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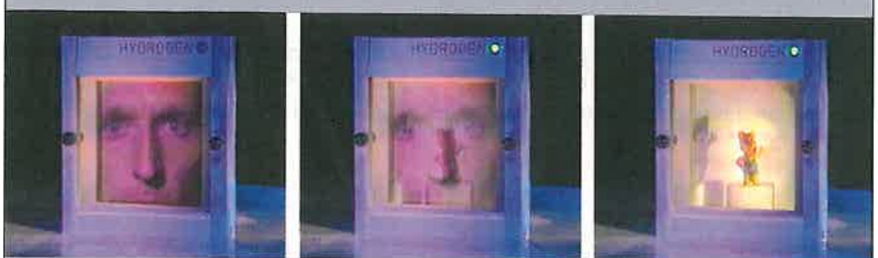

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International conference on women in physics

The International Union of Pure and Applied Physics will be organising and seeks funding and co-sponsors for an International Conference on Women in Physics to be held at UNESCO headquarters in Paris, France on March 7-9, 2002. The purpose of the conference is to understand the severe underrepresentation of women in physics worldwide and to develop strategies to increase their participation in physics.

It is widely acknowledged that the global scientific workforce is under-utilizing a large percentage of the available talent pool. Although the situation differs widely from country to country, there is remarkable consistency in one sobering pattern: the percentage of women in physics and engineering in all countries decreases markedly with each step up the academic ladder and with each level of promotion in industrial and government laboratories. If not reversed, this situation will have serious consequences for the future as all countries become more dependent on the availability of a large, scientifically trained workforce.

In recognition of this international concern, in 1999 IUPAP established a Working Group on Women in Physics (see attached list of members). In addition to organizing the Conference on Women in Physics, this group is undertaking an international benchmarking study on issues concerning women in physics. Demographic information on education and career attainment is being collected from countries in all parts of the world and will be analyzed by professional statisticians. A large number of case studies will also be examined. The results of this effort will be reported and discussed at the Conference. In addition, the following areas will be given special emphasis:

- Attracting girls to study physics in schools and universities
- Launching a successful career in physics
- Improving the institutional structure and climate for women in physics
- Getting women into the scientific power structure
- Learning from regional differences
- Balancing family and career

An understanding of the situation in physics is likely to produce insights and approaches applicable broadly to other fields and professions where underrepresentation is severe.

Teams of 3-5 physicists (females and males at different stages in their careers) will be invited to attend the Conference from countries throughout the world. Special emphasis will be given to attracting participants from member countries of IUPAP, but all countries will be welcome as space allows. Each team will be expected to take the ideas, strategies, and conference resolutions back to its own country, and to form a nucleus for positive change.

It is hoped that teams from at least 50 countries will participate. However approximately half of these countries are in the developing world or Eastern Europe; for them financial support is needed to help assure full global representation. In addition, funding is needed for the benchmarking survey, the publication of a conference proceedings, and general conference expenses. The organisers urge you to support the participation of one or more teams and to contribute in whatever way that you can to this very important event.

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Switchable Mirrors

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The discovery

In 1990, in the middle of the euphoric times of high-temperature superconductivity, we decided to search for other superconductors with a potentially high T_c. Since there were predictions that solid, metallic atomic hydrogen might become superconducting at temperatures as high as 200-250 K, we looked into the possibility to create new superconductors based on hydrogen. However, instead of trying to metallize pure hydrogen under very high pressures, we chose another route. We first incorporated hydrogen into a metal to break the molecular bond of H_2 and started to compress the sample under high pressures (not higher than 0.5 GPa) to increase its metallic character, thus favoring superconductivity.

As starting material we chose yttrium, which is able to absorb 300% hydrogen up to the composition YH_3. We evaporated a 500 nm thick yttrium film on one of the diamonds of a high pressure diamond-anvil-cell. Quite unexpectedly, upon hydrogen uptake under several thousands of atmospheres, around 240 K, the yttrium film changed from a shiny metallic into a transparent yellowish sample [1]. Although metal-insulator transitions had already been described in earlier work on rare-earth hydrides [2], no report whatsoever existed about such drastic changes in their visible optical properties, most probably because nobody really looked at hydrides during hydrogen uptake. Our great fortune was that the diamond-anvil-cell allowed us to optically monitor the hydrogen absorption *in situ*!

Very much intrigued by these spectacular changes, we tried to induce the same transition at room temperature and low hydrogen gas pressure (typically 1 bar). It worked admirably, provided the yttrium film was protected by a thin layer (5-20 nm) of palladium. With this protective layer we could take samples out of the ultra-high vacuum deposition system without danger of oxidation (a severe problem with highly reactive materials such as yttrium and rare-earths) and carry out a whole series of *ex situ* experiments (temperature dependence of the resistivity, magnetoresistance, Hall effect, photoconductivity, pressure dependence of the semiconducting gap, optical transmission and reflection, etc.) which are usually impossible on the corresponding *bulk* materials as hydrogenation reduces their trihydrides into powder.

Optical switching

The simplest way to get an impression of what switchable mirrors really are is to follow the changes which occur in an yttrium film during loading with hydrogen at room temperature. Figure 1 exhibits the evolution of the electrical resistivity and optical transmission for red light (with $\hbar\omega = 1.96$ eV) as a function of the time elapsed since the film has been brought into contact with hydrogen gas at 10^5 Pa. As the hydrogen uptake occurs approximately linearly, the time axis is essentially also a hydrogen concentration axis. Spectacular changes occur in both the electrical and optical properties. After a weak rise due to impurity scattering the electrical resistivity ρ decreases steadily until it reaches a minimum in the dihydride phase. YH_2 has at this point an electrical resistivity which is about 5 times *lower* than that of pure Y. At higher concentrations ρ increases by several orders of magnitude and is only limited by the conductivity of the 20 nm Pd caplayer. The optical transmittance remains low until in the dihydride phase a weak maximum occurs at approximately the same time as the minimum in ρ is reached. As demonstrated by Den Broeder *et al.* [3], this weak red transparency is most valuable for the visualization of hydrogen diffusion as it makes it possible to locate exactly the YH_2 phase in a diffusion experiment. The film transmittance suddenly rises and stays high as the H concentration is increased from 2 to 3. These changes are easily observed as a switch from high to low reflectivity and significant transmittance in the last two photographs of Fig.1. The transition back from the transparent trihydride to the shiny dihydride is reversibly induced by decreasing the surrounding hydrogen gas pressure. Gas loading is easily carried out; for a direct measurement of the hydrogen concentration it is necessary to use instead electrolytic charging. The time-integrated electrical current flowing in an oxygen-free electrolytic cell during hydro-

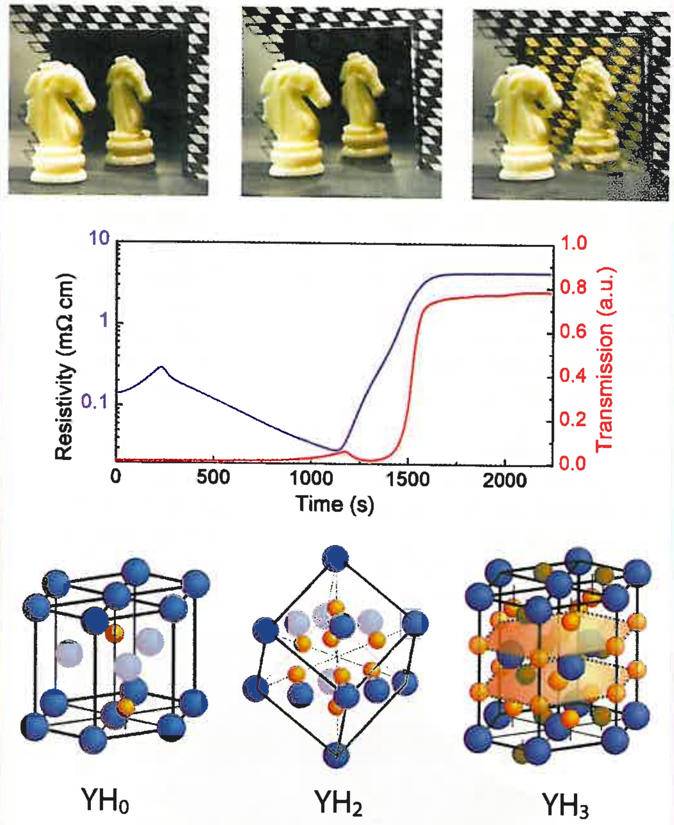


Fig. 1: Variation of the electrical resistivity and optical transmittance $\hbar\omega = 1.96$ eV) of a 300 nm thick yttrium film protected by a 20 nm thick Pd caplayer brought in contact with H_2 gas at 10^5 Pa pressure at room temperature. The hydrogen concentration is approximately proportional to the elapsed time *t*, except after 1600 s where both electrical resistivity and optical transmittance have reached saturation. This experiment is deliberately carried out slowly, but optical switching can in fact be much faster (see Fig. 4). The photographs illustrate the reflectance and transmittance of the film as deposited, in the dihydride and in the trihydride phase. The structures of the various phases are schematically depicted in the lower panel.

gen charging is a direct measure of the number of H injected into the switchable mirror. Measurements of optical transmittance and reflectance and other parameters as a function of H concentration are then possible. Whereas the drop in transmittance above $\hbar\omega = 2.8$ eV in YH_3 in Fig.2 is due to the onset of optical absorption, the oscillations in reflectance are due to multiple reflections within the sample.

Metal-insulator transition

The increase in ρ with increasing H concentration in Fig.1 and the decrease of the reflectance in Fig. 2 are indications of the occurrence of a metal-insulator (MI) transition. At first sight this MI-transition seems to have a rather trivial origin. As seen in Fig.1, YH_2 has a cubic structure while YH_3 is hexagonal. Many such transitions in nature are of first order (for example diamond to graphite, white to grey tin, vanadium oxides). In fact, YH_x is already in the hexagonal phase when the MI-transition occurs around x=2.86. YH_x is, therefore, one of the very few examples of a system with a *continuous* MI-transition; this alone makes it a fascinating material. In addition, the ease at which the H concentration can be modified is a tremendous advantage for experimental investigations. Instead of having to painstakingly prepare a whole series of samples with various degrees of doping (for example boron doped silicon, or Se substituted NiS_2) one can simply actuate a switchable mirror by controlling the surrounding hydrogen gas pressure or the voltage in an electrolytic cell.

The MI-transition is also *robust* in the sense that it occurs in all hydrides of the trivalent rare-earths. They all switch optically when the H concentration is increased from 2 to 3 although the crystal structure of the trihydrides can be hexagonal as for YH_3, cubic as for LaH_3 or more complicated as for SmH_3. A MI-transition also occurs in *cubic* YH_3 and in disordered alloys of yttrium and lanthanum, whose trihydrides are either cubic or hexagonal, depending on the composition [4]. In the trihydride state they are all transparent albeit with characteristic colors: for example, YH_3 is yellowish, LaH_3 red, while some alloys are colorless.

Theoretical models

Although the occurrence of a MI-transition in YH_x could have been expected on the basis of earlier work on bulk rare-earth hydrides [2], the transparency of $YH_{3-\delta}$ discovered by Huiberts *et al.* [1] came as a great surprise, since the state-of-the-art self-consistent band structure calculations in the early nineties predicted YH_3 to be a semi-metal with, in fact, a considerable band *overlap* (1.5 eV). The occurrence of large optical gaps in YH_3 and LaH_3, as well as the observed increase in resistivity with decreasing temperature, being incompatible with a metallic character, stimulated theorists to reconsider the YH_x and LaH_x systems in detail.

Somewhat as for the high-T_c superconductors two lines of thought developed:

i) Band structure models: Originally it was proposed that the semiconducting ground state of YH_3 was due to a so-called Peierls distortion of the crystal lattice. The total energy of YH_3 was indeed found to be extremely sensitive to the exact position of the H atoms, especially those close to the Y planes. So far, however, no experimental evidence has been found for the existence of a low symmetry crystal structure of YH_3. Very recently van Gelderen *et al.* [5] demonstrated that improved band structure calculations based on the so-called GW approximation led to a fundamental direct but dipole forbidden energy gap of 1 eV and an indirect optical gap of almost 3 eV without having to invoke any lattice distortion. The agreement of these calculations with the optical data is remarkable since they do not involve any fit parameters. A similar approach predicted that also *cubic* YH_3 should be a semiconductor.

ii) Strong electron correlation models: Other theorists [6] expected strong correlation effects to be especially large in YH_x and similar rare-earth-hydrides as a direct consequence of the large on-site repulsion between two electrons near the same proton. This repulsion is reflected in the radius of the negative H^--ion that is about 3 times larger than for a neutral H atom and its ionization potential, which is only 0.7 eV compared to 13.6 eV for neutral H. Electron correlation leads to a drastic narrowing of the H-derived band and therefore to a sizeable gap between this low-lying band and the La-derived 5d-bands in LaH_x or the Y-derived 4d-bands in YH_x. The swelling of neutral H when it transforms to an H^--ion led to the new concept of a *breathing* Hubbard Hamiltonian.

The GW calculations provide no direct insight into the mechanism of the metal-insulator transition. The strong electron correlation picture, however, leads to the following scenario first proposed by Sawatzky and co-workers. For simplicity, we consider the case of LaH_x. Although metallic La is hexagonal, LaH_2 is cubic with all tetrahedral sites occupied by H atoms (CaF_2 structure).

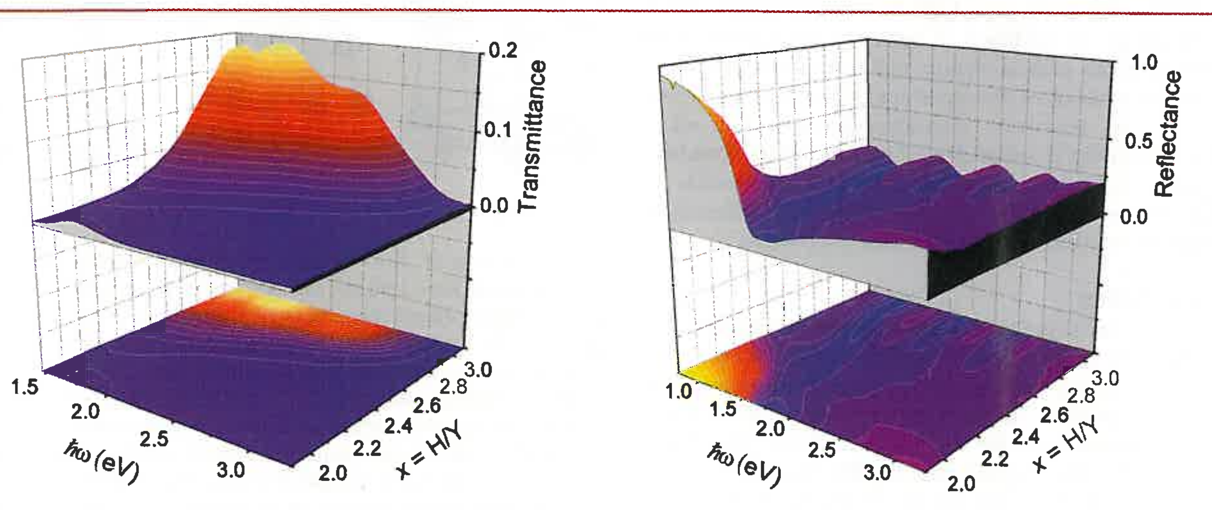


Fig. 2: Hydrogen concentration and photon energy dependence of a) the optical transmittance and b) the reflectance of a 300 nm thick yttrium film protected by a 15 nm thick Pd caplayer.

These H atoms are so strongly bound that they are not involved in the MI-transition that occurs around $LaH_{2.8}$. The nice thing about LaH_x at room temperature, is that it remains cubic all the way up to LaH_3. Each H added to LaH_2 occupies octahedral sites with six La nearest neighbors. It attracts a conduction electron to form a singlet in a way similar to what happens with two holes in high-T_c superconducting cuprates. One electron is on an orbital localized around the proton (with a radius of ≈ 0.5 Å) and the other is race-tracking on the neighboring La atoms (see Fig.3). Roughly speaking this resembles a huge H^--ion with a diameter of the order of the host lattice spacing (≈ 6 Å). As every H ties up an electron from the conduction band, electrical conductivity becomes increasingly difficult and the system tends towards a so-called Kondo-insulator. In an alternative picture, one may start from insulating LaH_3 and create vacancies in the octahedral H sublattice. Ng *et al.* [6] argue that H-vacancies are highly localized donors. This explains why 0.2 vacancies per La (a huge doping level compared to those usually involved in semiconductors) are required to create a band from overlapping donor wave functions and to drive the system metallic around $LaH_{2.8}$. The steady increase of charge carrier density with increasing vacancy density (i.e. decreasing x) is confirmed by Hall effect measurements.

The attractiveness of the strong-correlation picture is that it is local and therefore inherently robust. It is marginally affected by disorder or the overall crystal structure. It also provides a direct explanation for the effective negative charge of H observed in electromigration experiments [3] and the puzzling result of van der Molen *et al.* [7] that, at high temperatures, when H diffuses rapidly, the flux of H atoms measured in $YH_{3-\delta}$ by means of electromigration is equal to the current of electrons. It looks as if during a diffusion jump of a proton, one of the electrons in the original singlet is momentarily lent to the conduction band to be recaptured somewhat later at a neighboring site to reform a singlet.

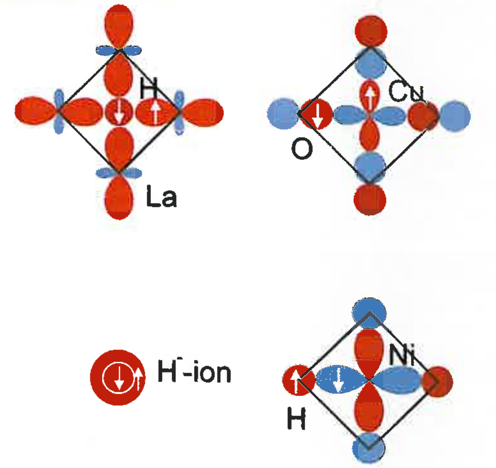


Fig. 3: Correlated singlet states depicted in a plane as antisymmetrized products of atomic-like orbitals. Lobes of opposite sign are shown in red and blue. In $LaH_{2+\delta}$ the singlet involves two electrons and resembles locally a huge H^--ion. In a cuprate such as La_2CuO_4 and the hydride Mg_2NiH_4 it involves two holes at the top of the metal-derived d-band.

Second generation switchable mirrors

A major step towards applications was set in 1997 when Van der Sluis *et al.* [8] reported that $Gd_{1-y}Mg_yH_x$ alloys with $y > 0.4$ could be made transparent and colorless in contrast to the yellowish YH_3 (see Fig.1). Moreover, the contrast between the reflecting and the transparent states is enhanced due to the absence of the weak transparency maximum, which is characteristic for YH_2, LaH_2 or REH_2 in their metallic state. In addition $Gd_{1-y}Mg_yH_x$ mirrors switched fast: as shown in Fig.4, the transition from the metallic state to the transparent insulating state occurs in less than 40 ms. The optical gap of $Gd_{0.5}Mg_{0.5}H_{2.5}$ being 3.4 eV, this switchable mirror is color neutral. This color neutrality has also been observed in Y-Mg and La-Mg alloys and is probably a general property of Mg-rare earth alloys. The possibility to fine-tune the optical gap is most important for applications of switchable mirrors.

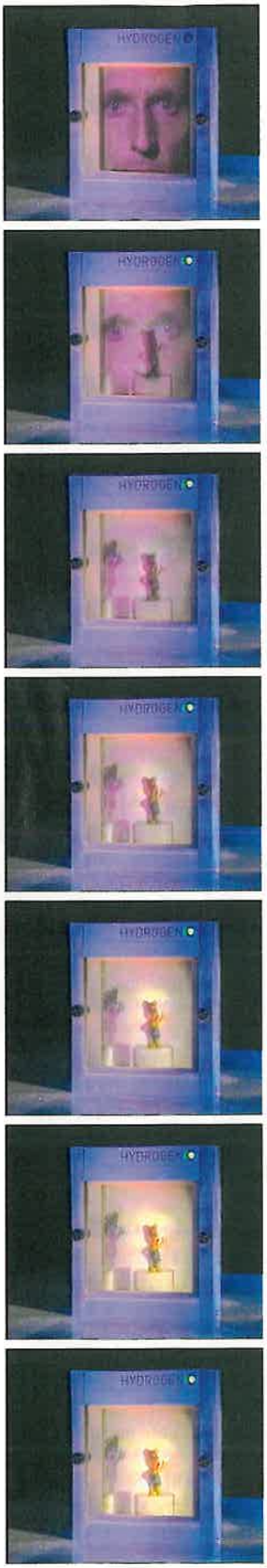
From a fundamental point of view these Mg-containing alloys confronted us with a new switching process. During the first hydrogen absorption $Y_{0.5}Mg_{0.5}H_x$ disproportionates first into YH_2 and Mg and subsequently, after formation of MgH_2, into a transparent composite of MgH_2 and YH_3. This composite switches back to a metallic composite of YH_2 and Mg . In this transformation Mg acts as a sort of *microscopic shutter* since it switches reversibly from an excellent metal to a large gap (about 6 eV) insulator. This suggested that multilayers of Y (or any rare-earth) and Mg would also act as color neutral switchable mirror which was indeed confirmed experimentally. This is at first sight not extremely surprising since MgH_2 has a much larger optical gap (approx. 6 eV) than YH_3. What is not trivial at all, however, is that the electrical resistivity of $Y_{0.75}Mg_{0.25}H_{2.75}$ is *four* orders of magnitude larger than that of $YH_{3-\delta}$! This cannot be understood in terms of a simple disproportionation and indicates that electronic effects are occurring at the Y-Mg interface.

Third generation switchable mirrors

A few months ago at a conference on electrochromics in Uppsala, Richardson *et al.* (Lawrence Berkeley Labs.) reported that a thin film of a Mg-Ni alloy also exhibited optical switching. This is a major extension of the class of switchable mirrors since it avoids Y, La or rare-earth metals. It is also of fundamental importance since the transparent phase is probably Mg_2NiH_4, a compound in which H and Ni orbitals hybridize strongly to form covalently bonded $(NiH_4)^{4-}$-complexes that are bound ionically to Mg^{2+}-ions. The gap is essentially determined by the most antibonding Ni-H state at the top of the d-band of nickel (see Fig. 3), a situation similar to that in cuprates (for example in La_2CuO_4). Since Mg_2CoH_5 and Mg_2FeH_6 can also be formed, it is probable that new switchable mirror materials based on such compounds will be discovered. This opens a completely new field of investigation of materials with remarkable optical properties in the visible part of the spectrum.

Epitaxial switchable mirrors

So far we have described electrical and optical properties of *polycrystalline* switchable mirrors. We found that it was also possible to synthesize YH_x *epitaxial* films on a transparent and electrically insulating substrate with evaporation at high temperature on a (111)-CaF_2 substrate. The crystallinity of these films deduced from X-ray diffraction is excellent and remains so even after repeated hydrogen loading and unloading. This is in itself remarkable since there is a 15% volume expansion between Y and YH_3! The process through which an epitaxial film can accommodate such high strains without deterioration of its crystallinity was recently identified by Kerssemakers *et al.* [9]. Using *in situ* Atomic Force Microscopy, combined with electrical resistivity and local optical transmission measurements, they discovered that micron-sized triangular domains switch one-by-one, homo-



geneously and essentially independently, during hydrogen absorption. These optically resolvable domains are defined by an extended self-organized ridge network, created during the initial hydrogen loading. The ridges block lateral hydrogen diffusion and act as a microscopic lubricant for the sequentially expanding and contracting domains. This block-wise switching results in a 'Manhattan skyline' in which optical and structural texture are intimately correlated. Their tunability is of technological relevance since it opens the way to a pixel-by-pixel switchable pattern with a minimal amount of inactive surface area. The domain switching of epitaxial films is *locally* very different from the behavior of polycrystalline films, which are optically homogeneous on a micrometer length scale. However, on a macroscopic scale, both polycrystalline and epitaxial switchable mirrors exhibit the same properties.

Conclusions

The great richness of new phenomena in the electrical, optical and mechanical properties of switchable mirror materials, the possibility to fine-tune their properties by alloying and the ease to change continuously their hydrogen content makes them especially attractive for fundamental condensed matter physics. Detailed studies of continuous metal-insulator transitions, fast diffusion and electromigration are drastically simplified since i) the concentration of the dopant (hydrogen) can be modified at willby simply changing the surrounding gas pressure or the voltage in an electrolytic cell, and ii) hydrogen migration can easily be monitored visually. Replacement of hydrogen by deuterium also offers unique opportunities to investigate isotope effects in many physical properties.

Fig. 4: Frames of a video taken during hydrogen absorption by a GdMg switchable mirror. The indicator lights up when gaseous H_2 is introduced in the system. The mirror image of the experimenter fades out rapidly while the little toy bear behind the mirror appears. The time between the first and last frame is 280 ms. The characteristic switching time is approximately 40 ms. (Courtesy P. Duine, Philips Research Labs., Eindhoven).

They offer also interesting possibilities for technological applications, such as smart windows to regulate the light and heat transfer in buildings, antireflection coatings for TV screens and monitors, variable reflectance rear-view mirrors in cars, variable transmittance glasses and smart light bulbs with adaptive optics. Epitaxial switchable mirrors may offer additional possibilities through their self-organized, pixel-by-pixel switchable domain pattern. Recently, two groups at Lawrence Berkeley and at Philips Research Labs [10] have demonstrated the feasibility of all-solid-state devices based on metal-hydride switchable mirrors. In such devices, the mirror layer is separated from a conducting transparent layer of indium-tin oxide by a solid electrolyte (e.g. ZrO_2). Applying a voltage one can control the hydrogen concentration in the switchable mirror and induce reversible switching. Although many materials problems still remain to be solved, such all-solid-state devices are an important step towards large-scale application of switchable mirrors.

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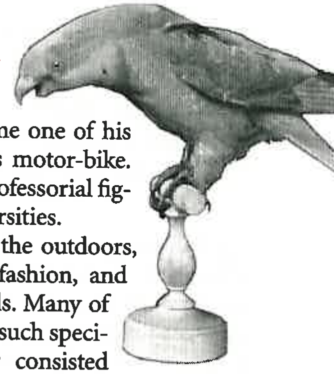
The parrot, the pince-nez and the pleochroic halo

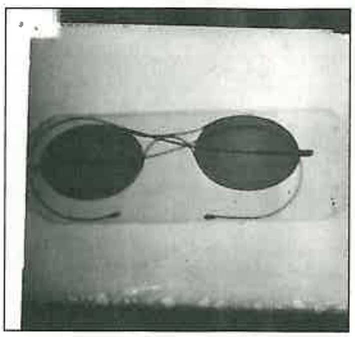
D. Weaire and S. Coonan

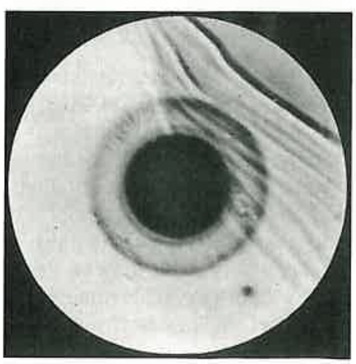


In the midst of the chaos of the 1916 Easter Rising in Dublin, a lone figure ventured forth from the defences of Trinity College, in search of fresh intelligence and cigarettes for his comrades. Whether by good fortune or the poor marksmanship of his enemy, John Joly survived this experience to become the grand old man of science in the independent state that he opposed. He is mostly remembered as a geologist but, as one obituary acutely observed, he was essentially a physicist.

Joly had a distinguished continental pedigree too elaborate to be recounted here, but he was born in Ireland and educated in Dublin. He was no great scholar in his youth and in another time he might not have prospered as a scientist. But that was the age of Kelvin and Edison, when the young man's interest in practical devices could secure him a prominent place in a list drawn up by the magazine Inventors and Inventions. This was just after he had graduated in engineering. He was already embarked on a remarkable surge of publication and patenting of physical instrumentation. Of the many instruments that he produced, the meldometer, the aphorometer and the steam calorimeter are long forgotten, but Joly's photometer will be familiar to many. While he progressed from Assistant in engineering to a similar position in physics, he contributed to a lively interdisciplinary community, whose doyen was the ebullient George Francis Fitzgerald.

The most promising of those inventions was a new method of colour photography, based on filters made up of lines of different colours. This enabled the taking of pictures in a single shot and their viewing by projection. The method was commercialised as the Joly Process, but a legal dispute arose with a Chicago inventor who was able to claim priority under US law. Technically Joly won the case, but it seems to have been a pyrrhic victory and his process was soon overtaken by others.



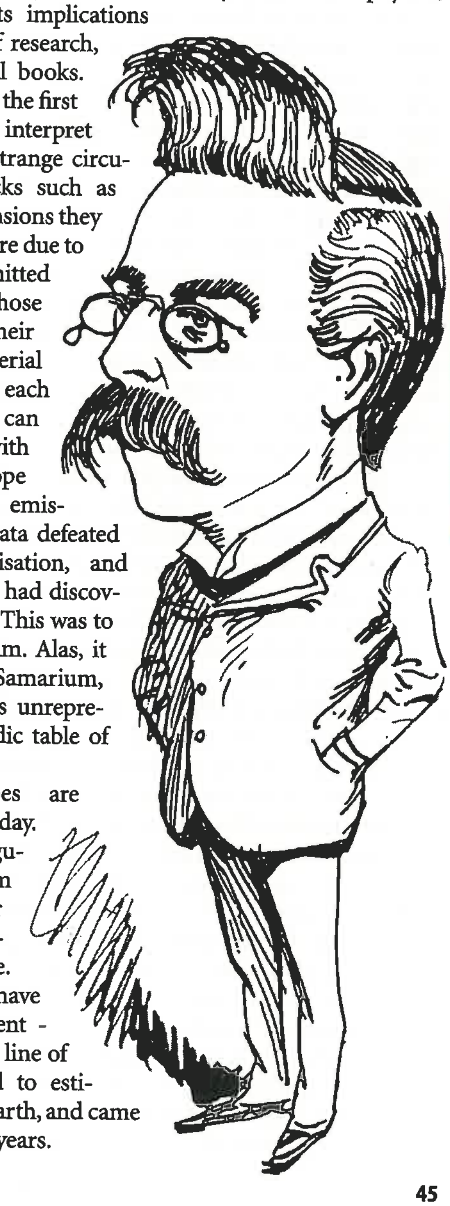


When we began some years ago to gather together the surviving records and lantern slides from that period, we visited the curator of Trinity's geology museum. From a cardboard box he pulled a small parrot which was to become very familiar to us, as Joly's favourite subject. It had survived many years of neglect, and turned up in a cleaner's cupboard.

Unfortunately most of his subjects were no more dramatic or dynamic than the stuffed parrot - the attractions of conventional still life to a photographic pioneer are irresistible. A black-and-white photograph that he took at much the same time, very soon after the announcement of the discovery of X-rays, is much more striking. It shows, within its wooden case, the pince-nez that became one of his personal trademarks. Another was his motor-bike. All in all, he cut the kind of eccentric professorial figure that is much prized in certain universities.

Early in life he developed a love of the outdoors, exploring the Alps in the Victorian fashion, and everywhere stooping to collect minerals. Many of his instruments were for the analysis of such specimens. For example, the meldometer consisted essentially of a platinum strip upon which small crystals could be placed, electrically heated and viewed, in order to determine their precise melting points. Such interests drew him towards geology and he became professor of that subject.

Joly brought to geology a keen appreciation of the importance of the exciting new subject of radioactivity and nuclear physics, and he explored its implications over two decades of research, expressed in several books. In particular, he was the first to correctly interpret pleochroic haloes, strange circular patterns in rocks such as mica. In three dimensions they are spherical. They are due to the decay of emitted alpha particles, whose lifetimes dictate their ranges in the material and hence radius of each circle. These radii can thus be identified with the radioactive isotope responsible for the emission. Some of the data defeated immediate categorisation, and Joly thought that he had discovered a new element. This was to be named Hibernium. Alas, it turned out to be Samarium, and Ireland remains unrepresented in the periodic table of the elements.



Pleochroic haloes are back in the news today. Creationists are arguing that some of them offer evidence for the recent divine creation of the universe. Joly himself would have enjoyed the argument - he was one of a long line of scientists who tried to estimate the age of the earth, and came up with 100 million years.

Absorption and phase imaging with synchrotron radiation

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All users agree on two essential virtues of synchrotron radiation: its high intensity in the X-ray range, and its continuous spectrum. The new, third generation, sources have another, at first sight less spectacular feature: the small divergence of the beam as seen from the sample. This characteristic is due to the very small cross-sectional area of the electron beam that acts as the source of radiation, and to the large source - sample distance. All three of these qualities lead to novel possibilities, among others in X-ray imaging. We will discuss some of the approaches developed in hard X-ray synchrotron radiation imaging, and some of its applications in quite diverse fields.

Synchrotron radiation refers to the electromagnetic radiation emitted by ultrarelativistic electrons (energies of several GeV), circulating in storage rings, at those parts of the rings where they are accelerated by a magnetic field. This can be uniform over a part of the trajectory in the bending magnets, or spatially oscillating in the "insertion devices". The spectrum of the light thus produced extends from the infra red into the X-ray range, the latter part being to most users the more valuable one. Emission is strongly concentrated in the forward direction with respect to the velocity of the emitting electrons, the characteristic angular opening being mc^2/E, with E the energy of the electrons, m their rest mass. Three machines in the world belong to the category of third generation, high energy sources : the European Synchrotron Radiation Facility (ESRF) in Grenoble, France, at 6 GeV; the Advanced Photon Source in Argonne, IL, USA at 7 Gev; and SPRING-8 in Japan, at 8 GeV. They are characterised by the thinness of the electron beam that produces the radiation (source dimensions < 0.1 mm), and by the provision, in between the bending magnets, of many straight sections. These allow the positioning of insertion devices, viz. wigglers or undulators, which can provide each experiment with the best suited beam.

Imaging is normally associated, in our minds, with lenses. Unlike visible light or electrons, efficient lenses are not (yet?) available for hard X-rays, essentially because they interact weakly with matter, resulting in a refractive index very close (to within 10^{-5} or 10^{-6}) to unity. Nevertheless X-ray imaging plays an immense role. Radiographs of hands of attendants made at the lectures on X-rays in 1896 are the historical banner of X-rays, while each of us benefited from medical radiography and enjoys the leak-tightness which industrial radiography controls in pipelines. X-ray tomography is used on a routine basis, under the name of computed axial tomography (CAT) or medical scanner, to visualise virtual cuts through human anatomy, obtained from attenuation measurements performed under different viewing angles. In radiography (two-dimensional images) as well as in tomography (three-dimensional exploration), only contrast associated with local variations in X-ray absorption was, until recently, considered. On the other hand, a different approach, based on Bragg diffraction ("X-ray topography"), reveals isolated defects, such as dislocations, inclusions, stacking faults, and sometimes domain walls, in single crystals. It largely contributed to the development of the processes that now provide the huge perfect crystals of silicon which make microelectronics so efficient.

The advent of synchrotron radiation was a boon to X-ray imaging through the possibilities for real-time observation or for refined beam preparation offered by the increase in intensity. However, the place imaging techniques have taken (15% of the activity of ESRF, i.e. much more than planned) on third generation sources also results from the entirely new avenues that have been opened through the high geometrical quality of the beams.

In the following, we separate the developments we consider as more closely associated to the gain in intensity (the quantitative aspect) from those more directly connected to the new geometric features (qualitative aspects). The results we describe were obtained on several instruments, mostly but not exclusively at ESRF.

Quantitative progress: absorption imaging ever more refined

Angiography

X-ray absorption changes abruptly with the energy or wavelength of the photons at the absorption edges, corresponding to the energy required to eject an electron from a deep atomic level. This variation has been used for the selective observation of blood vessels, in particular for the diagnosis of heart problems associated to the coronary arteries, via angiography. In the hospital version of this technique, a catheter is introduced along an artery to bring a contrast agent (an iodine-containing solution) near the coronary artery to be inspected. This approach involves a fatal risk of about 0.1%. SR makes it possible to obtain excellent images with reduced danger, because an injection of a contrast agent through a vein is enough. The higher dilution is compensated by the logarithmic subtraction of two images. Because the heart moves, the approach consists in simultaneously using two flat beams with slightly different energies, one above, the other below the K absorption edge of iodine (33.17 keV). The beams cross at the location of the investigated organ, and they are measured by two detector lines, while the patient is translated vertically. Fig. 1 shows the

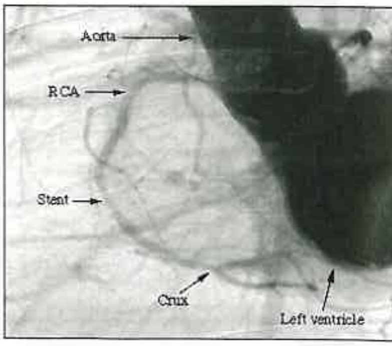

Fig. 1: Image of the heart and arteries o[f] the first human patient at ESRF's Medical Beamline: this differential angiogram results from logarithmic subtraction of two images obtained simultaneously on either side of the iodine absorption edge. The right coronary artery (RCA) shows a stent an[d] the crux (courtesy H. Elleaume, ESRF [H. Elleaume *et al.*, Phys. Med. Biol. **45**, L39-L43 (2000)]).

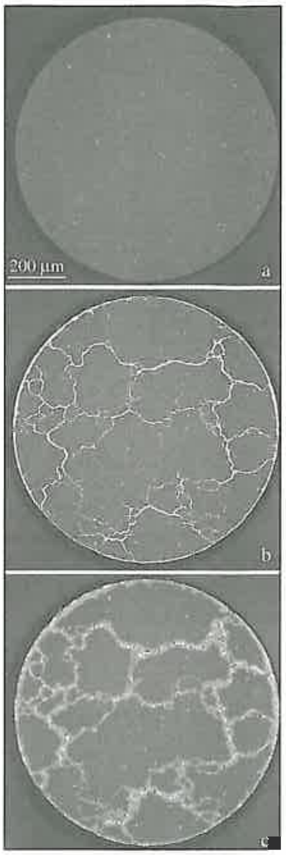

Fig. 2: Study of liquid metal embrittlement by means of high resolution absorption tomography. Reconstructed slices of a polycrystalline aluminium alloy: a) in its initial state b) after exposure for 4 hours to liquid gallium close to room temperature c) after a supplementary anneal for two hours at 300°C. The gallium appears in b) as white lines at the grain boundaries. These lines become diffuse in c) as gallium diffuses into the aluminium grains. The voxel size in the images is 1 µm, corresponding to a spatial resolution of 1.7 µm.

results recently obtained, after preliminary attempts on pigs, on human patients at the medical beamline ID17 of the ESRF.

Imaging through magnetic dichroism

Refinement is perhaps even more obvious in the use for imaging of magnetic X-ray dichroism, which several groups have developed in the "soft" X-ray range (energy < 1 keV). In a magnetic material, in the immediate vicinity of an absorption edge, absorption can, for a given polarisation state of the incident beam, depend on the magnetisation state of the sample. It is therefore possible to image the distribution of magnetisation, i.e. the magnetic domains, with only one chemical element at a time being sensed since the energy of the edge is different for each. This is obviously attractive in the case of magnetic multilayers, where the magnetisation directions vary from one layer to the other. Several approaches are used to change the small variation in X-ray absorption into an image. Some use an electron-optical system to produce an enlarged picture through the emitted photoelectrons, which are the more numerous the higher X-ray absorption is. These experiments, based on the use of secondary electrons, and on absorption edges corresponding to soft X-rays, can only be performed in a good vacuum, and only reveal the immediate neighbourhood of the surface. Another approach is the use of a transmission X-ray microscope, as at BESSY (Berlin), which proved a powerful tool for probing the magnetisation process in Gd-Fe multilayers.

Absorption microtomography

The three-dimensional (3D) reconstruction of complex structures, on the basis of many images obtained for different orientations of the sample with respect to the beam, is possible with spatial resolution down to 1 µm (microtomography). This is the smaller-scale analogue of the medical scanner or CAT. From the tomographic reconstruction, one can at will produce cuts or volume renderings of the object. The number of 2D images required is approximately equal to the number of pixel columns in the detector. At the imaging beamline ID19, this number is typically 900 when using a 1024x1024 pixel CCD camera. The time required for recording these 2D images with an extended, parallel and moderately monochromatic ($\Delta E/E \approx 10^{-2}$) beam is now less than 10 minutes, while the 3D reconstruction time, on a powerful computer, remains on the order of one hour. The spatial resolution is mainly determined by the detector specially developed for these experiments. The usual tool is an X-ray --> visible light converter screen coupled, via visible light optics, to a cooled CCD camera (FRELON, for Fast REad-out, LOw Noise) developed at ESRF.

Under specific conditions a liquid metal can penetrate into the grain boundaries of a polycrystalline solid metal, leading to a brittle behaviour of the normally ductile solid. This phenomenon, known as liquid metal embrittlement, was discovered more than a century ago. However, the mechanisms leading to rapid penetration along grain boundaries remain poorly understood. Absorption radiography and tomography, with a spatial resolution of about 1 micron, are well suited to studies on the kinetics of this process in the case of aluminium alloys. Gallium, which is liquid just above room temperature, attenuates X-rays much more than aluminium. This makes it possible to observe *in-situ* the penetration of gallium into the bulk. Figure 2 shows the same virtual slice of an aluminium alloy (Al 5038) at various stages. The first tomographic image (figure 2a) shows the initial state of the sample; the isolated white points correspond to Fe and Mn rich inclusions. Figure 2b was recorded after liquid gallium was allowed to penetrate, and after annealing the sample close to room temperature: the white lines that divide the sample into cells indi-

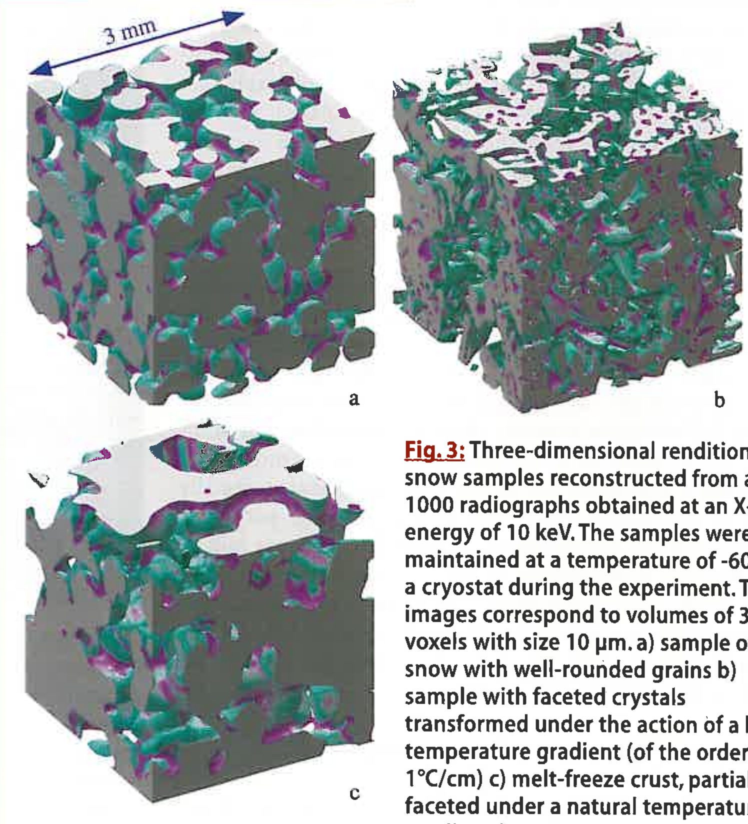

Fig. 3: Three-dimensional renditions of snow samples reconstructed from about 1000 radiographs obtained at an X-ray energy of 10 keV. The samples were maintained at a temperature of -60°C in a cryostat during the experiment. The images correspond to volumes of 300^3 voxels with size 10 µm. a) sample of wet snow with well-rounded grains b) sample with faceted crystals transformed under the action of a large temperature gradient (of the order of 1°C/cm) c) melt-freeze crust, partially faceted under a natural temperature gradient (courtesy C. Coléou).

cate the presence of gallium along the grain boundaries. The lines become diffuse and heterogeneous after a second anneal which allows gallium to diffuse into the grains (figure 2c): isolated gallium precipitates and cavities can be observed. These experimental observations should corroborate some of the antagonistic models proposed in the literature.

Figure 3 is a 3D rendition of spring snow that suffered metamorphic transformations. Metamorphism has radical consequences: the physical and mechanical properties can change over several orders of magnitude. This is related to the fact that some snows stick to almost vertical rock walls, while others yield under the weight of a single skier. The form and arrangement of the grains, and the quality of the bonds in the ice, are key factors in determining the properties of snow. The growth of ice particles is associated with the diffusion of vapour in dry snow, and to melting / resolidification in damp snow. Dry snows are usually warmer at the bottom. The value of the temperature gradient determines whether the crystallites take on a rounded (small gradient) or facetted (high gradient) form. The important parameters are the area per unit volume, the inter-grain connections, and the local radius of curvature of the grains. These parameters cannot be directly measured on 2D images. 3D images such as those of fig. 3 provide important data on statistically significant volumes, containing enough grains, and with spatial resolution limit much smaller than the grain size. They are quantitatively evaluated by a research group at the Snow Research Centre (Centre d'Etudes de la Neige) of the French weather agency (Météo-France).

These examples of synchrotron radiation absorption microradiography show two trends : the use of high spatial resolution in the first case, and specially designed sample environments in the second. Quantitative tomography, made possible by the monochromaticity of the X-ray beam, shifts the emphasis from the sample architecture, i.e. the geometry, to the densitometry of the solid parts through mapping of the linear absorption coefficient. Another development is "local" or "zoom" tomography, the high resolution reconstruction of a region of interest within a matrix that gets only low resolution reconstruction. This is essential for applications where it is not possible or not desirable to extract a small sample from its matrix.

Zone plate microscopes

The advent of synchrotron radiation also stimulated the development of microscopes for soft X-rays, in particular for the wavelength range (the "water window") where absorption by carbon is much stronger than by water. They are based on make-shifts for lenses, zone-plates, and reach very valuable performance for biological systems. Thus, 3D reconstruction of an alga cell was achieved, with a spatial resolution on the order of 60 nm. The use of zone plates also allows refinements that are usually thought to be possible only in the visible range, in particular Zernike's phase contrast technique. A transmission X-ray microscope operating with energies in the 2-7 keV range has been installed on the ID21 beamline of ESRF. The possibility to tune the energy to the vicinity of important absorption edges (Ca, Cr, ...) allows different elements and their chemical state to be mapped through spectro-microscopy.

Qualitative progress: scanning X-ray imaging, phase radiography and phase tomography

Two new families of imaging techniques depend more directly on the beam quality reached in third generation synchrotron radiation. They are the scanning imaging techniques on the one hand,

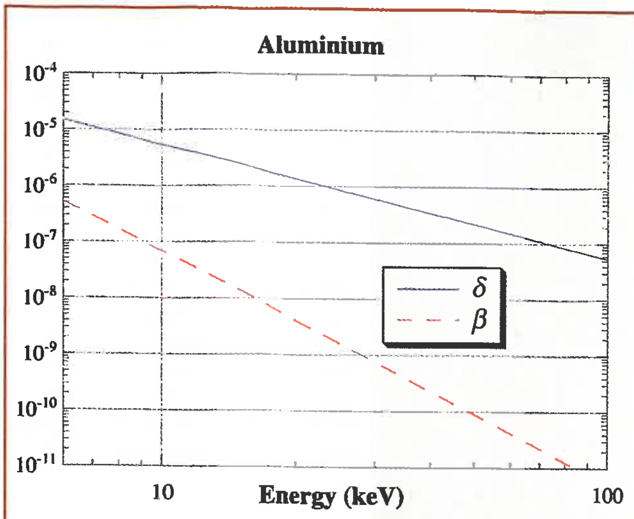

Fig. 4: The coefficients δ and β, representing respectively the phase and absorption, for aluminium as a function of the X-ray energy. The phase effects are expected to be dominant in the hard X-ray regime.

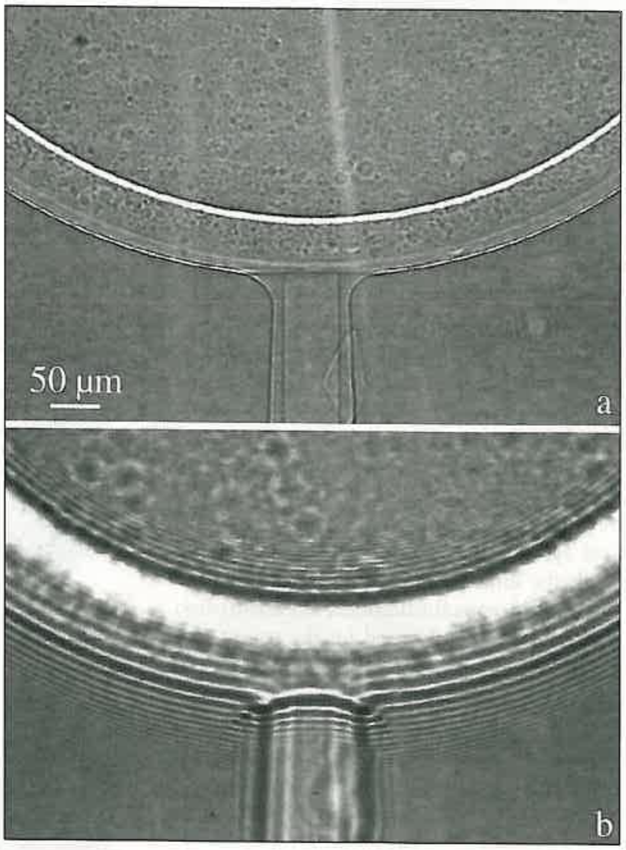

Fig. 5: Two images of a hollow sphere consisting of two different polymer layers. In image a), recorded at a sample-detector distance of 19 cm and representative of the edge-detection regime, the borders are revealed by white-black contrast. In image b), recorded at a distance of 3 metres and representative of the holographic regime, many interference fringes are observed.

and the easy observation of inhomogeneities in the optical phase of the outgoing beam on the other hand.

X-ray scanning imaging

The X-ray beams produced by undulators at third generation SR sources can, because they originate in a very small source, be focused into a very fine spot (on the order of a micrometer in linear size) with extremely high intensity. It is then possible to scan the sample with respect to the beam, with an appropriate detector or bank of detectors collecting quantitative information. This information is then displayed on an electronic device as a point with variable intensity and colour at the coordinates corresponding to the position of the beam. This provides the exact analogue of scanning electron microscopy. There is a wide variety in the type of information available : wide angle diffracted X-rays, or small-angle scattered X-rays, fluorescence photons, or secondary electrons. A whole range of scanning X-ray imaging techniques appeared, and they will certainly develop brilliantly over the next few years.

Why phase?

A beam of X-rays going through an object suffers, apart from absorption, a phase shift, because the refractive index of materials is slightly different from unity. The complex refractive index $n = 1 - \delta + i\,\beta$ describes both absorption (related to β) and the phase shift with respect to the beam in vacuum:

$$\varphi(x, y) = -(2\pi/\lambda) \int \delta(x, y, z)\, dz$$

where the integral is taken along the path of the beam. This phase is non-uniform over a cross-section of the X-ray beam if the thickness and/or the structure of the sample are inhomogeneous. δ is proportional to the electronic density of the material, hence approximately to its mass density; it must be corrected for dispersion when the photon energy is near an absorption edge. The phase cannot be measured directly, and variations in phase do not affect the intensity of the beam as it exits the sample. Phase images have been obtained, using laboratory sources or second generation synchrotron radiation, using elaborate devices (interferometers, many-crystal setups). With many images of the sample recorded while it is rotated in an interferometer, it is possible to reconstruct in 3D the distribution of refractive index, i.e. to perform phase tomography.

The qualitatively new character of third generation SR is that its lateral coherence makes it possible to visualise and reconstruct the phase variations of hard X-rays, both in simple radiography and in tomography, with great *instrumental simplicity*. Furthermore, better spatial resolution can be reached compared to existing phase imaging techniques. The required coherence is obtained thanks to the very small angular size α of the source as seen by a point in the sample (less than a microradian on the imaging beamline ID19), which entails a large lateral coherence L_c of the X-ray beam, with wavelength λ:

$$L_c = \lambda / 2\alpha$$

For example, $L_c \approx 100$ µm for $\lambda \approx 1$ Å. In optical terms, the effect used to turn local variations of phase into intensity variations is interference, at finite distance, between parts of the beam that have suffered different phase shifts but are coherent with one another. This is the analogue of defocusing in electron microscopy: it can be described in terms of Fresnel diffraction, or of in-line holography.

In practice, obtaining a phase-sensitive image just involves setting the detector (film or CCD camera) at a distance D on the order of one tenth of a meter from the sample. An absorption image is obtained if D is small (mm range). This corresponds to the fact that the region in the sample that affects the image at a point of the detector has a size $r = \sqrt{(\lambda D)}$, the radius of the first Fresnel zone. When D is a few mm, the size of this zone is below the resolution of the detector (µm), and no interference will be observed: only absorption contrast will be effective. For larger values of D, but with r remaining small with respect to the size a of the object to be imaged, the edges of the object behave independently, and are the only contribution to the image. The best sensitivity to a phase object of size a is obtained for a distance $D \approx a^2/2\lambda$, but then the image is a hologram which does not look much like the object.

The major advantage of this new type of imaging is the increased sensitivity it provides. Fig. 4 shows, for aluminium, that $\delta >> \beta$ in the hard X-ray range ($E > 6$ keV). This explains the gain observed, particularly for light materials such as polymers, or for composites consisting of materials which equally attenuate X-rays, such as Al and SiC.

The phase variations across the beam at the sample exit lead to variations in intensity, hence to contrast, provided the phase has a non-vanishing two-dimensional Laplacian, $(\partial^2\varphi/\partial x^2) + (\partial^2\varphi/\partial y^2) \neq 0$. They show up, for increasing values of D, through the appearance of a black-white line at the phase

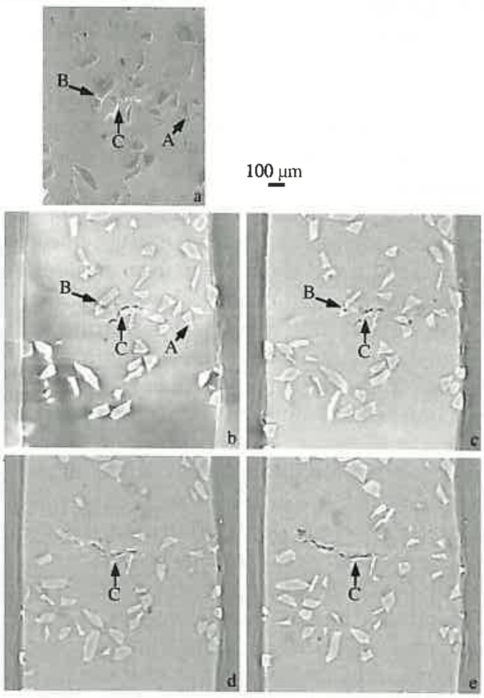

Fig. 6: a) Scanning electron microscope image of the surface of a composite material consisting of an aluminium matrix reinforced by SiC particles b)-e) Slices obtained by computed tomography corresponding to zones respectively at the surface, and 25 µm, 50 µm and 75 µm below the surface. The sample suffered a monotonic tensile test of 1%. Cracked SiC particles can be detected (arrows A and B), as well as a crack in the aluminium matrix (arrow C). The tomographic acquisition was performed at an X-ray energy of 25 keV and a sample-detector distance of 0.82 m (collaboration with J.-Y. Buffière, INSA, Lyon).

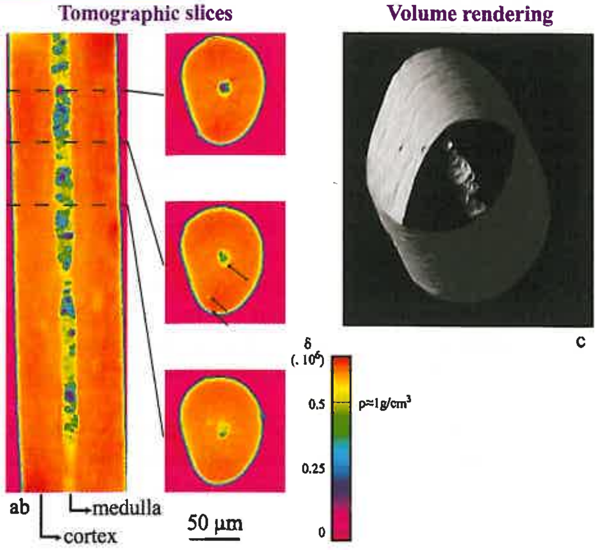

Fig. 7: Results of 3D density mapping (holotomography) of human hair. The tomographic slices in the a) axial and b) radial direction show the medulla as a low density region within the cortex. Cavities exist along the medulla and the arrows indicate low density regions. c) 3D rendition of the hair revealing the medulla within the outer surface. The 3D density mapping involves a phase retrieval method based on images recorded at several distances (three in this case), a procedure that is repeated for a large number of angular positions (X-ray energy 21 keV).

jumps (fig. 5a), then by a set of Fresnel interference fringes which become more and more obtrusive (fig. 5b): the image is then an in-line hologram.

The set-up used is simple: on the imaging beamline ID19 at ESRF, it essentially consists in a monochromator made up of perfect silicon crystals, located about 140 m from the insertion device (a variable gap wiggler or an undulator) which acts as its photon source. Of course, phase inhomogeneities give an image also if they do not arise from the sample. To avoid these unwanted images, the optical elements in the beamline (beryllium windows, filters and monochromators) are submitted to unusually stringent demands.

Tomographic observation through edge-enhancement

The next step consisted in extending this possibility of observing phase objects to three dimensions, in other words in going over to phase tomography. It was performed in two steps.

It turns out that the tomographic reconstruction codes developed for absorption images yield acceptable results when the phase images result from density jumps with sharp edges. In metallurgy, X-ray phase microtomography is particularly valuable for systems involving regions with neighbouring compositions. As shown by fig. 6, it has provided important results for the understanding of degradation mechanisms in aluminium-SiC composites. In this case, it is possible both to visualise the SiC particles easily, and to observe *in situ* the nucleation and growth of cracks when the sample is submitted to traction. These cracks occur first in the elongated particles, and this imaging technique shows that there are 50% more of these cracks than indicated by investigations restricted to the surface. The experimental results are now incorporated in programs that model the mechanical behaviour of these composite materials.

Quantitative reconstruction of the phase map

The second, recent step consisted in developing a procedure for the "holographic" reconstruction of the phase maps, which can serve as the more correct input data for the "tomographic" reconstruction. Phase retrieval is based on the use of a few images recorded at different distances from the sample. It therefore leads to acquisition times longer than for absorption tomography. The approach is derived from a method originally developed for electron microscopy by a group in Antwerp. It is quantitative, and determines the phase, well beyond simple edge images, with a spatial resolution limited by the detector (about 1 μm in our case). The combination with tomographic reconstruction, called holotomography, yields 3D quantitative images that show the distribution of electron density, hence of mass density, in the sample.

Figure 7 shows an example of 3D density mapping obtained on a human hair. The axial slice (figure 7a) through the middle of the hair shows that the medulla, the central hair region, is very inhomogeneous and varies along the hair shaft. The density is in general lower than the surrounding cortex with some regions revealed as cavities. The radial slices (figure7b) show low density regions, at the level of the medulla, but also near the outer border of the hair and in particular points of the cortex. The lower density of some regions can be ascribed to a higher lipid concentration and lower protein content.

Conclusion

The advent of third generation synchrotron radiation sources such as ESRF has opened new possibilities in X-ray imaging. These techniques are now beyond the stage of demonstration experiments, and they are appreciated in the solution of various scientific problems in materials science, biology and medicine. The applications are based, as far as absorption imaging is concerned, on the very broad choice in photon energy available (typically between 1 and 120 keV), which makes it possible to improve the contrast, on the improved spatial resolution (on the order of a μm), and on the quantitative data evaluation made possible by the monochromatic and parallel character of the beam. Furthermore, the very small source size makes scanning imaging techniques possible. It also provides, in an instrumentally simple way, phase images which reveal phenomena that are difficult to evidence by other means. This new technique can be used for two- or three-dimensional imaging, either qualitatively for edge detection (pores, inclusions...), or quantitatively, through phase retrieval complemented by tomographic reconstruction, in the approach called holotomography.

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New section members wanted

This is the first public announcement of a new Section on Beam Plasma and Inertial Fusion Physics (BPIFP) to be founded within the EPS Plasma Physics Division. The incentive originates from a wide-spread feeling that the division should broaden its scientific scope and put more attention to those areas of plasma physics which have strongly developed recently without being rooted in the division.

Following the creation of a Section on Dusty and Colloidal Plasmas in 2000, the BPIFP section responds to the rapid growth in dense plasma research with high power beams, in particular laser and ion beams. A large laser plasma community has evolved in Europe over the last 40 years with applications to Inertial Confinement Fusion (ICF) as a major driving force. With ICF ignition facilities now under construction in France and USA, the physics of inertial fusion will be a central topic of BPIFP activities, and this includes heavy ion beams and corresponding dense plasma research with nanosecond pulses.

Particular new drive for the BPIFP section stems from the recent success in producing ultrashort terawatt laser pulses in the range of femtoseconds, even with table-top devices. At focussed intensities, these pulses open a new branch of relativistic plasma physics with applications to ultrashort ultrabright X-ray sources including plasma X-ray lasers, to plasma-based high-gradient accelerators, to nuclear and particle physics, and also to inertial fusion. The interface with relativistic astrophysics (cosmic jets, etc.) will become important.

Beam plasma effects also find growing interest in the context of conventional accelerators and Free Electron Lasers (FEL). X-ray FELs now under construction at DESY in Hamburg and at SLAC in Stanford will generate 100 fs, keV, terawatt X-ray pulses which will produce solid-density plasmas up to keV temperatures and Gbar pressures. Also, laser electron and ion sources as well as applications to ion implantation are now developed at several places.

The BPIFP section will serve as a general forum for beam plasma physics within EPS and to foster interdisciplinary plasma research in these new fields. It will care for adequate presentation at EPS conferences and organize topical meetings, first of all within EPS structures. The intention is to do this without increasing the number of conferences, but rather to better coordinate existing conference and workshop series and to merge them from time to time.

Of course, this requires the support of the groups and institutions working in this field in Europe. The plans to create the BPIFP section are presently discussed among scientists from different European countries. All those interested to join this discussion should write to J. Meyer-ter-Vehn (jxm@mpq.mpg.de). A first meeting of the BPIFP initiating group will take place on Monday, 18 June 2001, during the EPS Conference on Controlled Fusion and Plasma Physics at Madeira (www.cfn.ist.utl.pt/EPS2001) and the satellite workshop on Fast Ignition of Fusion Targets (www.mpq.mpg.de/5th-FI-Workshop).

Global warming or nuclear waste – which do we want?

H.Nifenecker and E.Huffer

As the conference in The Hague was taking place, the outlook on global warming was increasingly alarming. In spite of the price increase of oil, a good thing from this point of view, and of gas in the near future, there does not seem to be any sign of a reaction similar to that of 1973. Though energy conservation, and the development of renewable energy sources are desirable, it is more obvious every day that these will not be sufficient to stabilise, and even less, to reduce the emission of greenhouse gases. Clearly, it is only through the renewed development of nuclear energy in the industrialised countries that we can obtain a significant and rapid reduction of gas emissions. We need only note that countries like France and Sweden, which produce their electricity without burning fossil fuels, generate half as much carbon dioxide per unit of energy consumed as Denmark whose electricity is produced essentially in coal or lignite plants. It seems paradoxical, then, that the energy supply scenarios put forward by such instances as the World Energy Council do not seem to consider seriously a renewal of nuclear energy. On the contrary, certain countries, like Germany, are considering pulling out of nuclear energy altogether. It's as though the dangers associated with nuclear energy were perceived as worse than those related to global warming. Does this view rest on objective data, or is it not, rather, irrational? We cannot do without thinking this matter through: the future of our planet may depend on the choices we make. We will attempt, here, to initiate such a reflection, as unbiased as possible. The first thing to do, then, is to compare the risks due to nuclear energy and to the production of greenhouse gases from the combustion of fossil fuels.

Nuclear risks

The risks associated with nuclear energy are well identified: major accident, diffuse irradiation, the handling of nuclear waste, proliferation. Though the dangers are real, they are, in general, over played by systematic opponents to anything nuclear, inducing reactions of fear that are out of proportion with the true danger in large fractions of the population, that professional anti-nuclear militants know how to make the most of. A detailed study of these risks is, of course, out of the scope of this paper but some considerations seem useful here to place the risks in perspective. First, let us remind ourselves that we are all exposed to natural radioactivity whose intensity varies by a factor of more than 5 from one place to another on this planet. No ill effects from natural radioactivity have ever been demonstrated. It is thanks to the existence of natural radioactivity (which has the same characteristics as artificial radioactivity) that nuclear industry was one of the first to be able to put in practice the precautionary principle : by limiting the additional irradiation due to human activities to a fraction of natural radioactivity, we can be sure that the effects on public health will be negligible. Claiming that any radiation dose, however small, is dangerous for our health is more political than scientific.

Major accident

Three major accidents serve as reference today: Three Mile Island (TMI), Tokaimura and, above all, Chernobyl. In the first instance, there were no fatal casualties. Two operators were significantly irradiated. There was no irradiation to the public. In spite of this, the TMI accident created a real panic in the USA, leading to, among other consequences, a loss of confidence in nuclear experts. The fact that there were no casualties had, in this regard, no influence. In a way, one can say that, after TMI, the approach to nuclear matters became totally irrational (paradoxically, it seems that only civilian nuclear applications are frightening). Tokaimura was a criticality accident in a fuel fabrication unit. Several technicians were irradiated and two of them died. There was no irradiation of the public. It seems that the communication by the Japanese authorities was catastrophic and the media, worldwide, concurred in publishing scary reports of the event, to the point that some referred to the fact that the criticality accident could have evolved into an atomic explosion similar to Hiroshima. This was, of course, totally impossible since, in the present case, the critical reaction stops automatically when the water boils up. Nevertheless, the Tokaimura accident, which appeared to be similar to many work accidents, had a devastating influence on the Japanese public's acceptance of nuclear power.

The Chernobyl disaster, of course, was on a completely different scale. Fourteen years after the disaster, the acknowledged toll on health, as given by the United Nation Scientific Committee on the Effects of Atomic Radiations (UNSCEAR), accounted for 35 deaths amongst the "liquidators" which occurred at the time of the accident or shortly after, and 1500 cases of thyroid cancer, mostly amongst children. Three of these cancers were fatal. Other kinds of cancer are hard to relate specifically to Chernobyl, because they can appear only as a small increase of 0 to 3% over and above the cancers that would have occurred in the population, even if there had been no disaster Approximately 5 million persons in Ukraine and Byelorussia live in an ambient radioactivity several times higher than that due to natural radioactivity before the disaster. This additional radioactivity is due to Cesium 137 whose half life is thirty years. In such a population, the number of fatal cancers expected to break out each year, in the absence of additional irradiation due to the accident is estimated at 20 000 while the excess due to Chernobyl would be, at the most, using a linear dose to effect law, approximately 500 per year. At the time of this writing, no statistically significant excess has been observed. It has been claimed, recently, and it was confirmed by the Russian minister of disasters, that 15 000 deaths have occurred amongst the "liquidators". It so happens that the mortality tables used by actuaries show that 15 000 deaths should be observed in 15 years in a population of 250 000 persons aged from 20 to 30 years, the age group of the "liquidators". As the total number of "liquidators" was 600 000, we see that the announcement of 15 000 deaths amongst them is not very meaningful, in the absence of more precise data on the population considered, and on the causes of the deaths. In any case, the consequences of the Chernobyl disaster on

Ukrainians and Byelorussians will be far less severe than those due to addiction to smoking and alcoholism. The Chernobyl disaster is considered as the archetype of the worst conceivable civilian nuclear disaster. Nuclear security experts estimate that the probability that a disaster of this amplitude occur with the reactors of the type used in the West is of the order of one millionth per reactor per year of operation. For France, one of the most heavily "nuclearised" countries, for instance, this means that such an event could occur once in 20 000 years. Other types of accidents capable of causing more casualties (dam rupture, explosion of a gas tanker, fire or chemical explosion, fall of a meteorite, tropical storm, fall of a large carrier plane, etc.) can occur with a much higher probability. Like a nuclear disaster, such accidents would have local and/or regional consequences but, in no way, (except the fall of a very large meteorite) global. In no way would the biosphere be threatened, nor any particular species.

Nuclear waste

It is customary to make the issue of nuclear waste the central reason to ban any civilian applications of nuclear energy. People stress the long half-life of these wastes, forgetting to mention that, unlike chemical waste, the dangerousness of nuclear waste is inversely proportional to the life time: the longer the half-life of a nucleus, the fewer the disintegration events per unit time. To what extent is the radioactivity generated by theses wastes a source of danger for the biosphere? In the short-term, the radioactivity of nuclear waste is well confined and under control, to the point where the incidence on health of these wastes is tiny if not nil. The security of deep storage would, as is obvious, be much better than that of surface or sub-surface storage. There is general agreement that, with deep storage, the radioactivity would remain confined for at least one thousand years. If we consider the storage sites as lying at depths of 500 to one thousand meters, we can compare the radioactivity that would potentially be released after one thousand years to that of the first thousand meters of the earth's crust. Working it out (without waste processing or incineration which would reduce the dangerousness by a factor of 100), again in the case of France, we find that the residual radioactivity corresponding to 100 years of production by 100 plants (at this time, there are 57 active nuclear plants in France) would be less than one per cent of the crust's natural radioactivity (due to their large size it would be five times less for the US, for the same level of "nuclearisation"). Thus, we see that deep storage does not represent a danger (barring an accident during transport) in the short or the mid term for people living in the vicinity of the sites and that, in the long term, it does not represent a risk for the biosphere taken globally. There could be a risk locally, in the case of an accidental intrusion within a given site, by drilling, for example. We should note that, because of the long half-life of the wastes still active after a thousand years, the products will disperse in the biosphere before they disintegrate in case they are released from their confinement, limiting, in principle, the local risk. In summary, we reach the same conclusions that we had come to concerning the characteristics of nuclear accidents (in a less severe way): their incidence is local, at the most regional and in no way global. The difference lies in the time scale and, here again, a bit of common sense would tend to convince us that, all things equal, a risk that may arise one to ten thousand years from now is preferable to a risk which threatens today or in the coming century.

Proliferation

The base materials used to manufacture nuclear explosives are Uranium 235 and Plutonium 249. Uranium 235 is present in natural Uranium in a proportion of 0.7% while the concentration of this isotope that is needed to make a bomb is 90%. It follows that isotopic enrichment procedures are required. Up until the seventies, the two procedures that were available, electromagnetic separation, and gaseous diffusion, were cumbersome, expensive, and heavy electricity consumers. Today, two new techniques are available, that are lighter and less conspicuous: gaseous centrifugation and laser separation. By using these different techniques, any country that has the human competence and a minimum of means is able to produce enough highly enriched Uranium 235 to manufacture several bombs. That is what Pakistan has done recently and what Iraq was in the process of doing. Iraq did not have a nuclear reactor. Pakistan had a reactor of the type used in Canada but did not use it to produce the fissile material it needed for its first bombs.

The other fissile material, Plutonium 249, is produced in nuclear reactors. All reactors that operate with Uranium, whether natural or slightly enriched, produce Plutonium that can be relatively easily extracted using chemical procedures. The truth is that none of the military nuclear powers acquired the status of nuclear power by using nuclear reactors built with a view to generating electricity. The transfer from civilian nuclear to military nuclear activity has not, to our knowledge, ever occurred. On the contrary, the inverse transfer, from the military to the civilian sphere has been frequent and explains some of the characteristics of the civilian nuclear industry that might not have been true in other circumstances: for example using enriched Uranium in water cooled plants. It is true, also, that some military nuclear powers, or powers that intended to become such, handled nuclear power reactors in such a way as to extract high quality Plutonium from them It was the case in France, with its graphite-gas reactors, and in the Soviet Union with its RBMK reactors (Chernobyl type). In reality, the countries wishing to equip themselves with commercial power reactors have to sign a non-proliferation treaty and, thus, renounce any development of nuclear weapons.

We see, then, that as far as States are concerned, the fear of seeing civilian nuclear power plants be diverted towards military ends has been futile until now. The States that have decided to acquire nuclear weapons have been able to do so, provided they had the human competence (physicists, engineers) and the material means. As for terrorist groups liable to practice nuclear blackmail, we should consider that the demise of the Soviet Union has, alas, already given them the means to acquire the needed goods.

Risks with fossil fuels

We won't dwell, here, on the dangers due to the production, the transportation and the use of fossil fuels: accidents in coal mines, fires in pipelines (5 000 death casualties in Nigeria a few years ago), explosions in gas pipes (Siberia, Mexico) and, of course, concerning gas, domestic explosions (100 death casualties per year in France) - these are well known. Likewise, we will not dwell on oil slicks, the environmental impact due to working the far North, the wars triggered by the will to control resources and pipelines (Biafra, Kuwait, Chechnya, Angola, etc.). All these dangers, all these wars related to the use of fossil fuels, however dramatic and deadly (much more so than the Chernobyl disaster!) remain circumscribed to the local or regional level and do not threaten the biosphere itself, barring the extension of regional conflicts to a world conflict. We will set our argument on the emission of greenhouse gases.

The use of fossil fuels induces the emission of greenhouse gases: carbon dioxide generated by combustion, in varying amounts (half as much with gas as with coal, for comparable technologies) and methane in the case of natural gas, not owing to combustion, but to leaks. The magnitude of these leaks is estimated at 5 to 30 % for fuel from Siberia, the one that Germany will use extensively to replace its nuclear reactors. Now, methane is fifty times more efficient than carbon dioxide for greenhouse effect, so that using Siberian gas is worse than burning coal, for greenhouse gas emissions, as long as the state of disrepair of gas pipelines persists, and the production techniques in Russia are not improved.

The emission of greenhouse gases induces a temperature increase. The models used in climate previsions are still not accurate enough to give a precise evaluation of the magnitude of the temperature increase which is estimated between 1.5 and 6 degrees Centigrade in the course of the 21st century. The local and regional effects of such an increase are even more difficult to anticipate. Many are the climatologists who consider that, now already, the 0.5 degree Centigrade increase of the average temperature on the globe since 1900 is due to emissions that originate from human activities, and that the temperature increase is accelerating. Many, too, are those who consider, though they cannot certify it, that the increasing violence of cyclones and storms is due to this rapid temperature rise. Others argue that the uncertainties of forecasts are such that it is too early to take determined steps towards reducing the emissions of greenhouse gases. Such an attitude is the antithesis of the application of the precautionary principle which implies, on the contrary, that the worst case evolution be considered, provided it is reasonably likely. In our case, this means a 6°C temperature increase within the century. Even worse, the very long life time of carbon dioxide in the atmosphere will lead to a mean temperature increase on the globe of at least 2°C even if emissions are reduced by a factor of three before 2050. If we were to take no strong action, some scenarios anticipate a temperature increase that could reach 9°C in the 22nd century. While one can hope that a 2°C temperature rise may remain globally acceptable, even if it may lead to local or regional disasters, no one really knows where a temperature rise of over 6°C might lead. Let us recall that, during the last ice age, the mean temperature on the earth was only 4°C lower than it is today. Will the ocean which absorbs half of the carbon dioxide of human origin today continue to play its damping role or, on the contrary, will it turn into an additional source of carbon dioxide? Will the biomass expand, thanks to better climatic conditions, in particular at high latitudes, or, on the contrary, will the eradication of numerous species due to extreme climatic conditions lead to the reduction of the biomass? Is there a risk that the enormous quantities of methane trapped in the permafrost ice of Canada and Siberia will be released seeing that the anticipated temperature increase will be greater than average at higher latitudes? In the event that the ocean and the earth's biosphere should become sources of greenhouse gases on their own, the earth could enter an unstable regime, the temperature rise triggering a sort of snowball effect. The concentration of carbon dioxide would increase while that of oxygen decreases. One can envision the Earth as a stifling and sterile place. Who is in a position, today, to assert that such a scenario is strictly unrealistic? Applying the precautionary principle requires that all possible steps be taken to avoid such a disastrous outcome. The Rio and Kyoto meetings have registered a surge of awareness but the target set by Kyoto, namely to stabilise emissions, a target that is not even close to being met, is totally insufficient to prevent a temperature increase. At best, it will lower the rate of rise. To achieve the stabilisation of the temperature at 2°C above the current temperature, it would be necessary, as mentioned earlier, to reduce the emissions by a factor of three. The timorousness displayed at Kyoto is all the more unfortunate since it would be possible, within ten years, to reduce the emissions by thirty percent without significant economic consequences.

Priorities

From the above considerations, we see that the potential danger due to the emission of greenhouse gases is on a completely different scale from that due to nuclear energy or other methods of energy production. The priority, then, is to pull out of fossil fuel energy altogether. It is only as a second step that we can consider pulling out of nuclear energy, if it can be proved that more secure, less polluting and reasonably competitive techniques of energy production are, indeed, available, and able to produce energy on the scale needed. Ecologists sincerely concerned with the issue should reconsider their priorities and their agenda. They will then agree that the major danger is, indeed, a climatic disaster and that all efforts must be made to avoid such an outcome. Of course, this does not free us from the obligation to remain vigilant towards nuclear applications and also towards other techniques for the production of electricity, such as hydraulic power and biomass burning, the best energy being the energy that is not consumed.

Solutions

France and Sweden, in particular, have demonstrated that it is possible to produce electricity without resorting at all to fossil fuels. They have done so by resorting to nuclear and hydroelectric power. Some claim that, by resorting to renewable energies such as wind or solar energy, similar results could be obtained. It would thus be possible for industrialised countries to commit to no longer build electric plants using fossil fuels, whether coal, gas or oil. The fact that this hypothesis is not even mentioned in the World Energy Council scenarios demonstrates the weight of the lobbies connected to the gas and oil industry and, also, the extent to which the irrational fear of nuclear applications can lead to nonsensical behaviour towards the environment. Let us recall that it took France ten years to build its set of reactors. It should be possible, in the United States, in Germany, in the United Kingdom, to achieve as much, with nuclear reactors, or any other means of energy production, if, as claimed, any alternative is available. To exclude hypocrisy, what are the German Greens waiting for to demand that none of the electricity formerly produced in the nuclear reactors that will be stopped be henceforth produced in coal or gas plants, or imported from third party countries that use such energy sources.

For developing countries, it would be advisable, as a first priority, to convince them to avoid resorting to coal, setting aside, for them, a priority option to use gas, with the provision that gas leaks would be minimised. It is likely, moreover, that large countries like China or India will rapidly resort to non fossil energy sources, including hydraulic and nuclear energy.

The simple fact of resorting to renewable or nuclear energy sources for the production of electricity should allow a reduction by approximately 20% of greenhouse gas emissions. A cut of the same order of magnitude could be secured by banning the use of fossil fuels in, first, collective heating systems, and subsequently in private heating systems. Using the biomass could be encouraged, provided it does not result in deforestation, as is currently the case in many developing countries, nor in diminishing the biodiversity of plants.

The issue of transportation is a more difficult one. It should be possible, in the short term, to allow only clean vehicles for intra urban traffic, whether electric or operated with compressed air, the inevitable consequence being an increase in the demand for electricity. Likewise, long distance transportation should be encouraged to use the railway whenever possible. In the long term, the use of hydrogen, obtained from the dissociation of water, here again requiring electricity, should be considered. The direct association of renewable energy sources that are intermittent in nature to the production of hydrogen could signal the advent of these energies on a large scale and, maybe, the possibility of pulling out from nuclear energy without inducing an ecological disaster.

The confinement of carbon dioxide in gas or oil reservoirs, in salt domes, or by developing forests in desertified zones could be encouraged with grants financed by a tax on the emission of greenhouse gases. The emission permits system could find its usefulness in such applications. In no instance should it be used to circumvent the banning of fossil fuels for the production of electricity or of low temperature heat for housing or industrial heating systems.

Political and economical stakes

As can be expected, pulling out from fossil energy sources will confront interests that are much more powerful than those of nuclear energy. The interests of coal, oil, gas industries, in the first place. These industries are, above all else, particularly the last two, active in the world economy globalisation process. The liberal market rules, which favour investments that are profitable in the short term, favour, today, the production of electricity with gas, the investments required for a gas plant being three times smaller than those for a nuclear reactor, and six times less than those for a wind farm. The problems associated with renewable energies and to nuclear energy are, from this point of view, very similar. Both require heavy investments, both have low operating costs, in particular regarding the fuel, both guarantee energy independence to countries which make this choice, both are contrary to the logic of world globalisation and restore power to the citizens. One would wish that the (legitimate) demand for transparency that is applied to nuclear energy be applied also to fossil energy sources, both on the national level and on the international level. As everybody knows, the oil and gas lobbies are among the most powerful and opaque on this planet.

Banning stereotypes and pretenses

We think that one should pull out from fossil fuel energy sources as quickly as possible. As a first step, there is good ground to demand that no new electricity production plant be allowed, whatever the circumstances, to resort to fossil fuels. One must, also, ban importing electricity that is produced from fossil fuels. If some countries believe that they can make this commitment and still pull out from nuclear energy, they will succeed in demonstrating their sincere commitment to ecology and will be in a position, but only under these conditions, to be taken seriously in their will to preserve the environment. Other countries which doubt that renewable energies would be sufficient should be free to resort to nuclear energy without being pointed to as the bad dog .

Appendix

The risks associated with radioactivity and irradiation in general are, usually, measured in Sieverts. For most people, even scientists, this unit has no real meaning. It may be useful to make a comparison with well known risks that have similar consequences. Those related to tobacco smoking are especially relevant since they are essentially related to cancer producing processes. The following tables compare the risks associated with irradiation with those associated with cigarette smoking. They are based on the following dose-effect relations: 0.04 lethal cancers per Sievert, and 1 lethal cancer per eighty thousand cigarette packs. It is assumed that if the dose-effect relations are not linear they remain proportional between the two hazards. Tables I et II are constructed in such a way that radiation doses and the number of cigarette packs smoked lead to the same number of premature deaths.

[1] *This article is adapted from an article published in Bulletin de la Société Française de Physique N° 126, p.15 (oct.2000)*

TABLE I
Comparison between effects of some irradiation exposures and of cigarette smoking

	Annual dose in millisieverts	Equivalent number of annual cigarette packs
Natural total Irradiation	3	9
Radon	2	6
Cosmic Rays	0.3	0.9
Medical X-rays	0.4	1.2
Public irradiation due to Nuclear reactors	0.0005	0.0015
Average estimated total external irradiation due to Chernobyl in Central Europe	1†	3†
Average estimated total external irradiation due to Chernobyl in Western Europe	0.2†	0.6†

TABLE II
Comparison of allowed doses of irradiation to effects of cigarette smoking

	Maximum allowed dose in millisieverts/year	Equivalent in cigarette packs/year
Professionals	20	60
Public	1	3
Evacuation limit around Chernobyl	5	15

The equivalencies given in tables I and II show that the all-out use of a linear dose-effect relationship applied to low doses contradicts common sense: is it really equivalent that one individual smokes ten thousand cigarette packs or that ten thousand people smoke one pack each?

† Total dose integrated over 30 years

First direct observation of the tau neutrino

Thomas Patzak for the DONUT Collaboration

History

In 1930 W. Pauli, in a famous letter to his colleagues, postulated the existence of a new particle – the neutrino. Pauli presented the neutrino as an explanation of the observation that the decay of the neutron produced a continuous ß-spectrum. Since then, great progress has been made in particle physics to describe the most fundamental constituents and interaction of matter. Nevertheless, many fundamental questions about neutrinos need to be answered. For example: Are neutrinos massive? Do they have a magnetic moment? Do they oscillate? Does a sterile neutrino exist? Is there direct evidence for the existence of the tau neutrino? The last question was finally answered in July 2000 by a group of 52 physicists from the DONUT Collaboration (Fermilab experiment E872) at Fermilab near Chicago.

The tau neutrino was postulated in 1975 after the discovery of the tau lepton by M. L. Perl *et al.* as the third generation neutrino in the Standard Model of electroweak interactions [1].
Glashow, Salam and Weinberg proposed the Standard Model in the late 1960s as a unified theory of the electromagnetic and weak interactions based on the gauge group SU(2) ×U(1). This model has been successful in describing all recent experimental observations. Neutrinos enter this model as massless, neutral fermions. From measurements of the Z^0 decay width, it was determined that there are three light neutrinos in nature. The charged and neutral leptons in the Standard Model are represented by three left-handed doublets of weak isospin.

Q	$L_e = 1$	$L_\mu = 1$	$L_\tau = 1$
-1	e^-	μ^-	τ^-
0	ν_e	ν_μ	ν_τ

Each flavor doublet carries a lepton flavor number (L_e, L_μ, L_τ) which is a conserved quantum number in the Standard Model. The DONUT experiment established the existence of the tau neutrino in the same manner as the two other neutrino flavors have been detected – by its charged current interaction.

The Experiment

The DONUT experiment (Direct Observation of NU-Tau) was built at Fermilab to observe the charged current interactions of ν_τ and its charge conjugate. These interactions are identified by the detection of the tau lepton as the only lepton created at the primary vertex. The tau has a lifetime of 2.9×10^{-13} s. At the beam energy of the DONUT experiment the tau typically decays within 2 mm from the vertex into a single charged particle and neutrinos:

$$\nu_\tau + N \rightarrow \tau^- + X$$

$$\tau^- \rightarrow (\mu^- \text{ or } e^-)\,\nu_\mu\,\nu_\tau \quad \text{or} \quad \tau^- \rightarrow h^-\nu_\tau$$

The characteristic signature of a tau neutrino event is the observation of a primary interaction track with a bend point or kink, identifying this track as a tau lepton.

Nuclear emulsions were used as high resolution tracking devices in this experiment.

The resolution achieved with emulsions is better than 1 μm. The emulsion target was followed by a spectrometer which was used to determine the charge, energy and particle identification of the decay products. A schematic of the experiment is shown in Figure 1.

The Neutrino Beam

The neutrino beam used by the experiment was produced by 800 GeV protons from the Fermilab Tevatron interacting in a one-meter long tungsten beam dump. The principal source (~85%) of tau neutrinos and tau anti-neutrinos is the leptonic decay of the charmed meson D_s, into τ and ν_τ, and the subsequent decay of the τ to ν_τ. All charged particles produced in the dump were swept away from the emulsion target region by magnets or were absorbed by concrete, iron and lead shielding.

The Detector

The DONUT detector consisted of a scintillation counter veto wall, emulsion target, trigger hodoscopes, analysing magnet, drift chambers, calorimeter and muon identifier. We used two different types of emulsion targets. The first type called "ECC" (Emulsion Cloud Chamber), was composed of 1 mm thick stainless steel plates interleaved with emulsion plates. These plates were composed of 100 μm thick emulsion layers on either side of a 200 μm

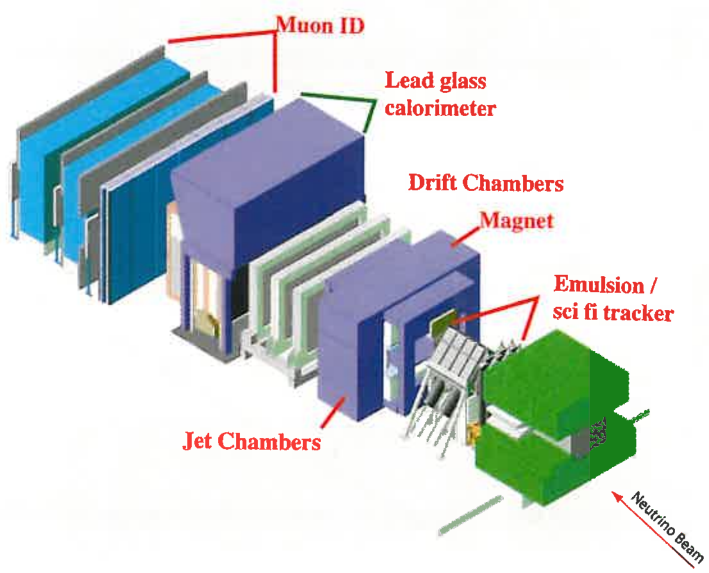

Fig. 1: Schematic view of the DONUT detector.

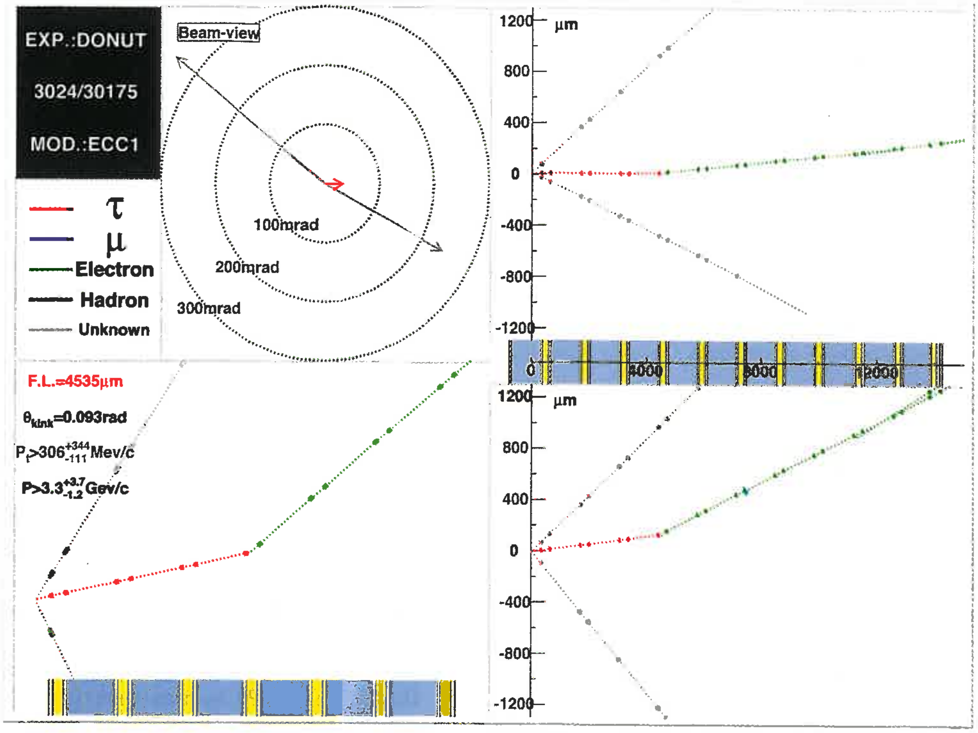

Fig. 2: One of the four observed tau neutrino charged current interactions. The kink signature of the tau decay is clearly visible. The target is represented at the bottom:
steel = blue
emulsions = yellow
In this example the tau decays into an electron.

or 800 μm thick plastic base. A target module consisted of ~50 steel/emulsion layer pairs to obtain a thickness of 0.16 interaction lengths. The bulk type was composed exclusively of emulsion plates with 350 μm thick emulsion layers on either side of a 90 μm thick plastic base. These modules were 0.13 interaction lengths thick. The transverse size of all emulsion and steel sheets was 50 cm × 50 cm. Between emulsion modules, 44 planes of scintillating fibers provided precision tracking, and were read out by an image intensifier system.

The Event Analysis

Neutrino interactions in the emulsion target were selected by trigger hodoscopes in the target region. For each accepted event all electronic detector components were read out. The information from the spectrometer and calorimeter was used to select possible candidate events. All charged particle tracks from these candidate events were projected back to the exit point of the emulsion target using the scintillating fiber tracking system. The reconstructed tracks were then used to reconstruct a vertex with a typical precision of 1 mm in the transverse coordinate and 7 mm in the beam direction. This event selection was used to limit the size of the search volume in the emulsion target. During the run, 4.0×10^6 triggers were recorded from 3.54×10^{17} protons incident on the tungsten target. After further cuts on the event geometry and energy a total of 898 events were classified as neutrino interaction candidates. Of the 898 candidates, 698 had a vertex predicted within the emulsion fiducial volume. Additional requirements on the event topology and vertex precision reduced the sample to 499 events. These 499 events were scanned using a fully automated emulsion scanning stations, which followed all tracks from the vertex through the different emulsion sheets. The result of this scanning is a 3D digitised image of the interaction with a precision better than 1 μm. A valid vertex was located for 262 of the 499 events.

A method of fully automated scanning has been developed over the past 20 years by the group of K. Niwa and his colleagues in Nagoya, Japan [2, 3]. This technique was used in the CHORUS experiment, and most recently allowed the direct observation of the ν_τ in DONUT. The capacity to analyse a large volume of emulsion will allow the use of massive targets of nuclear emulsion in future high-energy experiments.

The Result

Emulsion plates containing located events were rescanned within an adjusted scanning volume centred on the event. After further alignment 203 events satisfied the criterion of a track resolutions better then 0.6 μm. In these 203 events a detailed decay search was performed, looking for the event topology of a tau neutrino interaction – a kink in one of the primary tracks.

The selection criteria for ν_τ events were established by Monte Carlo simulation.

After the application of these selection criteria to the sample of 203 events, four events remained. This experimental result is consistent with the number of expected τ events in the sample, 4.2 events. The total number of background events is estimated to be 0.34 ± 0.05. Therefore the probability that all four events are a result of a background fluctuation is 4×10^{-4}.

Figure 2 shows one of the four events, the first direct observation of charged current tau neutrino interactions. These events confirm the existence of ν_τ as a partner of the tau lepton in the Standard Model of electroweak interactions.

For more detailed information on the event selection procedure see reference [4].

References

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The Word from Brussels

Tom Elsworth

We Research Directorate watchers are having a fine time trying to figure out what is going to be the situation in a couple of years from now when the next Framework Programme, number 6, is expected to go live. There are straws in the wind, for instance the new Directorate organisation has emerged as have the first draft proposals for Framework Programme 6.

The new Research Directorate "organigramme", at time of writing available only in French, shows that a number of well known names previously at the Director level, have been taken out of the direct line of management to advisory positions. Their jobs are termed "conseiller principal chargé de ....". The view of people who know the Commission is that such posts are set up to sideline officials due shortly to retire. The process of re-organisation was described to me as "significant, a clear out of the old wood". At the same time there are a few people who are officially at the level below director but who are now Acting Directors. It is thought that these are the people to watch, in due course their positions will be formalised. All of this can be studied at our leisure by going to the Research Directorate World Wide Web site (europa.eu.int/comm/dgs/research) and downloading the organigramme (it is a pdf file).

The first formal proposal from the Commission for Framework Programme 6 is due at the end of February. It is slated to be considered by the Commission on 21st February but unless all is plain sailing it is likely to fall back to 7th March, because the agenda for the 28th February meeting is already very full. The realistic amongst us feel it may be publicly available by the end of March. At this stage all I can report is hearsay on what is known of the draft. (There are of course two drafts in fact, the ordinary programme and the Euratom programme covering matters nuclear). So far the impact has been to raise eyebrows and cause concern.

The Euratom fission programme seems likely to focus on radioactive waste and nuclear safety studies with no allocation of funds for new concepts in nuclear energy, not even Professor Rubbia's accelerator driven transmutation concept for waste disposal. Rather surprising one might think given the emphasis of the Energy Green Paper on security of supply and therefore the need to maintain the nuclear supply option. Surely if we are to have the energy we need with minimum waste and maximum security then we need to develop new approaches to the nuclear fuel cycle? Many EPS members will view these apparent developments with some concern.

Away from nuclear power there are other worries. As I reported in the previous edition (January 2001) the thrust is for big (integrated) projects and the view of the commission is that bigger means more efficient and effective. The idea is being piloted in the Quality of Life Programme under Framework Programme 5 - but it seems a little rash (even, heaven forbid, courageous) to rush so soon to judgement. If the programme does turn out as presently drafted it may be a real shock for many scientists across Europe. I had heard that the draft excluded totally the now well established model of shared costs research and development actions, but the Research Directorate Press Office scotched this rumour. Perhaps the origin of the rumour is concern that "big" projects may leave no room for the smaller players. We understand that we are to have things called Networks of Excellence and Integrated Projects. How these will work remains a mystery and how SMEs and smaller institutions can be involved remains to be seen. People who know much more than we do postulate the creation of pan-European consortia to take on the management task (while the Research Directorate concentrates on science policy). What will be the realities of power and influence in this new world?

Will there be a backlash? One might have thought the smaller and poorer member states would not be too keen. Yet the DG is Greek! It has been said to me that the proposal has been rushed out and reflects the views of the commissioner's Cabinet, who want to do something (anything??) radical and the views of the DG's advisor on science policy (check that organigramme). One hears that the practical administrators even up to Director level have had little input. On the other hand Commissioner Busquin himself is quoted in a Press Release as saying "We cannot continue to work and to reason with the tools and approaches of the past". He made the excellent point that Member States must face up to the facts; we invest in research at rates 50% less than the USA and are even worse when compared with Japan. Speaking on a different occasion, Richard Escritt (a Director) said that to compete on the World stage it was essential to form an European Research Area (ERA) to bring together the present "mosaic of some 30 national policies". Mr. Escritt also spoke about the "big" projects. He suggested that they might be budgeted at a level greater than 5 million Euro but perhaps not an order of magnitude higher. Also they would be by no means universal across the new Framework Programme but rather in selected target areas as a "technology platforms for industrial research areas with the Commission providing a variable proportion of the total costs".

So fun and games; but seriously, I do think that all EPS members should look closely at the formal proposals when they are available and make their views known - to EPS, to their own Governments and to their MEPs. After the Commission publishes its formal proposals the matter moves into the political arena and there will be a preliminary "orientation" debate at the Research Council on 26th June.

The Environment

Brussels on 24th January also saw announcements in another very important area, the environment. The Commission adopted its proposal for the 6th environment strategy called "Environment 2010, Our Future, Our Choice". The Commissioner, Margot Wallstrom said "....Citizens are concerned about their environment. Therefore we have to act urgently - and that is what we are proposing in the new programme". The priority areas identified are no surprise;

- Climate change.
- Nature and bio-diversity.
- Environment and health.
- Sustainable uses of natural resources and waste.

There is plenty of scope for sound science in all of this and plenty of scope for contribution from the physics community. For example the programme points to the need for changes in the energy and transport sectors including research to contribute to reduction in emissions as well as efforts on energy saving and efficiency.

Calls for Proposals

Published on 27/01/01

Promoting a User-Friendly Information Society, 7th IST call for proposals, closing dates vary up to February 2002

Intelligent Manufacturing Systems, Joint call for proposals IST & GROWTH programmes, closing date is 19th September 2001

Published on 16/01/01

Improving Human Research Potential and the Socio-economic knowledge Base, call for proposals for Common Basis for Science, Technology and Innovation Indicators, closing dates 17/04/01 and 15/10/01.

Calls for Experts, Specialist Personnel and Research Fellowships

1. "NPPR Candidature" Candidates for temporary research posts. Contracts not exceeding a total of three years for the management of projects and contracts under the Fifth RTD Framework Programme. Closing date: 30.06.2002.
2. "Expert Monitoring" Selection of experts to monitor the RTD Fifth Framework Programme and Specific Programmes. Closing dates: 15.09.1999 - 15.09.2000 - 15.09.2001 - 15.09.2002.
3. "Expert Candidature" Experts for the evaluation of proposals received in response to calls made under the specific programmes implementing the Fifth Framework Programme. Closing date: 30.09.2002.
4. "PTA Call for Tender" invitation to tender relating to experts who, as project technical assistants (PTAs), are to be responsible for the technical monitoring and operation of research projects under the supervision of the commission services. Closing date: 15.11.2000.
5. "Research Fellowships" Young researchers can apply for research positions under the Marie Curie Fellowships and Research Training Networks activities of the Human Potential Programme.

Pre and Post-Doctoral Research Positions Available

Marie Curie Host Fellowships

Young researchers can apply for research positions under the following schemes:

- Marie Curie Training Sites offer opportunities for young researchers pursuing doctoral studies to benefit from short stays in internationally recognised groups.
- Industry Host Fellowships allow young postgraduate and post-doctoral researchers to receive training in an industrial or commercial environment.
- Development Host Fellowships seek young researchers with experience capable to transferring knowledge and technology to institutions in less-favoured regions.

Open positions for young researchers to be appointed to Marie curie Host Fellowships are advertised at: http://improving-mcf.sti.jrc.it/project/

Research Training Networks

Positions are also available within "Research Training Networks". These networks consist of at least five research groups from at least three countries who undertake a joint research project and a joint training programme.

Open positions for young pre- and postdoctoral researchers in the Research Training Networks are advertised at: http://improving-rtn.sti.jrc.it/vacancy/.

Communiqué PR is a communications consulting firm specialising in supporting organisations in the science, engineering and technology sectors. Areas of work that can be tackled include media relations, event management, video and print promotional material, public awareness activities, lobbying in Brussels or in relation to EU linked activities and strategic planning and integration of internal and external corporate communications, Public Relations and Public Affairs.

Tom Elsworth, one of the partners in Communiqué PR, has prepared this article (it reflects his own opinions on matters in Brussels). Tom has experience working in the external relations of major science based organisation extending over 25 years and in locations including London, Brussels and Washington DC. Recent customers of Communiqué PR include EPS, UK Atomic Energy Authority and the Commission of the EU.

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EC Budget breakdown for FP6 (2002–2006)

The budget proposal for the 2002-2006 Research Framework Programme has two parts since two different Treaties are involved: the Treaty of the European Community (EC) and the Euratom Treaty. The indicative total for both Treaties is 17.5 billion Euros compares with 14.960 billion Euros for the current Framework 5 Programme.

The total allocated under the EC Treaty is Euro 16.475 billion. Thematic priorities will receive 12.770 billion Euros. The programmes targeted as Thematic priorities are Genomics and biotechnology (health), Information society technologies, Nanotechnologies, intelligent materials, new production methods, Aeronautics and space, Food safety and health risks, Sustainable development and global change Energy, transport,Citizens and governance in European society, and Anticipation of scientific and technological needs of the Union, emerging technologies (including the Joint Research Centre).

The total budget allocated to the structural actions of European Research Area is Euro 3.050 billion. The programmes defined under this heading are Research and Innovation,

Human resources (including grants), Infrastructures (example: research installations), and Science and society.

A specific budget of Euro .450 billion for strengthening the research base of the European Research Area stengthening research base is also foreseen. This includes Coordination of activities, and the Development of coherent policies

The total Euratom Treaty budget is Euro 1.230 billion, and will be used for programmes for Treatment and stocking of waste, Thermonuclear fusion, Other Euratom actions (such as radioprotection, safety, training), and Euratom actions of the Joint Research Centre (example: nuclear safety and security; measurements reference materials, transformation of waste).

The EPS honours Lise Meitner and nuclear science

To encourage scientific excellence, the EPS has a series of prestigious prizes for outstanding work in different fields in physics. The Nuclear Physics Board has created the Lise Meitner Prize for Nuclear Science sponsored by Eurisys Mesures.

The prize has been named after Lise Meitner to honour her presence in many decisive moments of the history of nuclear science. Her life reflects the fate of scientists in the last century in Europe, particularly in Germany.

Born in Vienna in 1878, Lise Meitner was brought up in a liberal atmosphere. In order to obtain a university qualification she was obliged to take private courses because at that time girls were not admitted to the gymnasium. She obtained her "Matura" in 1901. In 1902 she became one of the first female students to study physics in Vienna. There she attended lectures by L. Boltzman, who had a big influence on her ambition to continue as a physicist. She completed her doctoral thesis in theoretical physics in 1905, and became the second woman to receive such a degree in Vienna.

In 1907 she moved to Berlin in order to "increase her true understanding of physics". She was "permitted" to hear lectures by Max Planck, with whom she kept contact throughout her life. Soon after coming to Berlin, she became "collaborator" of the chemist Otto Hahn in the Kaiser Wilhelm Institute. She was, however, not supposed to use the main entry of the Institute, and Otto Hahn installed a laboratory in a shack.

The collaboration was extremely fruitful. As the physicist in the partnership Lise Meitner was the driving force. Many important publications emerged from this period of her life. In 1913 she became a Scientific Member of the Kaiser-Wilhelm-Gesellschaft (a permanent position). From 1918 she was in charge of her own group in the radio-physical laboratory of the KW-Institut in Berlin-Dahlem (the building still exists). In 1918 Lise Meitner and Otto Hahn discovered element Z=91, which they named "Protactinium", because it was the missing link between the elements Uranium (Z=92) and Actinium (Z=89).

She looked set for a brilliant future in science. At the SOLVAY-congresses in Brussels she participated with many of the top of scientists of that time. She was awarded the title of Professor in 1928, but because of her Jewish origin, this was withdrawn from her in 1933/34.

As an Austrian citizen, she stayed in Germany until 1938 under the Nazi regime. When Austria was occupied she escaped to Sweden (without an exit visa) with the help of Dutch colleagues. She missed participating in the discovery of fission by only 6 months. Nuclear fission was discovered by Hahn and Strassman by very careful chemical separation techniques. The culmination of the collaboration of Hahn and Meitner was published without her name, possibly also for political reasons. In 1939 she published the first interpretation of nuclear fission with her nephew Otto Frisch who coined the term "fission".

Her life in Sweden was difficult. In the second half of the last century, women were seldom seen in leading positions in science. She became Professor of Physics in Stockholm at the age of 67, and acquired Swedish citizenship in 1948. In 1960 she moved to Cambridge in order to live close to her nephew Otto Frisch, where she died 1968.

Only in the late stages of her life was she honoured by various national and international institutions and received high ranking prizes. To mentioned only the last one, the Enrico Fermi Award of the USA in 1966, which was given to the team Hahn, Meitner and Strassmann. In 1945 the Nobel Prize for Chemistry (not Physics) for the discovery of fission was given to Otto Hahn alone. Her life and work has received more attention recently. Articles about her life have appeared in Physics Today (Sept. 1997, p. 26) and Scientific American (Jan. 1998, p. 58). In Germany, schools (and gymnasia) in more than 10 cities bear her name. In the state of Hessen, a Lise Meitner prize, which provides support for women in the natural sciences, has been awarded for 7 years. The Technische Universität Wien has a literature prize (Lise Meitner Literaturpreis) for texts written by female authors with emphasis on technical issues and science. In 1998 the Institute of Physics of the Humboldt University of Berlin created a Lise Meitner prize for outstanding PhD Thesis work. This was recently awarded for the second time.

Recipients for 2000

The Lise Meitner prize for outstanding contributions to nuclear science

The Nuclear Physics Board of the EPS is please to announce that the first recipients of the Lise Meitner Prize are:

- Peter Armbruster (GSI, Darmstadt)
- Gottfried Münzenberg (GSI, Darmstadt
- Yuri Oganessian (Flerov Laboratory of Nuclear Reactions, Dubna).

The prize is awarded for their unique work over a long period on the synthesis of heavy elements, which has led to the discovery of the new elements in the region of nuclear charges of Z=102 to 105 (Dubnium), as well as Bohrium (Z=107), Hassium (Z=108) and Meitnerium (Z=109). These discoveries involved extensive developments of experimental techniques, and the use of a specific reaction mechanism, the "cold" fusion of two heavy nuclei. Measurements of the properties of these heavy elements provide an important cornerstone of the concept of deformed shells in nuclei, whose existence is responsible for the increased stability of the new nuclei. Because of this work the study of the properties of very heavy elements (Z=108-118) is a very active field in nuclear science.

The physics case:

The new elements (Z=102–109), increased stability for deformed nuclei

The search for missing and new elements has played a key role in chemistry and in nuclear physics in the last 100 years. The discovery of new radioactivite elements in the first decades of the 20^{th} century were associated with the names of Curie, Joliot, Hahn and Meitner. Mendeleev's original table had missing elements with low mass. These are the radioactive species Technetium (Z=43,

$T_{1/2}$ = 2.6 million years), and Promethium (Z= 61, $T_{1/2}$ = 265 days), which have rather short lifetimes compared to the age of our planet (4.5 billion years). Other short-lived elements between Uranium and Lead, namely Polonium (Z=84), Astatine (Z=85), Radium (Z=86), Francium (Z=87), Radon (Z=88) and Protactinium (Z=89), were discovered and given names which reflected the national origins of the various groups of scientists working in the field. There exists a comparable "stable" island of elements consisting of the isotopes of Thorium (Z=90) and Uranium (Z=92). Later the hunt for the transuranium elements started with the irradiation of Uranium with neutrons. Enrico Fermi received the Nobel Prize in 1938 for "demonstrations of the existence of new radioactive elements produced by neutron irradiation". This result was later correctly reinterpreted with the discovery that these new radioactive elements were not transuranium species, but fission fragments of ^{235}U. The fission process was discovered in the irradiation of Uranium with neutrons by the chemists Hahn and Strassman in 1938. Already during World War II large amounts of the elements Z=93 (Neptunium) and Z=94 (Plutonium) were produced in nuclear reactors.

Irradiations of ^{238}U with different heavy ion beams (helium, carbon, oxygen isotopes) at Berkeley led to the discovery of elements with nuclear charges of Z=95-100. Heavier elements were produced in several laboratories (Sweden, Russia and USA). E.M. McMillan and G.T. Seaborg (from Berkeley) received the chemistry Nobel Prize (in 1951) "for the discoveries in the chemistry of the transuranium elements".

Finally, the era of fusion reactions between heavy nuclei started with the availability of beams of nuclei heavier than oxygen or neon in several laboratories in the world. The first heavy transuranium elements were produced with heavy ion beams by the irradiation of heavier targets, like Plutonium (Z=94) and Americium (Z=95). In this way several elements in the region of Z=102-106 were synthesized by the group of G.N. Flerov and Y. Oganessian at the laboratory of JINR in Dubna, and in LBL in Berkeley by the group of G.T. Seaborg and A. Ghiorso. Later, physicists (and chemists) turned back to using lighter targets such as lead ^{208}Pb (Z=82) and bismuth ^{209}Bi (Z=83) and the appropriate heavier projectiles. Thus element 102 can be produced with the [(Pu(Z=94)+^{18}O(Z=8)] combination, or with the [^{208}Pb(Z=82)+^{48}Ca(Z=20)] combination. When the closed shell nuclei Pb and Ca are used the energy balance (the Q-value) of the reaction becomes more negative. The excitation energy Ex of the fused system (E_x=E_{CM}+Q) is minimized and only a very small number of neutrons are emitted. The incident kinetic energy E_{cm} is chosen to be as low as possible while still being sufficient to overcome the Coulomb repulsion between the colliding nuclei. It is very important to minimize E_x because the decay probability of very heavy elements, in particular the fission decay probability, is thereby reduced. This is the concept of "cold" fusion reactions between two heavy nuclei, introduced by Y. Oganessian in Dubna. Theoretical concepts developed by theorists at Frankfurt had independently also suggested this type of reactions, namely that particular "fusion valleys" would give favourable conditions for cold reactions. However, the full impact of this concept of "cold" fusion reactions became clear only in the last 20 years with the synthesis of even heavier elements by the GSI-group led by Armbruster and Münzenberg.

These experimental studies were triggered by several groups of theoretical physicists in the mid sixties, that proposed a new "island of stability" of very heavy elements (called "Super heavy elements") would exist in the region of nuclear charges of Z=114-126, similar to the very stable "magic" spherical nuclei like the Pb-isotopes, and some isotopes of Z=114 were predicted to be stable enough to be detected in nature. Later their lifetimes were found to be much shorter than the 4.5 billion years of the Earth. Just as interesting, these studies showed that deformed nuclei with charge number between Z=104 to 112 and away from closed shells may also have increased stability. Generally the Coulomb repulsion between the protons becomes so strong that the nuclear forces could stabilise only nuclei up to a maximum charge of Z~100. However, detailed theoretical studies in the last 20 years of several groups in Europe, in particular in Germany, Poland, Sweden and the Ukraine have shown, that because of certain quantal effects associated with nuclear deformation, nuclei are stabilized to the extent, that they can be observed in the laboratory.

The main experimental difficulty in identifying the new heavy elements is the low probability of their formation, which calls for unusual high intensities of ion beams to be used on fragile targets, and the separation of the surviving compound nucleus from the very high flux of incident projectile nuclei, typically at 0° with respect to the beam direction. For this purpose the GSI-Giessen group built a "Wien" velocity filter, consisting of crossed magnetic and electric fields. This instrument has been in operation at the UNILAC heavy ion accelerator of the GSI since 1976. The second step in the identification of very short-lived isotopes produced with cross sections of nano-barns and below is a measurement of the nuclear charge and mass. This is achieved by a measurement of the decay energies and half-lives of a complete α-particle decay chain down to elements with known properties. The chemistry of these elements has recently been carried out with only several atoms per experiment!

To conclude, the study of the properties of the elements Z=102–109 by the 3 laureates over the last 30 years and the observation of their increased stability has beautifully confirmed the concept of "deformed magic" nuclei. Recent reports on discoveries and detailed studies of the properties of even heavier elements in the region of charges Z=108–116 illustrate the actuality of this field of nuclear science.

Photographs: **(from left to right) Yuri Ts. Oganessian, Peter Armbruster, Gottfried Müzenberg**

activities

noticeboard

The Pantaneto Forum

The Pantaneto Forum (www.pantaneto.co.uk) aims to promote debate on how scientists are coping with the increasingly important role of science within society.

The border area between philosophy and science is often neglected or worse still invaded by those whose agenda is suspect. As a result the public understanding of science is poorly served and reasoned debate is mired in rhetoric based on ignorance and even tyranny. A large part of the problem scientists have with the "Public Understanding of Science", is the "Scientist's Understanding of the Public". This covers not only communication with the media, government and other sections of the public, but also communication with other scientists.

The Pantaneto Forum will appear quarterly. The Forum is multidisciplinary with submissions welcome from scientists as well as philosophers, political and social scientists, or anyone who feels they want to make a contribution. We welcome articles up to 3000 words and short discussion comments on articles which have appeared in The Forum.

Please post or send any articles to me at nigel@pantaneto.co.uk. All submissions will be refereed.

European Commission: Descartes Prize

The Descartes Prize will be awarded to outstanding scientific and technological achievements resulting from European collaborative research. Candidates must be nationals of a member state, or associated state, or residing in the EU for at least the last five years. The competition is open to all fields of scientific endeavour, including social and economic sciences. Up to 50,000 will be awarded per team associated with the selected project.

http://www.cordis.lu/improving/calls/descartes_200002.htm

Closing date: 6 April 2001

Move to campus

C. Rossel and D. Lee met recently with the Technical Services of the Université d'Haute Alsace to discuss the future office space of the EPS on campus. The project has received Euro 76,000 in 2001 for a site study and preliminary design. The total budget for the office spaces is Euro 760,000.

EPCS Elections

The EPS would like to welcome D. Bulfone and J.F. Gournay as the newly elected members of the board for the Interdivisional Group of Experimental Physics Control Systems.

ELECTED:

D. BULFONE 29 votes

J.-F. GOURNAY 20 votes

N. N. Bogoliubov Prize for Young Scientists

The Joint Institute for Nuclear Research announces the N.N. Bogoliubov Prize for Young Scientists.

The prize, established in 1999 in memory of the eminent physicist and mathematician Nikolai Nikolaevich Bogoliubov (1909-1992), is awarded to young (upper age limit = 33) researchers for outstanding contribution in the fields of theoretical physics related to Bogoliubov's scientific interests. Nikolai Nikolaevich Bogoliubov's scientific activity began in Kyiv at the age of 14 and important results followed from the age of 20. His main interests were nonlinear mechanics, statistical physics, quantum field theory and elementary particle theory.

As a rule the prize is awarded to a scientist who showed early scientific maturity and whose results are recognised worldwide. Entries should try to emulate Bogoliubov's own skill in using sophisticated mathematics to attack concrete physical problems.

The first N.N. Bogoliubov Prize was awarded in the summer of 1999 and presented at the Conference dedicated toN.N.Bogoliubov's 90th birthday was held in Dubna at the end of September.

Entries for the 2001 prize (including curricilum vitae and a one to two-page abstract of the submitted papers) should be forwarded to Directorate of the Bogoliubov Laboratory of Theoretical Physics of the Joint Institute for Nuclear Research until 1 June, 2001 by e-mail: premia01@thsun1.jinr.ru or to Dr. V.I. Zhuravlev, Scientific Secretary of Bogoliubov Laboratory of Theoretical Physics, JINR, Joliot--Curie str. 6, 141980 Dubna, Moscow Region, Russia.

EWTF web site

The new address of EWTF is:

http://spin.fzu.cz/varia/ewtf

Open archives and the European physicist

Claus Montonen

The advent of electronic communication has surely changed the ways of scientific communication within the physics community. No longer are preprints circulated, no longer do we reach for the latest issues of our favourite journals to find out what are the recent advances in our field. Starting with high-energy physics and spreading into all other areas of physics, the e-print archive at Los Alamos and its mirrors have taken over the role of the way to let the world know what you have done and to learn what everybody else is doing. And - to be honest - they are doing it fantastically well.

There is, however, a large body of physics information that does not come neatly packaged into papers: data sets, spreadsheets, dissertations of various kinds, audiovisual material etc., which is also available in electronic archives, e.g. on "our" PhysNet. The Open Archives Initiative (OAI, http://www.openarchives.org/), started in 1999, aims at developing interoperability standards allowing free open access to material in distributed heterogenous electronic archives and searching across them. This is achieved by adhering to an agreed set of metadata elements, a standard syntax for the representation and transfer of metadata, and a common protocol allowing the extraction of the metadata from the archives.

The adoption of the OAI could lead to a dream come true: A general, comprehensive information system for all of science allowing easy access (not necessarily free, though; some data providers will charge for the use of their material). It thus deserves the full support of the European physics community.

There are two obvious weaknesses in present e-print archive systems: Absence of refereeing and long-term preservation. A small conference is being organised in CERN this spring (see http://documents.cern.ch/OAi/) discussing i.a. how these two points could be addressed, with the aim of blueprinting an open electronic alternative to the present journal-based publication structure. I am not convinced, however, that this is the way to go. Existing journals have provided the value-adding functions of quality control and editing, and have guaranteed preservation of their electronic material at least until general agreement is reached on who will be responsible for the long-term archiving. It would be natural to continue co-operating with those publishers adopting a policy of price restraint and showing an understanding of the plight of the scientific establishment in face of continuing cut-backs. And, last but not least, we, as European physicists, should support the imaginative initiatives taken in Europe of new electronic physics journals exploiting the advantages of the new medium in full.

Claus Montonen is the Chariman of the Action Committee on Publications and Scientific Communication.
He can be contacted at: claus.montonen@helsinki.fi

activities

Secretary General's Report

Nominations to the Executive Committee

Below are the nominations to the Executive Committee. A short curriculum vitae and statement are available at eps.org

Current members standing for re-election

M. Ducloy – President
A. Wolfendale – Vice President
P. Reineker - Treasurer
C. Rossel – Secretary
D. Krupa
P.A. Lindgard
R. Sosnowsky
K. Gaemers

New Candidates

G. Delgado Barrio
C. Zerefos
M. Allegrini

Not standing for re-election

R. Klein
A.M. Eiro
D. Jerome

New Technology Group Chairman

The EPS is pleased to welcome Dr. F. Bourgeois as the new chairman of the Technology Group. The Executive Committee would like to thank K. Kaski for his time and energy.

An interview with Busquin

Interview with the EU Commissioner for Research
G. Morrison and D. Lee met with P. Busquin, the Commissioner for DG Research. The interview covered topics such as the perceived strength of European Research, the priorities in Framework Programme 6 and the role of the EPS in science policy. The full interview will be published in 32/3.

FEANI Co-operation

E. Lingemann, secretary of the Professional Qualification Committee was invited to the FEANI Council meeting to present the EPS EurPhys programme. The EPS and the FEANI will study the possibility of joint lobbying for EU recognition of their respective qualification programmes.

David Lee is the Secretary General of the EPS
***email* d.lee@univ-mulhouse.fr**

Thoughts around the third World Congress of the Physical Societies in Berlin, December 2000

Which path is physics taking?

It started with two Nobel gala-lectures in the impressive Berliner Schauspielhaus. There must have been close to a thousand in the audience; many celebrated physicists. Von Klitzing spoke vividly about Planck[1] – his time and his quantum *h*. Did you know that the great interest in black-body-radiation had the practical background, to find a reliable standard for the intensity of light (black-body-radiation depends only on temperature and not on material properties etc.). The politicians should decide whether to use gas or electricity to illuminate Berlin. Then Cohen-Tannoudji talked with great elegance about the cute curiosities (exclusively) which make atomic and laser physics boom presently (leading to e.g. laser-cooling, 100 times more accurate time-measurements which for example allows a better exploration for oil, finding what extinguished the dinosaurs etc.). There is still plenty of life and kicks in the precisely 100 year old quantum ideas. Planck announced his discovery of h on December 14 1900. That is what was celebrated.

It has often struck me that Nobel-prize-winners have an original, highly simple approach to physics and can talk directly to the fantasy and the imagination[2]. It sounds so easy; sparks the "that-could-I-also-have-found-out" feeling. Physics becomes present, fun, relevant and essential. Maybe they unintentionally happened to put the finger right on the sore point. So few can now really enthuse or enthral students and common folks for just physics.

The festive afternoon was held against a very sinister background. In the last few years the number of physics students in Germany has dropped by a factor of three (number of PhD students fallen from 1700 to 500). The problem was considered so serious by the Germany Physical Society (DPG) that, in an attempt to increase the interest for physics, DPG had proposed to declare year 2000 "The Year of Physics" in Germany. There has been a whole series of well-attended arrangements. A fine, colourful and good book has been produced, which can be bought for just 10 DM. And so on. It has been a great success in the sense that very favourable mention has occurred in both Nature and Science. This celebration was the culmination. The arrangement had been fully backed and financially supported with several millions of DM by the German ministry for Research and Education (R&E). It will be interesting to follow if it has the desired effect; or if other means are needed – for example a better treatment of post-doctorats. Given is that the misery is a result of a catastrophic policy conducted some ten years ago.

There was also an impressive, longer speech by the R&E-minister, E. Buhlmann, a young woman who radiated authority and competence. She spoke about physics with an insight, clarity and easiness which could make many physicists envious – and then went on to talk well about policy and the need for investing in physics. As a Dane one couldn't help wondering. One came to think about our corresponding ministry and those who are running it. It has even recently changed its name from Ministry of Research and Information Technology to that of Information Technology and Research. A thought also touched the miserable destiny physics has had at Risø, the largest research establishment in Denmark, after the shut down of the research reactor DR3.

The Third World Congress of the Physical Societies started hereafter. It was the third in the series, not for third world countries in particular. It was arranged by EPS and DPG. It was held in the interesting old "Magnus Haus", which was built at the end of the 1800-century and belonged to the influential physicist Magnus. It is situated right across from the Pergamon museum, close to the Humbolt University and all the imposing buildings in Greek and neo-classic style in the old Berlin Centrum. Interesting that a physics professor once could have had such an enormous, elegant house right in the centre. Around him he had a handful of students, many whom are still known in physics. They were among those who provided the basis for a new way of thinking, insisting on understanding and tests.

It is a paradox of today's physics. There are so many physicists – most of whom will not be remembered in 200 years time. But they are needed to keep up the growth in all technology – from increase in computer power and memory to more effective food production. From directors to common folks – this growth is simply expected, if not willingly paid for. Another aspect is the inflation the words *research* and *science* have suffered – soon it may be regarded as research to surf the Internet (witness the name change of the ministry). There is something to think about.

There were about 100 delegates. They came from USA with some of the leading persons in AIP and APS, and from Japan, where they have two large societies (one for applied physics), from West and East Europe, from China, Asia, New Zealand and South America to the small almost non-existing societies in Africa. I participated as a representative of the Danish Physical Society and as a member of the executive committee of EPS. The problem was unanimously the same: falling interest for physics – although not equally alarming in all places, and not so serious as in Germany. All spoke about the foreseeable and overwhelming problem of a lack of qualified teachers of physics in a few years to come. The problem spreads over all levels from school to university. It can be damaging for the "trade" of physics. And coupled to that is the question: why are so few girls choosing to study physics. Nobody had the answer.

There was a great consensus that physicists are extremely "useful" and that there are no problems in obtaining job, as such. It was generally seen as an asset for the future to have the solid ballast of basic knowledge, which is precisely what is acquired in the demanding physics study. One voice (from Holland) raised the question whether the highly treasured abilities

The participants agree to M. Ducloy's proposal to proclaim 2005 as the World Year for Physics

elegates put the final touches on the solutions coming from the World Congress

(like flexibility, being critical, able to learn new things, being able to generalise etc.) perhaps could be taught in a more direct way. Is it really necessary to write a PhD thesis in quantum mechanics to be a good money-man in Wall Street. I believe too, and said, that many physicists are in fact over-educated for the jobs they eventually take. If in the end they are to compete with engineers, they are worse off and the salary will generally be lower, simply because of labour union realities, at least in Denmark. So why not take the direct road. Another aspect is that a long and demanding education no longer gives a reasonably probable admission to a career wanted, if interest in physics should be of prime interest. Perhaps, one needs to revaluate physics education altogether.

In the Easter European countries there is still a good (old fashioned) education, but a declining number of students. There seems to be a problem with brain drain, in particular to USA, but also successively from Russia to Poland, Poland to Germany etc. The problem is obviously quite complex. There was some dispute about whether it was – or for who is was – good or bad. The president of EPS, Sir Arnold Wolfendale, who has been travelling a lot in Eastern Europe, raised the issue and suggested that the richer countries should compensate (economically) for the loss of the talents. The president for IUPAP, B. Richter (Nobel prize winner from USA) and some representatives from the Easter countries spoke for the point of view, that it was an unavoidable problem, a temporary problem, of use for the individuals and for creating scientific contacts – but that the problem is foremost that of the governments in the involved countries – and their responsibility to solve. Something I would tend to agree with and which the rich little Denmark perhaps could learn from. The problem here is to provide attractive opportunities for those more than willing to return. Not too surprisingly, it was even worse in the little rich New Zealand, where there is a tradition for walking in rather small shoes, economically. There the demand for immediate "usefulness of science" is predominant and devastating, I understood. Some very well formulated contributions from Africa and Asia showed there are similar problems, although probably on a rather different level.

Other subjects were discussed, for example the revolution one will expect with respect to electronic communication and publication, not to speak about archiving. While it is possible to read 2000-year-old papyrus roles, there are problems with 15-year-old electronic data. Something must be done, and fast. It is clear that the electronic media do not diminish the amount of paper used. Many of the large physical societies are rich and depend on the publication activities for their income. Some concern is rising how to maintain a reasonable income. There are also legal problems, which can be uncontrollable with respect to ownership of databases and access to these with increasingly strict laws in various countries. There are people in the Physical Societies who are thinking about these kinds of problems for us. But there can or will be big changes in the way physics results are communicated in the coming few years. A debate about how physicists see the problems best solved would be highly useful, for example if conducted in EPN.

The meeting ended with agreement on three resolutions (see www.eps.org). Two are aimed at influencing governments and decision makers by elucidating the problems physics finds itself in the middle of, and at seeking to ameliorate the conditions for researchers and in particular teachers of physics – and one aimed at the physical societies proposing more collaboration. It was announced that EPS will work on making year 2005 a "World year of physics". It is the 100-year anniversary for Einstein's great theories – about both the quantum and the relativity phenomena. Internationally there should be made big interesting arrangements in order to make physics visible as the important breeding-box or seed-bed for new ideas that it is – so technology is not running with all the honour, and the money too. Contributions and ideas to the project would be welcome.

This is a personal account of the meeting, spiced with a few personal opinions. Others could have summarised and coloured it differently. The meeting was surprisingly inspiring. If IUPAP, EPS, AIP, APS IOP, DPG and all the other physical societies can work together, we represent several hundred thousand physicists; with surrounding persons it amounts in millions. Then politicians will begin to listen, as our American colleagues said, and they know the conditions for lobbying. There is obviously a lot of important work going on in the various societies. It is important that all members of the national societies are aware of this and actively participate in the solution of the various problems that appear on the horizon.

The abbreviations stand for:
AIP (American Institute of Physics), APS (American Physical Society), DPG (Deutsche Physikalishe Gesellschaft), EPS (European Physical Society), IOP (Institute of Physics – England), IUPAP (International Union of Pure and Applied Physics), EPN (EurophysicsNews).

[1] Von Klitzing told the story about a cautious, young professor Planck, who would himself not quite like to admit the consequences of his discovery: the need for a small, but finite minimum energy unit, the quantum h. Planck seemed not to have much valued his "interpolation" formula, which could fit the frequency dependence of the black-body-radiation, simply perfectly for all frequencies. He missed an understanding – a possibility to build on known foundations. A good description of the story can be found in Physics World, December 2000, Max Planck, the reluctant revolutionary, by H. Kragh.

[2] I remember personally, right after graduation from the, by then, matured Niels Bohr Institute, being heavily loaded with concepts one knew, or led to feel one had to know to the very bottom, wherever that was. One dared hardly think about them, much less pronounce them. Everything was a tip of an iceberg. The mantra taught had been "be cautious" and not "be curious" or "be courageous". To carry around such a heavy burden is not promoting creative thinking. One needs not drive in the first gear all the way. What one should have learned was also to be able to move along in highest gear – even if on thinner ice – in order to catch an idea. That is where the creativity is – in the combination. If that was taught it would probably appeal to the more enterprising students. But it was not so – and is still not.

The full text of the three resolutions resulting from the World Congress can be found on the EPS web site: www.eps.org

activities

EUROPEAN PHYSICAL SOCIETY CONFERENCES

7th European Conference on Atomic and Molecular Physics ECAMP VII
02-06 April 2001 – Berlin (Germany)
Contact: Dr. Wolfgang Sandner
Secretary Silvia Szlapka
Max-Born-Institut, Max-Born-Str. 2A, D - 12489 Berlin
tel +49 30 6392 1300/1301 *fax* +49 30 6392 1309
email sandner@mbi-berlin.de or szlapka@mbi-berlin.de
web site http://www.ecamp7.de

European East-West Coordination Meeting on Nuclear Science SANDANSKI - 2
05-09 May – Sandanski (Bulgaria)
Contacts: Prof. W. Von Oertzen (Chairman)
Hahn-Meitner-Institute
Glienickerstr. 100, D - 14109 Berlin, Germany
tel +49 30 8062 2700 *fax* +49 30 8062 2293
email oertzen@hmi.de
Scientific Secretary: Prof. R. Kalpakchieva
Fleevov Lab. of Nuclear Reactions
JINR RU - 141980 Dubna, Russia
tel +7 096 21 64 857 *fax* +7 096 21 65 083
email kalpak@sungraph.jinr.ru

Polymer Electrolytes Symposium 2001
14-16 May 2001 – Noordwijkerhout (Netherlands)
Contact: Ms. Maria Roodenburg
Department of Applied Physics
Delft University of Technology
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tel +31 15 278 1440 *fax* +31 15 278 6081
email M.Rodenburg-vanDijk@TNW.TUDelft.NL
web site http://www.cp.tn.tudelft.nl/pes

CLEO Focus Meetings:
1. Progress in Solid State Lasers
2. Non Linear Devices and Applications to Photonics
3. Quantum Information and Communications
18-22 June 2001 – Munich (Germany)
Contacts: Prof. Gunter Huber
University of Hamburg
Institut für Laser-Physik Jungiusstr. 9a
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tel +49 40 42838 3628 *fax* +49 40 42838 6281
email huber@physnet.uni-hamburg.de
Prof. Sandro De Silvestri
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email sandro.desilvestri@fisi.polimi.it
Prof. Ralf Menzel
University of Potsdam (Germany)
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email menzel@rz.uni-postdam.de
Secretariat: Mrs. Christine Bastian
European Physical Society
34 rue Marc Seguin, 68060 Mulhouse (France)
tel +33 389 32 94 42 *fax* +33 389 32 94 49
email c.bastian@univ-mulhouse.fr
web site http:// www.eps.org/cleofocus

Discrete Simulation of Fluid Dynamics: New Trends, New Perspectives
02-07 July 2001 – Cargèse (Corsica - France)
Contacts: Prof. Jean-Pierre Boon
Université Libre de Bruxelles
Boulevard du Triomphe - C.P. 231
B - 1050 Bruxelles (Belgium)
tel +32 2 650 55 27 *fax* +32 2 650 57 67
email jpboon@ulb.ac.be
Secretariat in Cargèse:
Institut d'Etudes Scientifiques
F - 20130 Cargèse (Corse, France)
tel +33 4 95 26 80 40 *fax* +33 4 95 26 80 45
email brigitte@cargese.iesc.univ-corse.fr
web site http://poseidon.ulb.ac.be (go to) Cargese2001

International Conference on High Energy Physics HEP-2001
12-18 July 2001 – Budapest (Hungary)
Contact: Prof. Andras Patkos
Department of Atomic Physics of Eotvos University
Pazmany P. s. 1/A
Budapest, Hungary 1117
email hep2001@hep2001.elte.hu
web site http://www.hep2001.elte.hu

Dynamical Networks in Complex Systems
25-27 July 2001 – University of Kiel (Germany)
Contacts: Dr. Stefan Bornholdt
Institute of Theoretical Physics
University of Kiel Leibnizstrasse 15
D - 24098 Kiel
tel +49 431 880 4071 Fax +49 431 880 4094 Emails: bornholdt@theo-physik.uni-kiel.de Or networks@theo-physik.uni-kiel.de
Secretary: Dr. Konstantin Klemm
Niels Bohr Institute Blegdamsvej 17
DK - 2100 Copenhagen
tel +45 35 32 52 73 *fax* +45 35 32 54 25
email klemm@nbi.dk
web site ysik.uni-kiel.de/~networks

Waves and Wave Turbulence
12-15 August 2001 – Nyborg (Denmark)
Contacts: Prof. Mogens Levinsen
Niels Bohr Institute
Blegdamsvej 17, DK - 2100 Copenhagen
Tel. +45 35 32 52 95 *fax* +45 35 32 52 14
email levinsen@nbi.dk
Secretary: Dr. Konstantin Klemm
tel +45 35 32 52 95 *fax* +45 35 32 52 73
email klemm@nbi.dk

Morfology and Properties of Crystalline Polymers
03-05 September 2001 – Eger (Hungary)
Contact: Prof. Béla Pukanszky
Budapest University of Technology and Economics
Dept. of Plastics and Rubber Technology
P.O. Box 92, H - 1521 Budapest, Hungary
tel +36 1 463 2015 *fax* +36 1 463 3474
email pukanszky@muatex.mua.bme.hu

Conference on Computational Physics 2001
05-08 September 2001 – Aachen (Germany)
Contacts: Prof. Friedel Hossfeld
Research Centre Jülich
John von Neumann Institute for Computing (NIC)
Central Institute for Applied Mathematics (ZAM)
tel +49 2461 61 6402
email f.hossfeld@fz-juelich.de
Conference Secretary:
Dr. Norbert Attig
tel +49 2461 61 4416 *fax* +49 2461 61 66 56
email n.attig@fz-juelich.de
web site http://www.fz-juelich.de/ccp2001

Fourth Southern European School of the European Physical Society PHYSICS AND MEDICINE
01-12 September 2001 – Faro (Portugal)
Contact: Dr. Leonor Cruzeiro-Hansson
Universidade do Algarve Area
Dept. Fisica / UCE, Campus de Gambelas 8000
Faro (Portugal)
fax +351 289 8000987 *email* eps@ualg.pt
web site www.ualg.pt/eps-school/programme.html

Int. Conference on Inertial Fusion Sciences and Applications (IFSA)
09-14 September 2001 – Kyoto (Japan)
Contact: Professor Kunioki Mima
Institute of Laser Engineering
Osaka University
2-6 Yamada-Oka, Suita, JP - Osaka 565-087, Japan
tel +81 6 6879 8704 *fax* +81 6 6877 4799
email ytsujii@ile.osaka-u.ac.jp

European Particle Accelerator Conference EPAC 2002
03-07 June 2002 – Paris,(France)
Cité de la Science,
Centre des Congrès de la Villette (France)
Contact: Prof. J. Le Duff
LAL Laboratoire de l'Accélérateur Linéaire Université de Paris Sud
Bât. 34 F - 91898 Orsay Cédex
tel +33 1 64 46 84 30 *fax* +33 1 69 07 14 99
email leduff@lal.in2p3.fr
Mrs. Ch. Petit-Jean-Genaz
CERN - AC, CH - 1211 Geneva 23
tel +41 22 767 32 75 *fax* +41 22 767 94 60
email Christine.petit-jean-genaz@cern.ch
web site http://epac.web.cern.ch/EPAC/

EPS Sponsored conferences

IXth Vienna Instrumentation Conference
19-24 February 2001 – Vienna (Austria)
Contact: Professor Meinhard Regler
Secretary: Mrs. Susanne Kalina
Institute of High Energy Physics of the Austrian Academy of Sciences
Nikolsdorfer Gasse 18, A-1050 Vienna, Austria
tel +43 1 544 73 28 42 *fax* +43 1 544 73 28 54
email wcc@hephy.oeaw.ac.at

MECO – 26 Middle European Cooperation in Statistical Physics
08-10 March 2001 – Prague (Czech Republic)
Contact: Dr. Miroslav Kotrla
Institute of Physics
Academy of Sciences of the Czech Republic
Na Slovance 2, CZ - 182 21 Praha 8 Czech Republic
tel +420 2 660 52 904 *fax* +420 2 821 227
email kotrla@fzu.cz meco26@fzu.cz
web site http://www.fzu.cz/conferences/meco26

Symposium on Metallic Multilayers (MML01)
24 - 29 June 2001 – Aachen Eurogress (Germany)
Contacts: Prof. Dr. Gernot Güntherodt
II. Physikalisches Institut RWTH Aachen
D - 52056 Aachen
tel +49 241 80 7055 *fax* +49 241 8888 306
email gernot.guentherodt@physik.rwth-aachen.de
Prof. Dr. Harmut Zabel
Experimentalphysik/Festkörperphysik
Ruhr-Universität Bochum, D - 44780 Bochum
tel +49 234 322 3649 *fax* +49 234 321 4173
email harmut.zabel@ruhr-uni-bochum.de
web site http://www.mml01.de

European Magnetic Symposia : JEMS'01
28 Aug-1 Sept 2001 – Grenoble (France)
Contact : JEMS'01 Conference Secretary
Mr. Pierre Molho
Laboratoire Louis Néel,
CNRS B.P. 166, F - 38042 Grenoble Cédex 9, France
tel +33 4 76887438 *fax* +33 4 76887927
email JEMS01@polycnrs-gre.fr
web site http://www.polycnrs-gre.fr/JEMS01/

12th International Conference on Surface Modification of Materials by Ion Beams
09 - 14 September 2001 – Marburg (Germany)
Contacts : Prof. Wolgang Ensinger
Universität Marburg Fachbereich Chemie
tel +49 6421 2825 727 *fax* +49 6421 2822 124
email ensinger@chemie.uni-marburg.de
Dr. Dorothee Rück GSI Planckstr. 1
D - 64291 Darmstadt
tel +49 6159 712630 *fax* +49 6159 712905
email d.rueck@gsi.de
web site www.GSI.DE\SMMIB2001\

Neutrinos in astro, particle and nuclear physics
18 - 26 September, 2001 – Erice (Italy)
Contact: A. Faessler,
Universität Tuebingen,
Institut für Theoretische Physik,
Auf der Morgenstelle 14, D-72076 Tübingen
tel + 49 7071 29 76 370 *fax* + 49 7071 29 53 88
email amand.faessler @ uni-tuebingen.de
Or erice2000@uni-tuebingen.de

International Conference on Theoretical PhysicsTH-2002
22-26 July 2002 – Paris - UNESCO (France)
Contacts : Prof. Daniel Iagolnitzer
tel +33 1 69 08 81 15 *email* iago@spht.saclay.cea.fr
Prof. Jean Zinn-Justin
tel +33 1 69 08 74 68 *email* zinn@spht.saclay.cea.fr
CEA-Saclay, Service de Physique Théorique
F - 91191 Gif-sur-Yvette Cédex, France

EUROPEAN PHYSICAL SOCIETY CONFERENCES

HEP2001

The European Physical Society's International Europhysics Conference on High Energy Physics (HEP2001) will take place from 12-18 July in Budapest. See http://www.hep2001.elte.hu. Participation is normally restricted to those nominated by their national contact persons, however it can also be done by contacting directly the above mentioned WEB site. The conference will follow the traditional pattern of three days of parallel talks, followed by an excursion day (15 July) and three days of plenary presentations. It will include on its third day the Plenary ECFA meeting, to allow young physicists the possibility of learning first hand about the future projects for European High Energy Physics. At the meeting, the 2001 High Energy Particle Physics Prize of the European Physical Society's will be bestowed, as will three newly founded awards: the Prize for Young Particle Physicists, the Gribov Medal honouring a young theoretician, and the Outreach Prize for the best popular explanation of particle physics discoveries.

4th Southern European School

The Portuguese Physical Society and the University of Algarve host the 4th Southern European School of the European Physical Society - Physics in Medicine, which will take place in the University of Algarve, Faro, from 1 to 12 September 2001.

The School is intended for young postgraduate and last years graduation physicists and also for hospital technical personnel, from Southern Europe and Northern AFrica. Activities will give the participants the opportunity to learn the most recent scientific and technological advances in Medical Physics; they are designed to broaden the participant's understanding of physics in medicine and familiarize them with the latest advances in related technological applications.

The main topics to be discussed are:

Radiation Physics and Detectors (Maria Abreu), Biophysics (Leonor Cruzeiro-Hansson), Brain Activity (Eduardo Ducla Soares), Cardio-Vascular Physiology (David Evans), Respiratory Activity (Manuel Paiva), Medical Physics (José Pedroso Lima), Magnetic Resonance Imaging (Steffen Petersen), Brain Modelling (Carla Silva), Status of Clinical Medical Physicists (Marina Téllez), Lasers in Medical Physics (Sigrid Avrillier) and Monte Carlo Simulations Applied to Radiotherapy (Luis Peralta).

The deadline for registration is the 30th April 2001.

There are some scolarships available; they should be requested up to the 28th February 2001.

For registration forms and further information please visit the web site http://www.ualg.pt/eps-school, or contact the organization via e-mail: eps@ualg.pt

meetings

Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung mbH

EC-Human Potential Programme (HPP)
Transnational Access to Major Research Infrastructures
EU Contract N° HPRI-CT-1999-00028

BESSY

European Research with Synchrotron Radiation at BESSY II
CALL FOR PROPOSALS

BESSY grants researchers in the European Union (EU) and Associated States access to the vacuum ultraviolet (VUV) and x-ray synchrotron radiation facility BESSY II in Berlin, Germany, through the Human Potential Programme of the European Commission. The programme also includes first time access for Small and Medium size Enterprises registered in the European Union or an Associated State.

Researchers wishing to:

- collaborate with distinguished European scientists in the field of research with synchrotron radiation,
- perform experiments with synchrotron radiation in physics, chemistry, biology or related fields,
- pioneer and exploit new technological applications of synchrotron radiation,
- and train young scientists in this expanding field

are invited to send a brief project proposal.

The 1.7 GeV storage ring BESSY II is Europe's most modern 'third generation' high-brightness source for synchrotron radiation in the VUV and x-ray region. Presently HPP projects can be carried out on 19 insertion device and 12 dipole beamlines. By the end of 2001 over 40 beamlines will be available for research and development projects. Experimental chambers and equipment maintained by BESSY are also available.

All project proposals are evaluated on the basis of scientific merit by an independent panel. Approved projects receive access free of charge, including on-site infrastructural, logistical, technical and scientific support. Travel and per diem expenses will be reimbursed to citizens/permanent residents of the EU or an Associated State who work in the EU (Germany excluded) or an Associated State.

For further information please contact:

BERLINER ELEKTRONENSPEICHERRING-GESELLSCHAFT
FÜR SYNCHROTRONSTRAHLUNG mbH (BESSY)
Albert-Einstein-Str. 15 - D-12489 Berlin

Beamtime Coordinator: Dr. Walter Braun, tel:++49(30) 6392-2927, e-mail: Braun@bessy.de
EU-Contract Manager: Dr. Patrick Bressler, tel:++49(30) 6392-2941,
e-mail: Bressler@bessy.de, **Fax: ++49(30) 6392-2989/-4673/-4980**
BESSY Users' Office: e-mail: useroffice@bessy.de, **Home page: http://www.bessy.de**

The forthcoming deadline for applications for magnet time allocation (September 2001 to January 2002) at the

GRENOBLE HIGH MAGNETIC FIELD LABORATORY

is **June 1st, 2001**.

Scientists of EU countries and Associated States* are entitled to apply under theHPP Programme « Transnational Access to Major Research Infrastructures » to obtain a financial support according to rules defined by the EC. Application forms are available on request.

**Bulgaria, Czech Republic, Republic of Cyprus, Estonia, Hungary, Iceland, Israel, Latvia, Liechtenstein, Lithuania, Norway, Poland, Romania, Slovakia, Slovenia.*

Please contact :

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38042 Grenoble Cedex 9
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Tel : 33-4.76.88.74.87
Fax : 33-4.76.85.56.10
e-mail : mossang@polycnrs-gre.fr

LIMANS III: European Cluster of Large Scale Laser Installations

LCVU:
Laser Centre Vrije Universiteit
Amsterdam, Netherlands

LENS:
European Laboratory for Non-Linear Spectroscopy
Firenze, Italy

LIF-ENSTA-X:
Laboratoire d'Optique Appliquée
École Polytechnique
Palaiseau, France

LLC:
Lund Laser Centre
Lund University
Lund, Schweden

MBI:
Max-Born-Institut
for Nonlinear Optics and Short Pulse Spectroscopy
Berlin, Germany

ULF-FORTH:
Ultraviolet Laser Facility
Foundation for Research and Technology - Hellas
Iraklion, Crete, Greece

Call for proposals

he above institutions are funded under the current IHP Programme of the European Union to provide :cess to researchers or research teams of Member States and Associated States. Within the cluster they ffer state-of-the-art scientific laser equipment and reserach environments with a wide range of research pportunities, allowing for today's most advanced light-matter interaction experiments in broad regimes of ower, wavelengths, or pulse durations. Access is provided free of charge; travel and living expenses are overed by the host institution.

terested researchers are invited to contact the LIMANS III website at **http://limans3.mbi-berlin.de**, from here they find all relevant information about the participating facilities and local contact points. Access is anted on the basis of proposals, which will be reviewed by an external panel of referees. Details about the ubmission procedure may be found under the LIMANS III website. Applicants are encouraged to contact ny of the facilities directly to obtain additional information and assistance in preparing a proposal. oposals are accepted at any time and from any eligible researcher or research team.