php/beamlines/sis/index.html	50-900 eV	10000	High-resolution PES Fermi surface mapping XAS Photoelectron Diffraction	User operation since 2003
SLS (Switzerland) Surface and Interface Microscopy SIM UE56 http://sls.web.psi.ch/view.php/beamlines/sis/index.html	50-900 eV	10000	XPEEM XRMS (commissioning)	User operation since 2003

Other beamlines

BEAMLINE	Energy range	DE/E	Techniques	Status
Saskatoon (Canadian Light Source) Soft X-ray Spectromicroscopy (10-ID.1) http://www.cls.usask.ca/experimental/sm.php	205- 2000 eV	8000	XPEEM Scanning transmission microscopy	Commissioning since summer 2004
Soleil (France) ID7M-XMCD	350-2000 eV	>6000	XMCD (7T, 2K) XMLD(7T, 2K) XRMS TXM	Approved by SAC
http://www.synchrotron-soleil.fr/anglais/science-and-users/experiments/xmcd/APS-xmcd.pdf				
Soleil (France) Photoelectron spectroscopy ID8M-TEMPO	50-1500 eV	>10000	Scienta detector High energy Mott detector Time resolved Experiments on Materials With Picosecond time-resolution	Approved by SAC Operationnal first trimester 2006
http://www.synchrotron-soleil.fr/anglais/science-and-users/experiments/xmcd/APS-xmcd.pdf				
Diamond (UK) NanoScience Beamline (I06) http://www.diamond.ac.uk/Activity/I06	200-900 eV		XPEEM Scattering (4-circle UHV diffractometer)	January 2007 Phase I
Diamond (UK) BLADE – BeamLine for Advanced Dichroism	400-2000 eV		XMCD XMLD (7 T, 2K) Scattering (XRMS)	Recommended by SAC May'04
http://www.diamond.ac.uk/Activity/Beamlines				

ANNEX IV: TABLE OF SPANISH SR USERS AND POTENTIAL (NEAR FUTURE) USERS that would benefit of POLUX

	Affiliation & Contact e-mail	Scientists	Research lines and Keywords	Research areas & SR Techniques	SR sources used
1	**Instituto de Ciencia de Materiales de Madrid CSIC** jesus.m.gonzalez@icmm.csic.es fjpalomares@icmm.csic.es	F. Javier Palomares Jesús González Fernando Pigazo Oxana Fesenko-Morozova Felipe García Sánchez	Magnetic nanostructured systems : surfaces, interfaces, grain boundaries Link between properties and local electronic structure modification Local magnetic moments and thermal dependence: biomedical applications: Analysis of the orbital component of the magnetic moment and its correlation to the surface/interface magnetocrystalline anisotropy	XD PES: XPS, ARPES XAS (XANES, EXAFS) XMCD XPEEM SXRD GIXRD	BESSY I BESSY II LURE ELETTRA MAXlab ALS ESRF
	E.U.I.T. de Telecomunicación Universidad Politécnica de Madrid	Federico Cebollada fede@euitt.upm.es			
2	**Instituto de Ciencia de Materiales de Madrid CSIC** malonso@icmm.csic.es	María Alonso Federico Soria María Moreno Natalia Galiana	MBE growth and characterization (chemical, structural, electronic, magnetic,….) of thin film magnetic systems (metals and semiconductors): i) multilayers, interfaces, heterostructures. ii) Metallic alloys, Heusler alloys iii) Arrays of nanostructures	PES: XPS, ARPES XMCD NEXAFS EXAFS SXRD GIXRD	
3	**Dpto. de Física Universidad de Oviedo** javidiaz@condmat01.geol.uniovi.es	Javier Díaz Carlos Quirós R. Morales J. M. Alameda	Structural and electronic characterization of thin films of "hard" amorphous carbon. Characterization of polymeric systems by absorption spectroscopy (NEXAFS) and microscopy (PEEM) XPEEM on amorphous magnetic films, CN films, and others.	XPS NEXAFS, EXAFS, XMCD XPEEM, XPLEEM SXRD SXRMD	ESRF, BESSY-I, BESSY-II, ALS, ELETTRA, SRS LURE.

4	**Instituto de Ciencia de Materiales de Madrid CSIC** mdavila@icmm.csic.es	MªCarmen Asensio José Ávila María Dávila Juan F. Sánchez	Synchrotron Radiation studies of advanced materials in the area of Solid State Physics (as superconducting and magnetorresistive oxides, among others) Geometrical determination of ordered interfaces and adsorbed systems Determination of the Fermi surface and electronic band structure of interfaces and massive materials of low dimensionality.	Hi-Res XPS, ARPES, ARUPS XRD Photoelectron Diffraction XMCD XAS, EXAFS X-ray standing waves.	LURE ESRF MAXlab …
5	**Dpto. de Electricidad y Electrónica.** **Universidad del País Vasco** malu@we.lc.ehu.es	Mª Luisa Fernández Gubieda Manu Barandiarán	Amorphous ferromagnets Transition metal amorphous thin films Nanoaggregates	EXAFS, XANES, XMCD, XRD, High magnetic field, Low temperature	Adone SRS ESRF Spring-8
6	**ICMM – CSIC** yves@imm.cnm.csic.es	Yves Huttel E. Román	Surface and interface effects: (spin and orbital moments of epilayers grown in-situ and ex-situ) Anisotropy in transition metal ultrathin films and nanoclusters.	EXAFS/XANESXMCD TEY detection thin films in-situ and ex-situ	LURE-DCI & SuperACO, ESRF, Daresbury, SRC-Wisconsin
	IMM – CNM **CSIC**	A. Cebollada G. Armelles			
7	**Dpto. Física Aplicada** **U. Autónoma de Madrid** pilar.prieto@uam.es	P. Prieto K. Pirota J.M. Sanz	Thin films of transition metal compounds, hard coatings and magnetic nitrides.	PES RPES XAS XMCD	LURE, BESSY, ESRF, Elettra
8	**Dpto. de Física** **Universidad de Oviedo** pgk@pinon.ccu.uniovi.es	Dr. J. A. Blanco Dr. P. Gorría Dr. S. Palacios Dr. R. Iglesias J. Fernández Rodríguez D. Martínez Blanco	Amorphous ferromagnets Iron Invar alloys XRMS theoretical description	EXAFS XANES XMCD Topografía Teoría	LURE Daresbury ESRF

9	**ICMM, CSIC** ada@icmm.csic.es	Alicia de Andrés José Luis Martínez Carlos Prieto Javier Sánchez Benítez Merche Vila F. Jiménez-Villacorta	Doping effects on the valence band of Tl2Mn2O7 pyrochlores: relation to magnetoresistance. Magnetoresistance and Mn valence in Ca2Cu3Mn4O12 perovskite derivatives	XAS Diffraction XPS XMCD	ESRF
10	**CITYMAT** **Universidad de Cantabria** barquinl@unican.es;	Luis Fernández Barquín Jesús Rodriguez José C. Gómez Sal Jose Espeso	Magnetic nanoparticles Amorphous ferromagnets Higly correlated electron systems	EXAFS, XANES, XMCD, XRD High magnetic field, Low temperature, High Pressure	Adone SRS ESRF
11	**ICMAB** **CSIC** garcia.munoz@icmab.es	José Luis García-Muñoz Benjamín Martínez Josep Fontcuberta Carlos Frontera	Semiconductor oxide ferromagnets Mixed valence oxides Magnetic and transport properties of oxides	Diffraction Reflectivity	ESRF
12	**Dept. de Física Fonamental** **Universitat de Barcelona** xavier@ffn.ub.es	Xavier Batlle Amilcar Labarta Felix Casanova Oscar Iglesias Zorica Konstantinovic, Victor Franco Neus Bastus M. García del Muro	Magnetic Nanoparticles and thin films. Magnetocaloric materials Phase transitions	XRMS XMCD	ALS
13	**Laboratori de Mesures Magnètiques i Tèrmiques** **Autónoma de Barcelona** Dolors.baro@uab.es	Dolors Baró S. Suriñach J.S. Muñoz, J. Sort V. Abad-Langlais	Nanoestructures, thin films and multilayers: - Depth-dependent magnetism - Magnetic profilometry of multilayers. Buried layers. - Local probes of the amgnetization process in lithographically prepared nanostructures. 2D Molecular magnets	Time-resolved powder diffraction X-ray topography, XMCD Nuclear resonant Scattering	ESRF
13	**ICREA** josep.nogues@uab.es	Josep Nogués V. Skumryev			

14	**Centro de Micro-Análisis de Materiales** **Universidad Autónoma de Madrid (UAM)**	José Emilio Prieto Juan de la Figuera Bayón Dirk Boerma	Nanoestructures, thin films and multilayers Magnetooptics of Rare earth-films LEEM-PEEM	XMCD, XRMS, XMOKE SRPES	Bessy ESRF Maxlab ALS
15	**Dept. Estructura i Constituents de la Materia** **Universitat de Barcelona**	Lluis Manosa	Thermodynamics of magnetic systems Phase Transitions Magnetocaloric effect and materials		
16	**Universiteit van Amsterdam** miguel@science.uva.nl	Jorge Miguel	Dynamics of the magnetization at the critical point. Magnetic speckles Thin film magnetism	XRMS, Coherence	ESRF, LURE, Elettra
17	**PSI - Swiss Light Source** arantxa.fraile-rodriguez@psi.ch	Arantxa Fraile	Soft x-ray spectromicroscopy of *single* nanocrystals. Exchange spring magnets.		SLS
18	**Microscopy section,** **ELETTRA, Trieste** lucia.aballe@elettra.trieste.it	Lucia Aballe	Electronic structure of thin films and nanoparticles, surface reactivity of ultrathin films, surface reactions. Scanning and imaging X-Ray spectromicroscopy of surfaces.	XPEEM-XPLEEM, SPEM XPS, UPS	Elettra BESSY SRRC (Taiwan)
19	**X-ray Absorption and Magnetic Scattering Group** **ESRF** valvidares@esrf.fr	S. M. Valvidares	Amorphous ferromagnetic alloys in thin films and ultra-thin single crystal films Magnetic nanostructures	Surface x-ray diffraction, MOKE, XMOKE XRMS	ESRF
20	**UAM** julio.camarero@uam.es	Julio Camarero Juan José de Miguel Miguel Angel Niño A. L. Vázquez de Parga Juanjo Hinarejos Jesús Alvarez Rodolfo Miranda	Magnetism on nanoestructures, thin films and multilayers. Exchange Bias system. Magnetic imaging techniques Magnetization Reversal Dynamics	Surface x-ray diffraction, Small-Angle scattering XMCD, XRMS, XMOKE XPEEM Time resolved-XPEEM/XRMS	ESRF Elettra BESSYI-II SLS, MaxLab LURE Hassylab

21	**INA** **Universidad de Zaragoza** morellon@unizar.es	Luis Morellón Jose Mª de Teresa Pedro Algarabel José I. Arnaudas Ricardo Ibarra	Spintronics Nanoparticles, nanoaggregates and self-organized nanophases Bioengineering and biomedical nanotechnological applications.	XMCD XRD XPS	ESRF
22	**ICMA** **Universidad de Zaragoza-CSIC** bartolom@unizar.es	Fernando Bartolomé Luis M. García Fernando Luis Juan Bartolomé Julia Herrero	Magnetic oxides Element specific magnetometry Orbital magnetism and phase transitions Magnetic interactions and hibridisation Novel ferromagnetic semiconductors	XANES XMCD XRMS X-ray reflectivity XMOKE RIXS & MCD-RIXS	ESRF KEK Photon Factory Spring- 8 NSLS ALS LURE-DCI SRS

ANNEX V A SELECTION OF RECENT PUBLICATIONS by the Contributing Groups, related to the POLUX proposal.

GROUPS 1 & 2 (INSTITUTO DE CIENCIA DE MATERIALES DE MADRID, CSIC AND E.U.I.T. DE TELECOMUNICACIÓN, UNIVERSIDAD POLITÉCNICA DE MADRID)

E. D. Tober, F. J. Palomares, R. X. Ynzunza, R. Denecke, Z. Wang, J. Morais, J. Liesegang, Z. Hussain and C. S. Fadley
Observation of a Ferromagnetic-to-Paramagnetic Phase Transition on a Ferromagnetic Surface Using Spin Polarized Photoelectron Diffraction
Physical Review Letters 81, 2360-2363 (1998)

M.Moreno, J.L.Sacedón, M. Alonso, M.Höricke, R.Hey, J.Avila, M.C.Asensio, K.Horn, K.Ploog.
Si and Be intralayers at GaAs/AlAs(100) heterojunctions: Doping effects.
Phys. Rev. B. 58 13767-13777 (1998).

M. Moreno, M. Alonso, J.L. Sacedón, M. Höricke, R. Hey, K.Horn and K.H. Ploog.
Si and Be intralayers at GaAs/AlAs and GaAs/GaAs junctions: Low temperature photoemission measurements.
Phys. Rev. B 61 16060-16067 (2000).

F.J.Palomares, M. Alonso, I. Jiménez, J. Avila, J.L. Sacedón, F. Soria
electron-beam-induced reactions at O_2/GaAs(100) interfaces
Surf. Sci. 482-485, 121-127 (2001).

F. J. Palomares, M. Serrano, A. Ruíz, F. Soria, K. Horn and M. Alonso
ARPES study of the surface states from Au/Ag(111): evolution with coverage and photon energy.
Surf. Sci. 513, 283-294 (2002)

M. Moreno, B. Jenichen, V. Kaganer, W. Braun, A. Trampert, L. Däweritz, K. H. Ploog
MnAs nanoclusters embedded in GaAs studied by x-ray diffuse and coherent scattering.
Phys. Rev. B 67, 235206 1-8 (2003).

Esther Barrena, Elisa Palacios-Lidón, Carmen Munuera, Xavier Torrelles, Salvador Ferrer, Ulrich Jonas, Miquel Salmeron, and Carmen Ocal
The Role of Intermolecular and Molecule-Substrate Interactions in the Stability of Alkanethiol Nonsaturated Phases on Au(111)
J. Am. Chem. Soc.; 126(1) 385 (2004)

GROUP 3 (DEPARTAMENTO DE FÍSICA, UNIVERSIDAD DE OVIEDO)

T. Schmidt, S. Heun, J. Slezak, J. Díaz, K.C. Prince, G. Lilienkamp, E. Bauer.
SPELEEM: Combining LEEM and spectroscopic imaging.
Surface Review and Letters Vol. 5 (6) (1998) 1287-1296.

C. Quirós, J. Gómez-García, F.J. Palomares, L. Soriano, E. Elizalde and J.M. Sanz. "Correlation between N *1s core level x-ray photoelectron and x-ray absorption spectra of amorphous carbon nitride films*
Applied Physics Letters, 77 (2000) 803-805.

J. Díaz, S. Anders, X. Zhou, E.J. Moler, S.A. Kellar, and Z. Hussein.
Analysis of the p and s* bands in the X-ray absorption spectrum of amorphous carbon*
Phys. Rev. B 64, 125204 (2001)

M. Sánchez-Agudo, L. Soriano, C. Quirós, M. Abbate, L. Roca, J. Avila and J.M Sanz
Resonant photoemission and x-ray absorption study of the electronic structure of the TiO_2-Al_2O_3 interface
Langmuir, 17 (2001) 7339-7343.

M. Sánchez-Agudo, L. Soriano, C. Quirós, L. Roca, V. Pérez-Dieste and J.M. Sanz.
Electronic structure of TiO_2 monolayers grown on Al_2O_3 and MgO studied by resonant photoemission spectroscopy

Surface Science, 507/510, (2002) 672-677.

J. Díaz, N. Hamdan, P. Jalil, Z. Hussain, S. M. Valvidares and J. M. Alameda.
Understanding the magnetic anisotropy in Fe-Si amorphous alloys
IEEE Transactions on Magnetism 38 (2002) 2811

Velez M, Meny C, Valvidares SM, Diaz J, Morales R, Alvarez-Prado LM, Panissod P, Alameda JM
Amorphous to polycrystalline transition in CoxSi1-x alloy thin films
European Physical Journal B 41, 517 (2004).

Gustafson J, Mikkelsen A, Borg M, Lundgren E, Kohler L, Kresse G, Schmid M, Varga P, Yuhara J, Torrelles X, Quiros C, Andersen JN
Self-limited growth of a thin oxide layer on Rh(111)
Physical Review Letters 92, 126102 (2004).

GROUP 4 (INSTITUTO DE CIENCIA DE MATERIALES DE MADRID, CSIC; AND LURE, FRANCE)

A. Mascaraque, J. Avila, M. C. Asensio, S Ferrer and E.G. Michel
Nature of the low-temperature 3 x 3 surface phase of Pb/Ge(111)
Phys. Rev. Lett. 82 (1999) 2524.

A. Arranz, J.F. Sanchez-Royo, J Avila, V. Perez-Dieste, P. Dumas and M.C. Asensio.
Electronic properties and Fermi surface of Ag(111) films deposited onto H-passivated Si(111)-(1x1) surfaces
Phys. Rev. B 65, 0754051 (2002)

S. Bengio, M. Martin, J. Avila, M.C. Asensio and H. Ascolani
Atomic structure of the Sb-terminated Si(111) surface: A photoelectron diffraction study
Phys. Rev. B 65, 2053261 (2002).

J.F. Sanchez-Royo, J. Avila, V. Perez-Dieste, M. DeSeta and M.C. Asensio
Two-domains bulklike Fermi Surface of Ag films deposited onto Si(111)-(7x7)
Phys. Rev. B 66, 035401 (2002)

A. Arranz, J. F. Sanchez-Royo, J. Avila, V. Perez-Dieste, P.Dumas and M.C. Asensio.
Quantum-well states in ultrathin Ag(111) films deposited onto H-passivated Si(111)-(1x1) surfaces
Phys. Rev. B 65, 195410 (2002)

M. Sánchez-Agudo, L. Soriano, C. Quirós, L. Roca, V. Pérez-Dieste and J. M.Sanz
Electronic structure of TiO2 monolayers grown on Al2O3 and MgO studied by resonant photoemission spectroscopy
Surf. Sci. 507-510, 672-677 (2002)

M. E. Dávila, S.L. Molodtsov, C. Laubschat and M.C. Asensio
Structural determination of Yb single-crystal films grown on W(110) using photoelectron diffraction
Phys. Rev. B 66, 035411 (2002).

M.C. Asensio, J. Avila, L. Roca, A. Tejeda,G.D. Gu, M. Lindroos, R.S. Markiewicz and A. Bansil
Emergence of multiple Fermi surface maps in angle-resolved photoemission from $Bi_2Sr_2CaCu_2O_{8+d}$
Phys. Rev. B 67, 014519 (2003).

S.L.Molodtsov, F. Schiller, S. Danzenbacher, Manuel Richter, J. Avila, C. Laubschat and M.C. Asensio
Folded bands in photoemission spectra of La-graphite intercalation compounds
Phys. Rev. B 67, 0115105 (2003).

M.E. Dávila, S.L. Molodtsov, J. Avila, C. Laubschat and M.C. Asensio.
Spectroscopic structural characterization of epitaxial Yb films grown onto W(110) under ultra high vacuum conditions

J. of Applied Physics 93(9), 5075 (2003).

V. Pantin, J. Avila, M.E. Dávila, J.E. Bonnet and M.C. Asensio
Photolectron Diffraction study of Ag growth mediated by an arsenic layer on Si(111)1x1
J. of Electron Spectroscopy and Related Phenomena 137, 155 (2004).

L. Roca, M. Izquierdo, J. Avila, D.G. Gu and M.C. Asensio.
Photon energy and polarisation dependence of the Fermi surface in optimally doped Bi2Sr2CaCu2O8+X superconductors
J. of Electron Spectroscopy and Related Phenomena 137, 657 (2004).

M. Izquierdo, M.E. Davila, C.M. Teodorescu, J. Chrost, H. Ascolani, J. Avila and M.C. Asensio.
Influence of the substrate surface termination on the properties of bcc-cobalt films: GaAs(110) versus Sb/GaAs(110)
Applied Surface Science 234, 468 (2004).

M.E. Dávila, J. Avila, H. Ascolani, G. Le Lay, M. G–thelid, U.O. Karlsson and M.C. Asensio.
Surface phase transitions at metal-semiconductor interfaces: a revisit is needed
Applied Surface Science 234, 274 (2004).

GROUPS 5, 8 AND 10 (DEPTO. DE ELECTRICIDAD Y ELECTRÓNICA, UNIVERSIDAD DE PAÍS VASCO; DEPTO. DE FÍSICA, UNIVERSIDAD DE OVIEDO; AND DEPTO CIENCIAS DE LA TIERRA Y DE FÍSICA DE LA MATERIA CONDENSADA, UNIVERSIDAD DE CANTABRIA)

C. Medrano, F. Heyroth, M. Schlenker, J. Baruchel and J. Espeso.
Two- and three-beam x-ray diffraction imaging of domains in magnetite
J. Appl. Cryst. 31, 726-732 (1998).

J. I. Espeso, J. C. Gómez Sal, M. C. Sánchez and J. Chaboy.
X-Ray spectroscopic evidences of the electronic change of regime of Ce in the CeNixPt1-x solid solution
Physica B 259-261, 1140-1141 (1999).

Medrano C, Schlenker M, Baruchel J, Espeso J, Miyamoto Y
Domains in the low-temperature phase of magnetite from synchrotron-radiation x-ray topographs
Physical Review B 59, 1185 (1999)

M. L. Fdez-Gubieda, I. Orue, P. Gorria, A. García-Arribas, J. M. Barandiarán, R. Lopez, S. Pizzini, A. Fontaine
Different ferromagnetic character of Fe on FeB and FeP amorphous alloys
J. Magn. Magn. Mater., 196/197 (1999), 204.

J. I. Espeso, J. C. Gómez Sal and J. Chaboy
Role of the electronic state of cerium in the magnetic properties of CeNi1-xPtx compounds
Phys. Rev. B 63, 14416 (2000).

M. L. Fdez-Gubieda, A. García-Arribas, J. M. Barandiarán, R. López Antón, I. Orue, P. Gorria, S. Pizzini, A. Fontaine
Local structure and ferromagnetic character of Fe-B and Fe-P amorphous alloys
Phys. Rev. B 62, 5746 (2000).

M. L. Fdez-Gubieda, I. Orue, P. Gorria, S. Pizzini, A. Fontaine.
X-ray magnetic circular dichroism in FeZrB amorphous alloys: the influence of the tensile stress
J. Synchrotron Radiat. 8, 443 (2001).

Q. A. Pankhurst, N. S. Cohen, L. Fernández Barquín , M. R. J. Gibbs y G. V. Smirnov.
Moment canting and structural anisotropy in amorphous alloys: experiments using synchrotron mössbauer radiation.
J. Non-Cryst. Sol. 287, 81-87 (2001).
JC Gómez-Sal, Espeso JI, Fernandez JR, Marcano N, Blanco JA
Long-range magnetic order, spin-glass and evanescence of the magnetism in strongly correlated Ce-based compounds

Journal of Magnetism and Magnetic Materials 242, 125 (2002)

Samper PM, Izquierdo A, Suderow H, Fernandez JR, Espeso JI, Aliev FG, Sa JCG, Vieira S
The evanescence of ferromagnetic order in the Ce1-xYxNi0.8Pt0.2 dense Kondo system
European Physical Journal B 28 103 (2002)

Barquin LF, Sal JCG, Gorria P, Garitaonandia JS, Barandiaran JM
Reentrant spin-glass behavior in Fe-Zr-B amorphous alloys
Journal of Non-Crystalline Solids 329, 94 (2003)

Barquin LF, Sal JCG, Gorria P, Garitaonandia JS, Barandiaran JM
Dynamic susceptibility of reentrant Fe-rich inhomogeneous amorphous alloys
European Physical Journal B 35, 3 (2003).

Pankhurst QA, Martinez AY, Barquin LF
Interfacial exchange pinning in amorphous iron-boron nanoparticles
Physical Review B 69, 212401 (2004)

Gorria P, Martinez-Blanco D, Blanco JA, Hernando A, Garitaonandia JS, Barquin LF, Campo J, Smith RI
Invar effect in fcc-FeCu solid solutions
Physical Review B 69, 214421 (2004)

GROUP 6 (INSTITUTO DE CIENCIA DE MATERIALES DE MADRID, AND INSTITUTO DE MICROELECTRÓNICA DE MADRID – CENTRO NACIONAL DE MICROELECTRÓNICA, CSIC)

Martin-Gonzalez MS, Huttel Y, Cebollada A, Armelles G, Briones F
Surface localized nitrogen incorporation in epitaxial FePd films and its effect in the magneto-optical properties
Surface Science 571, 63 (2004).

Huttel Y, Gomez H, Clavero C, Cebollada A, Armelles G, Navarro E, Ciria M, Benito L, Arnaudas JI, Kellock AJ
Cobalt nanoparticles deposited and embedded in AlN: Magnetic, magneto-optical, and morphological properties
Journal of Applied Physics 96, 1666 (2004).

Navarro E, Huttel Y, Clavero C, Cebollada A, Armelles G
Magnetic coupling between Fe nanoislands induced by capping-layer magnetic polarization
Physical Review B 69, 224419 (2004).

Navarro E, Huttel Y, Clavero C, Armelles G, Cebollada A
Capping-layer-induced magnetic coupling in a two-dimensional nanostructured system
Applied Physics Letters 84, 2139 (2004).

Huttel Y, van der Laan G, Johal TK, Telling ND, Bencok P
Induced V and reduced Co magnetic moments at the V/Co interface
Physical Review B 68, 174405 (2003).

Sepulveda B, Huttel Y, Boubeta CM, Cebollada A, Armelles G
Linear and quadratic magneto-optical Kerr effects in continuous and granular ultrathin monocrystalline Fe films
Physical Review B 68, 064401 (2003).

Huttel Y, van der Laan G, Teodorescu CM, Bencok P, Dhesi SS
Magnetic V embedded in copper evidenced by x-ray magnetic circular dichroism
Physical Review B 67, 052408 (2003).

GROUP 7 (DEPTO. DE FÍSICA APLICADA, UNIVERSIDAD AUTÓNOMA DE MADRID)

L. Soriano, M. Abbate, A. Fernández, A.R. González-Elipe, F. Sirotti, and J.M. Sanz
Oxidation state and size effects in CoO nanoprticles
Journal of Physical Chemistry B 103 (1999) 6676.

M. Liberati, G. Panaccione, F. Sirotti, P. Prieto and G. Rossi.
Surface Magnetrometry with Photoemission Dichroism : Ultrathin Epitaxial Fe-Co bcc alloys on Fe (100).
Physical Review B, 59(6) (1999) 4201.

F. Sirotti, S. Girlando, P. Prieto , L. Floreano and G. Panaccione
Dynamics of Surface Magnetization on a nanosecond time scale.
Physical Review B, 61(14) (2000) R9221.

C. Quirós, J. Gómez-García, F.J. Palomares, L. Soriano, E. Elizalde and J.M. Sanz
Correlation Between X-Ray Photoemission and X-Ray Absoprtion Spectra of the N 1s signal in Amorphous Carbon Nitride Films.
Applid Physics Letters 77 (2000) 803.

M. Sánchez-Agudo, L. Soriano, C. Quirós, M. Abbate, J. Avila and J.M. Sanz
Resonant photoemission and x-ray absorption study of the electronic structure of the TiO_2/Al_2O_3 interface.
Langmuir 17 (2001) 7339.

G.G. Fuentes, P. Prieto, C. Morant, C. Quirós, R. Núñez, L. Soriano, E. Elizalde and J.M. Sanz.
Resonant Photoemission of TiN Films.
Physical Review B, 63(9) (2001) 75403.

M. Sánchez-Agudo, L. Soriano, C. Quirós, L. Roca, V. Pérez-Diest and J.M. Sanz
Electronic Structure of TiO_2 Monolayers Grown on Al_2O_3 and MgO sutuded by resonant photoemission spectroscopy.
Surface Science, 507 (2002) 672.

Prieto P, Quiros C, Elizalde E, Sanz JM
Quantitative REELS of amorphous carbon and carbon nitride films
Surface and Interface Analysis 36, 820 (2004)

GROUP 9 (INSTITUTO DE CIENCIA DE MATERIALES DE MADRID, CSIC)

A. Muñoz-Martín, C. Prieto, C. Ocal, J.L. Martínez and J. Colino
Magnetic behavior of oxidized iron thin films prepared by at very low temperatures
Surf. Sci. 482-485, 1095-1100 (2001).

A. Muñoz-Martín, M. Vila, C. Prieto, C. Ocal and J.L. Martínez,
Microstructural characterization of iron thin films prepared by sputtering at very low temperatures.
Vacuum, 67, 583-588 (2002).

M. Vila, F. Jiménez-Villacorta, C. Prieto and A. Traverse
EXAFS characterization of nickel clusters in Ni/Si3N4 sputtered thin films
Physica Scripta (2004)

J. Sánchez.Benítez, A. de Andrés, C. Prieto,J. Ávila, L. Martín-Carrón, J.L. Martínez, J.A. Alonso, M.J. Martínez-Lope and M.T. Casais.
Doping effects on the valence band of Tl2Mn2O7 pyrochlores: relation to magnetoresistance
Appl. Phys. Lett. 84, 4209 (2004)

J. Sánchez-Benítez, C. Prieto, A. de Andrés, J.A. Alonso, M.J. Martínez-Lope, M.T. Casais.
Coexistence of two Manganese states in magnetoresistive Ca2Cu3Mn4O12 perovskite derivatives
Phys. Rev. B. 70, 024419 (2004)

GROUP 13 (LABORATORI DE MESURES MAGNETIQUES I TERMIQUES, UNIVERSITAT AUTÓNOMA DE BARCELONA AND ICREA)

J. Baruchel, E. Boller, J.I. Espeso, H. Klein, C. Medrano, J. Nogués, E. Pernot, M. Schlenker
Bragg-diffraction imaging of magnetic crystals with third generation synchrotron radiation
Journal of Magnetism and Magnetic Materials 233, 38-47 (2001)

J. Baruchel, P.C. de Camargo, H. Klein, . Mazzaro, J. Nogués, A. de Oliveira
New possibilities of synchrotron radiation diffraction topography for the investigation of 'exotic' magnetic domains
Journal of Physics D: Applied Physics 34, A114-A116 (2001)

J.L. Uriarte, A.R. Yavari, S. Surinach, P. Rizzi, G. Heunen, M. Baricco, M.D. Baro, A. Kvick
Properties of FeNiB-based metallic glasses with primary BCC and FCC crystallization products
Journal of Magnetism and Magnetic Materials 254-255, 532-534 (2003)

Sort J, Nogues J, Surinach S, Munoz JS, Baro MD
Correlation between stacking fault formation, allotropic phase transformations and magnetic properties of ball-milled cobalt
Materials Science and Engineering A 375-77, 869 2004

Sort I, Langlais V, Doppiu S, Dieny B, Surinach S, Munoz JS, Baro MD, Laurent C, Nogues J
Exchange bias effets in Fe nanoparticles embedded in an antiferromagnetic Cr2O3 matrix
Nanotechnology 15, S211 2004

Popovici M, Gich M, Roig A, Casas L, Molins E, Savii C, Becherescu D, Sort J, Surinach S, Munoz JS, Baro MD, Nogues J
Ultraporous single phase iron oxide-silica nanostructured aerogels from ferrous precursors
Langmuir 20, 1425 (2004)

Gloriant T, Surinach S, Baro MD
Stability and crystallization of Fe-Co-Nb-B amorphous alloys
Journal of Non-Crystalline Solids 333, 320 (2004)

Role of stacking faults in the structural and magnetic properties of ball-milled cobalt
Sort J, Surinach S, Munoz JS, Baro MD, Wojcik M, Jedryka E, Nadolski S, Sheludko N, Nogues J
Physical Review B 68, 014421 (2003)

Gich M, Casas L, Roig A, Molins E, Sort J, Surinach S, Baro MD, Munoz JS, Morellon L, Ibarra MR, Nogues J
High-coercivity ultralight transparent magnets
Applied Physics Letters 82, 4307 (2003)

GROUP 14 (INSTITUT FÜR EXPERIMENTALPHYSIK, FREIE UNIVERSITÄT BERLIN)

J.E. Prieto, F. Heigl, O. Krupin, G. Kaindl, and K. Starke
Magneto-optics of Gd and Tb in the soft-x-ray resonance regions
Phys. Rev. B 68, 134453 (2003).

O. Krupin, J.E. Prieto, S. Gorovikov, K. Starke, and G. Kaindl
Ferrimagnetic spin order in O/Gd surface monoxide
Thin Solid Films 428, 98 (2003).

K. Starke, F. Heigl, J.E. Prieto, O. Krupin, and G. Kaindl
Soft X-ray magnetooptics in lanthanides at the N4,5- and M4,5-thresholds
Nucl. Instrum. Methods B, 199, 313 (2003)

J.E. Prieto, F. Heigl, O. Krupin, G. Kaindl, and K. Starke
Prediction of huge X-ray Faraday rotation at the Gd N4,5 threshold
Phys. Rev. B 66, 172408 (2002).

K. Starke, F. Heigl, J.E. Prieto, O. Krupin, A. Vollmer, G. Reichardt, F. Senf, R. Follath, N.B. Brookes, and G. Kaindl
X-ray Magneto-Optics
Advances in Solid State Physics, Volume 41, pp. 161-170. Editor: Bernhard Kramer, Springer-Verlag Berlin Heidelberg (2001)

GROUP 16 (VAN DER WAALS ZEEMAN INSTITUUT, UNIVERSITEIT VAN AMSTERDAM)

J. F. Peters, J. Miguel, M. A de Vries, O. M. Toulemonde, J. B. Goedkoop, S. S. Dhesi, and N. B. Brookes
Soft x-ray resonant magneto-optical constants at the Gd $M_{4,5}$ and Fe $L_{2,3}$ edges
Phys. Rev. B 70, 224417 (2004).

Miguel-Soriano J, Chaboy J, Garcia LM, et al.
X-ray magnetic circular dichroism at the rare earth $L_{2,3}$ edges in $R_2Fe_{14}B$ intermetallics
Journal of Applied Physics 87, 5884 (2000).

GROUP 17 (PSI - SWISS LIGHT SOURCE)

U. Wiedwald, M. Spasova, E. L. Salabas, M. Ulmeanu, M. Farle, Z. Frait, A. Fraile-Rodriguez D. Arvanitis, N. S. Sobal, M. Hilgendorff, and M. Giersig
Ratio of orbital-to-spin magnetic moment in Co core-shell nanoparticles
Phys. Rev. B 68, 064424 (2003)

Fraile-Rodriguez A, Rubio-Pena L, Lopez-Echarri A
The specific heat of the urea/alkane inclusion compounds around the structural phase transition
Ferroelectrics 301: 207-209 2004

Fraile-Rodriguez A, Rodriguez PP, Perez-Saez RB, et al.
Intrinsic kinetic effects during martensitic transformations
Journal De Physique Iv 112: 133-137 Part 1 Oct 2003

Diaz-Hernandez J, Lopez-Echarri A, Ruiz-Larrea I, et al.
The heat capacity of 4-4 '-dichlorobenzophenone
Ferroelectrics 268: 753-758 2002

Fraile-Rodriguez A, Ruiz-Larrea I, Rubio-Pena L, et al.
Anomalous behaviour of the specific heat in the urea/n-heptadecane inclusion compound around the phase transition
European Physical Journal B 24 (2): 189-195 Nov 2001

Fraile-Rodriguez A, Ruiz-Larrea I, Lopez-Echarri A, et al.
An AC calorimeter for the study of solid-solid phase transitions
Thermochimica Acta 377 (1-2): 131-140 Oct 17 2001

Lopez-Echarri A, Ruiz-Larrea I, Fraile-Rodriguez A
The thermoelastic properties of [N(CH3)(4)](2)ZnBr4 and [N(CH3)(4)](2)MnBr4
Phase Transitions 71 (2): 101-111 Part A 2000

Ruiz-Larrea I, Diaz-Hernandez J, Fraile-Rodriguez A, et al.
The specific heat of N(CH3)(4)MnBr3 by adiabatic calorimetry
Journal of Physics-Condensed Matter 11 (10): 2259-2264 Mar 15 1999

GROUP 18 (MICROSCOPY SECTION, ELETTRA, TRIESTE)

Aballe L, Barinov A, Locatelli A, Heun S, Kiskinova M
Tuning surface reactivity via electron quantum confinement
Physical Review Letters 93, 196103 (2004).

Aballe L, Barinov A, Locatelli A, Heun S, Cherifi S, Kiskinova M.
Spectromicroscopy of ultrathin Pd films on W(110): interplay of morphology and electronic structure
Applied Surface Science 238, 138 (2004).

Aballe L, Gregoratti L, Barinov A, Kiskinova M, Clausen T, Gangodadhyay S, Falta J
Interfacial interactions at Au/Si3N4/Si(111) and Ni/Si3N4/Si(111) structures with ultrathin nitride films
Applied Physics Letters 84, 5031 (2004).

Aballe, L; Rogero, C; Horn, K
Quantum-size effects in ultrathin-Mg films: electronic structure and collective excitations
Surface Science 518, 141 (2002).

Aballe, L; Rogero, C; Horn, K
Quantum size effects in ultrathin epitaxial Mg films on Si(111)
Physical Review B 65, 125319 (2002).

Aballe L, Rogero C, Kratzer P, Gokhale S, Horn K
Probing interface electronic structure with overlayer quantum-well resonances: Al/Si(111)
Physical Review Letters 87, 156801 (2001).

Casaletto MP, Zanoni R, Carbone M, Piancastelli MN, Aballe L, Weiss K, Horn K
Ethylene adsorption on Si(100)2X1: A high-resolution photoemission study
Physical Review B 62, 17128 (2000).

Ebert P, Urban K, Aballe L, Chen CH, Horn K, Schwarz G, Neugebauer J, Scheffler M
Symmetric versus nonsymmetric structure of the phosphorus vacancy on InP(110)
Physical Review Letters 84, 5816 (2000).

GROUP 19 (EUROPEAN SYNCHROTRON RADIATION FACILITY, GRENOBLE)

Robach O, Quiros C, Valvidares SM, et al.
Structure and Pt magnetism of FePt nanoparticles investigated with X-ray diffraction
Journal of Magnetism and Magnetic Materials 264, 202 (2003).

Velez M, Valvidares SM, Diaz J, et al.
Structure and magnetic properties of amorphous Co-Si alloy films
IEEE Transactions on Magnetics 38, 3078 (2002).

Diaz J, Valvidares SM, Morales R, et al.
Study of the magnetic anisotropy of amorphous Fe1-xSix deposited by magnetron sputtering
Journal of Magnetism and Magnetic Materials 242, 166 (2002).

Valvidares SM, Martin JI, Alvarez-Prado LM, et al.
Inverted hysteresis loops in annealed Co-Nb-Zr and Co-Fe-Mo-Si-B amorphous thin films
Journal of Magnetism and Magnetic Materials 242, 169 (2002).

Valvidares SM, Alvarez-Prado LM, Martin JI, et al.
Inverted hysteresis loops in magnetically coupled bilayers with uniaxial competing anisotropies: Theory and experiments
Physical Review B 64, 134423 (2001).

GROUP 20 (INSITUTO "NICOLÁS CABRERA", UNIVERSIDAD AUTÓNOMA DE MADRID)

Kuch W, Vogel J, Camarero J, et al.
Exploring spin valve magnetization reversal dynamics with temporal, spatial and layer resolution: Influence of domain-wall energy
Applied Physics Letters 85, 440 (2004).

Pennec Y, Camarero J, Toussaint JC, Pizzini S, Bonfim M, Petroff F, Kuch W, Offi F, Fukumoto K, Van Dau FN, Vogel J
Switching-mode-dependent magnetic interlayer coupling strength in spin valves and magnetic tunnel junctions
Physical Review B 69, 180402 (2004).

Camarero J, Pennec Y, Vogel J, et al.
Perpendicular interlayer coupling in Ni80Fe20/NiO/Co trilayers
Physical Review Letters 91, 027201 (2003).

Vogel J, Kuch W, Bonfim M, et al.
Time-resolved magnetic domain imaging by x-ray photoemission electron microscopy
Applied Physics Letters 82, 2299 (2003).

Camarero J, Pennec Y, Vogel J, et al.
Field dependent exchange coupling in NiO/Co bilayers
Physical Review B 67, 020413 (2003).

Camarero J, Pennec Y, Vogel J, et al.
Dynamical properties of magnetization reversal in exchange-coupled NiO/Co bilayers
Physical Review B 64, 172402 (2001).

Camarero J, de Miguel JJ, Miranda R, et al.
Influence of film morphology on perpendicular magnetic anisotropy
Physical Review B 64, 125406 (2001).

Bonfim M, Ghiringhelli G, Montaigne F, et al.
Element-selective nanosecond magnetization dynamics in magnetic heterostructures
Physical Review Letters 86, 3646 (2001).

Prieto JE, Camarero J, de Miguel JJ, et al.
Reduced coercivity in ferromagnetic Co-Cu coevaporated epitaxial films on Cu(111)
Applied Physics Letters 77, 889 (2000).

Gomez L, Slutzky C, Ferron J, et al.
Novel microscopic mechanism of intermixing during growth on soft metallic substrates
Physical Review Letters 84, 4397 (2000).

GROUP 21 (INSTITUTO DE CIENCIA DE MATERIALES DE ARAGÓN, CSIC-UNIVERSIDAD DE ZARAGOZA)

F. Bartolomé, M. Krisch, J.M. Tonnerre, D. Raoux.
Quadrupolar excitation channels at the L3 Edge of Rare-Earth Ions probed by Resonant Inelastic X-ray Scattering
Physical Review B, 60, 13497-13506 (1999)

F. Bartolomé, J.M. Tonnerre, N. Jaouen, D. Raoux, J. Chaboy, L.M. García, H. Maruyama, R. Steinmann.
Strong noncollinearity between non-equivalent Nd magnetic moments in $Nd_2Fe_{14}B$ at low-temperature
Journal of Applied Physics 87, 4762 (2000).

J. Miguel-Soriano, J. Chaboy, L.M. García, F. Bartolomé, H. Maruyama
X-Ray Magnetic circular dichroism at the rare earth L2,3 edges in R2Fe14B intermetallics
Journal of Applied Physics 87, 5884-5886 (2000)

N. Jaouen, J.M. Tonnerre, E. Bontempi, D. Raoux, L. Sève, F. Bartolomé, A. Rogalev, M. Müenzenberg, W. Felsch, H. A. Dürr, E. Dudzik, H. Maruyama.
Chemical and magnetization profile study of Ce in [CeLaCe/Fe] and [LaCeLa/Fe] multilayers by resonant X-ray reflectivity
Physica B, 283, 175 (2000)

L.M. García, J. Chaboy, F. Bartolomé, J.Goedkoop
Orbital magnetic moment instability at the spin reorientation transition of $Nd_2Fe_{14}B$.
Physical Review Letters 85, 429 (2000)

J.P. Rueff, Y. Joly, F. Bartolomé, M. Krisch, J.L. Hodeau, L. Marqués, M. Mezouar, A. Kaprolat.
"X-ray raman scattering from the carbon K-edge in polymerized C60: experiment and theory"
Journal of Physics: Condensed Matter 14, 11635 (2002)

F. Bartolomé, J. Herrero-Albillos, L.M. García, A.T. Young, T. Funk, N. Plugaru, E. Arenholz
Orbital moment at the Curie temperature in $ErCo_2$
Journal of Magnetism and Magnetic Materials 272-276, 319 (2004)

F. Bartolome, J. Herrero-Albillos, L.M. García, J. Bartolome, N. Jaouen, A. Rogalev
Negative magnetization and element specific magnetometry in $NdMnO_{3+d}$
Journal of Applied Physics, in press (2005)

ANNEX VI SCIENTISTS EXPRESSING INTEREST IN THE DESIGN AND CONSTRUCTION OF THE PROPOSED POLUX BEAMLINE

The main proposers of this project compromise themselves to collaborate in the design as well as in the beamline construction under requirements of the ALBA scientists.

The following researchers have explicitly confirmed their intention to participate in the design and construction of the proposed POLUX beamline at ALBA. This is just a list of contacts, without any pretension of reflecting any complete CV of the listed people. Some of their recent publications are already included on the Annex V, and will not be repeated here.

- **Dr. Lucía Aballe**, actually holds a "Marie Curie" post-doc Microscopy section, ELETTRA, Trieste.

  Email: lucia.aballe@elettra.trieste.it

  Scientific interests: Electronic structure of thin films and nanoparticles, surface reactivity of ultrathin films, surface reactions. Scanning and imaging X-Ray spectromicroscopy of surfaces.

  Expertise on: XPEEM-XPLEEM, SPEM, XPS, and UPS; at Elettra, BESSY and SRRC.

- **Dr. Arantxa Fraile**, actually holds a contract with the Swiss Light Source (PSI, Villigen), for working at the the SIM (microscopy) beamline.

  Email: arantxa.fraile-rodriguez@psi.ch

  Scientific interests: Soft x-ray spectromicroscopy of single-nanocrystals.
  Exchange spring magnets. Magnetic nanoparticles. Ratio of orbital-to-spin magnetic moment in nanoparticles

  Expertise on: XMCD and XPEEM-XPLEEM at SLS, ESRF, BESSY

- **Dr. Carlos Quirós**, actually holds a "Ramón y Cajal" contract at the University of Oviedo.

  Email: carquir@string1.ciencias.uniovi.es

  Scientific interests: Magnetic nanoparticles, surface science, surface magnetism, polymers, amorphous magnetic films, hard CN films.

  Expertise on: XMCD, Surface-XRMS, and surface x-ray diffraction at ESRF and Elettra.

- **Jorge Miguel-Soriano** actually finishing his PhD at the van der Waals – Zeeman Instituut of the Universoty of Amsterdam.

  Email: miguel@science.uva.nl

Scientific interests: Rare-earth – transition metal thin film magnetooptics and soft x-ray magnetic scattering. X-ray Coherent scattering, magnetic Speckles. Magnetic Critical fluctuations at the paramagnetic state. Magnetic Imaging. Time dependent experiments.

Expertise on: XRMS, XMCD and XAS at ESRF, Elettra, SLS.

- **Manuel Valvidares** actually finishing his PhD at the ESRF, will stay for a postdoc period at ID8 (ESRF) with a Spanish fellowship.

  Email: valvidares@esrf.fr

  Scientific interests: Dimensionality effects on magnetism, Buried interfaces and interface magnetism. Magnetic dynamics. Magnetic coupling and proximity effects.

  Expertise on: structural characterisation techniques as surface x-ray or electron diffraction, magnetic characterisation techniques as the magneto-optical Kerr effect in the visible range and magnetic-resonant surface x-ray diffraction at ESRF.

ANNEX VII

EXPRESSIONS OF INTEREST AND SUPPORT.

VII.1. LETTER OF SUPPORT FROM THE INSTITUTE OF RESEARCH ON NANOSCIENCE OF ARAGÓN (University of Zaragoza).

INSTITUTO UNIVERSITARIO DE INVESTIGACIÓN EN NANOCIENCIA DE ARAGÓN

UNIVERSIDAD DE ZARAGOZA

Zaragoza 28 Noviembre 2004

Dear Members of the Scientific Committee,

The Institute of Nanoscience of Aragón is developing activities within the field of the main areas pointed in the "Scientific case report" for POLUX and most of them are related to the key issues of interest in the current activities in the field of nanomagnetism. We support this scientific case as we consider that the implementation of a soft x-ray beamline dedicated to polarization dependent spectroscopies and microscopy is of the major importance for our Institute.

Prof. M. Ricardo Ibarra García

Director del Instituto Universitario de Investigación en Nanociencia de Aragón (INA)

Edificio Inter II • c/ Pedro Cerbuna, 12 • 50009 ZARAGOZA
Tlfnos.: +34 976 76 27 77 • +34 976 76 27 83 • Fax: +34 976 76 27 76
e-mail: ina@unizar.es • web: http://ina.unizar.es/

VII.2 Extract from the Act of the 2004 Annual Meeting of the Spanish Magnetic Club (followed by a letter to the members and a full member list)

ACTA DE LA REUNIÓN DEL **CLUB ESPAÑOL DE MAGNETISMO**

Santander, a 10 de Octubre 2004, 16:00 horas

Asisten los socios que figuran en el anexo 1

Orden del día

1.- Lectura y aprobación, si procede, del acta anterior
2.- Informe de actividades (Presidente)
3.- Informe económico (tesorero)
- Balance económico del ejercicio 2004-2004
- Aprobación del presupuesto 2004-2005
4.- Propuesta de nuevas actividades para 2005
5.- Ruegos y preguntas.

1) En primer lugar, J. M. Barandiaran, el presidente del CEM, agradece la asistencia a la reunión a todos los presentes. Continúa con el uso de la palabra para decir que si no hay ninguna observación o comentario al Acta de la Reunión anterior del CEM celebrada en Leioa en Octubre de 2003, se aprueba por unanimidad, siendo así aprobada la misma.

2) Acto seguido se pasa al segundo punto del orden del día en el que informa que este año finalmente se ha podido abrir la cuenta bancaria en el BSCE, con domicilio en Madrid. El Vicepresidente, Manuel Vázquez, informa que tras múltiples vicisitudes y formalismos, al final se abrió en dicha entidad la cuenta bancaria…

3) En el tercer punto, dado que el Tesorero, Juan Antonio Bas, no ha podido asistir a la reunión, el Presidente presenta la memoria económica…

4) En el punto cuarto, el presidente informa que para el año 2005, y para años posteriores, se va a empezar la organización de una escuela de Magnetismo…

A continuación el presidente aborda el tema de la petición de apoyo de la línea de dicroísmo para el Sincrotrón ALBA del Vallés tanto para la línea de fotones blandos como duros (F. Bartolomé—J. Chaboy) por conversaciones mantenidas con los responsables de coordinar dichas líneas. De nuevo **el presidente señala que enviará en breve carta de apoyo del CEM pues los documentos con los casos científicos de las diferentes líneas deben de presentarse en breve al SAC.**

Por último en el punto de actividades se informa que se van a celebrar diferentes eventos…

Sin más asuntos por tratar se da por concluida la reunión a las 17:00 horas

El secretario,

Jesús A. Blanco

club español de magnetismo

Asociación profesional sin ánimo de lucro para la promoción y defensa de los intereses de sus socios en materias científicas y tecnológicas relacionadas con el Magnetismo.

Registro de asociaciones **nº 169.773**

Página Web. **http://www.we.lc.ehu.es/ClubMagnetismo/index.htm**

Ref: 04/01

SAC Sincrotrón ALBA

Leioa, a 29 de Diciembre de 2004

Queridos colegas:

Tengo el gusto de comunicaros que en la segunda Asamblea ordinaria del Club de Magnetismo, celebrada el pasado 17 de Diciembre, a instancias de Jesús Chaboy y Fernando Bartolomé, se acordó ratificar, de manera vehemente , el apoyo manifestado en su día (1ª asamblea del club en Octubre 2003) a la inclusión de líneas dedicadas a dicroísmo magnético en el futuro Sincrotrón del Vallés.

La Comisión que estudió el tema desde la anterior asamblea ha considerado que la dedicación de haz a dicroísmo magnético debería cubrir tanto los bordes L de los metales de transición 3d como los de las Tierras Raras y metales 5d. Esto supone un alcance considerable en energía, desde unos 600 eV para el Mn hasta más de 13 keV en el Au y Pt, objeto actualmente de interesantísimas investigaciones sobre su momento inducido.

Todo lo anterior implica que las posibilidades de desarrollar experiencias de dicroísmo deban repartirse entre varias líneas optimizadas para distintas energías.

Dichas líneas servirían de manera eficaz al desarrollo de un gran número de experiencias de los socios del Club, encuadrados tanto en Universidades y centros públicos de investigación, como en las pocas, pero dinámicas, empresas dedicadas al Magnetismo en España.

Si bien nuestro Club es modesto y joven, creo que representa el sentir de la comunidad magnética, como puedes ver por la lista de socios que te adjunto. Por ello os rogamos toméis en consideración, dentro de lo posible, la propuesta de esta carta.

Gracias de antemano por vuestro interés.

Recibid un cordial saludo de

José Manuel Barandiarán
Presidente del Club,

../... carta de la 1ª asamblea, listado de socios fundadores

ASTURIAS.-	
Alameda Maestro, José María	Univ. OVIEDO
Blanco, Jesús Angel	
Cerdeira García, Mª Angeles	
Contreras Sainz, Carmen	
de la Prida Pidal, Víctor	
Elbaile Viñuales, Laura	
Fernández Calleja, Javier Jesús	
García Diaz, José Angel	
Gorria Korres, Pedro	
Hernando Grande, Blanca	
Iglesias Santamarina, Isabel	
Iglesias Pastrana, Roberto Luis	
Kourliandskaia, Galina	
Martín Carbajo, José Ignacio	
Matarranz Fernández, Rafael	
Rivas Ardisana, Montserrat	
Sánchez Rodriguez, Mª Luisa	
Santos Rodriguez, Jesús Daniel	
Vélez Fraga, María	
García Granda, Santiago	
BARCELONA.-	
Bas, Juan Antonio	AMES
Balcells, Lluis	ICMAB
Fábrega, Lourdes	
Fontcuberta, Josep	
García Muñoz, José Luis	
Martínez, Benjamín	
Obradors, Xabier	
Roig, Anna	
Veciana, Jaume	
Altimira, Ricardo	Ing. Magn. Apli.
Baró, Maria Dolors	UAB
Mora Aznar, Mª Teresa	
Muñoz Dominguez, Juan	
Nogués Sanmiquel, Josep	
Sort, Jordi	
Suriñach Cornet, Santiago	
Batlle, Xabier	Univ. Barcelona
Labarta, Amilcar	
Tejada Palacios, Javier	
BILBAO.-	
Rojo Aparicio, José Mª	INTAS
Muñoz, Juan Luis	SIDENOR I+D
Agirre Zamalloa, Gabriel	UPV/EHU
Apiñaniz, Estibalitz	
Barandiaran García, José Manuel	
de Cos Elices, David	
Fernández Gubieda, Mª Luisa	
García Arribas, Alfredo	
García Prieto, Ana	
Gutierrez Etxevarria, Jon	
Insausti Peña, Maite	
Lezama Diago, Luis	
López Antón, Ricardo	
Martín Rodriguez, Damián	
Mesa Rueda, José Luis	
Orúe Goikuria, Iñaki	
Peña Zorrilla, Alazne	
Plazaola Muguruza, Fernando	
Rojo Aparicio, Teo	
Sáiz Garitaonandia, José Javier	

CADIZ.-	
Barrera Solano, Carmen	
Domíngiez de la Vega, Manuel	
CANARIAS.-	
Ruiz Pérez, Catalina	Univ. La Laguna
CIUDAD REAL.-	
López de la Torre, Marco Antonio	U. Cast-La Mancha
Riveiro Corona, José Manuel	
GIPUZKOA.-	
Gracia Gaudó, Javier	CEIT
Alvarez, Santiago	COPRECI
González Estevez, Julián	UPV/EHU
Telleria Echeverria, Isabel	
GUADALAJARA.-	
Cortés, Miguel	Hispano Ferritas
San Román, Marta	
MADRID.-	
Ascasibar Zubizarreta, Enrique	CIEMAT
Poza, Manuel	COTEC
Batallán, Francisco	ICMM
Brey Abalo, Luis	
de Andrés Miguel, Alicia	
García Hernández, Mar	
Gonzalez, Jesús Mª	
Guinea, Francisco	
Martínez, José Luis	
Prieto de Castro, Carlos	
Serna, Carlos	
Tchubykalo, Oksana	
Vázquez Villalabeitia, Manuel	
Zhukov, Arkady	
Hernando Grande, Antonio	IMA, RENFE-UCM
Marin Palacios, Pilar	
Rivero, Guillermo	
Crespo, Patricia	
Briones, Fernando	IMM
Cebollada, Alfonso	
Agudo Madurga, Pedro	Micromag2000
Cortina Blanco, Pedro	
Baró, Arturo	UAM
Boerma, Dirk	
de Miguel Llorente, Juan José	
Miranda, Rodolfo	
de Abril Torralba, Oscar	UCM
Gonzalez Calbet , José	
López, Eloísa	
Moreno, Jorge	
Núñez Cubero, Felisa	
Pérez García, Lucas	
Saez Puche, Regino	
Sánchez Trujillo, Mª del Carmen	
Vallet, Marita	
Velázquez Cano, Julián	
Vicent, José Luis	
Aroca Ros, Claudio	UPM
Cebollada, Federico	
Céspedes Prieto, Enrique	
Morón Fernández, Carlos	
Sánchez Sánchez, Pedro	

NAVARRA.-	
Gómez Polo, Cristina	UPNa
Pérez de Landazabal, Iñaki	
Recarte Callado, Vicente	
SALAMANCA.-	
García Flores, Ana	Univ. Salamanca
Iñiguez, José Ignacio	
López Díaz, Luis	
Raposo, Víctor Javier	
Torres Rincón, Luis	
Zazo, Marcelino	
SANTIAGO/CORUÑA.-	
Baldomir Fernández, Daniel	Univ. Santiago C.
Blanco Varela, Mª Carmen	
Castro Paredes, Javier	
Fondado Fondado, Alfonso	
López Quintela, Arturo	
Mira Pérez, Jorge	
Rivas Rey, José	
Señarís Rodriguez, Mª Antonia	Univ. Coruña.
SANTANDER.-	
Espeso, José Ignacio	Univ. Cantabria
Fernández Barquín, Luis	
Frontera, Carlos	
García Calderón, Rebeca	
Gómez Sal, José Carlos	
Rodriguez Fernández, Jesús	
Yedra Martínez, Angel	
SEVILLA	
Blázquez Gámez, Javier	Univ. Sevilla
Borrego Moro, Josefa Mª	
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Conde Amiano, Clara	
Franco García, Victorino	
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Coronado, Eugenio	Univ. Valencia
Galán Mascarós,José Ramón	
Gómez García, Carlos	
Modesto Clemente, Juan	
VALLADOLID.-	
Alejos Ducal, Oscar	Univ. Valladolid
de Francisco Garrido, Carlos	
Hernández Gómez, Pablo	
Merino de la Fuente, Ramiro	
Muñoz Muñoz, José Mª	
Torres Cabrera, Carlos	
ZARAGOZA.-	
Algarabel Lafuente, Pedro	ICMA
Arnaudas, José Ignacio	
Bartolomé Sanjoaquín, Juan	
Bartolomé Usieto, Fernando	
Blasco Carral, Javier	
Burriel Lahoz, Ramón	
Camon Lasheras, Agustin	
Campo Ruiz, Javier	
Chaboy Nalda, Jesús	
de Teresa Nogueras, José Mª	
del Moral , Agustín	
García Vinuesa, Luis Miguel	
Ibarra García, Manuel Ricardo	
Luis Vitalla, Fernando	
Luzón Marco, Javier	
Magen Domínguez, César	

Marquina García, Clara Isabel	
Millán Escolano, Angel	
Morellón Alquézar, Luis	
Morón Lafuente, Mª Carmen	
Palacio Parada, Fernando	
Palacios Latasa, Elías Angel	
Rillo Milán, Conrado	
Serrate Donoso, David	
Stankiewitz, Jolanta	
OTROS.-	
Castaño, Fernando	MIT (USA)
Hernández Velasco, Jorge	HMI (Berlin)
Rodríguez Carvajal, Juan	LLB