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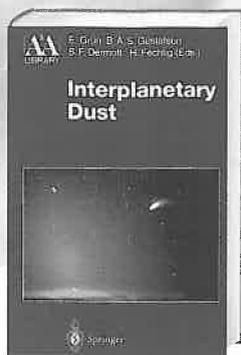
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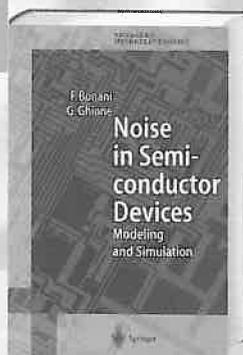
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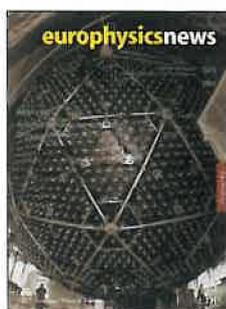
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Resolving the solar neutrino problem.
Photo courtesy of Ernest Orlando Lawrence Berkeley National Laboratory. see page 180

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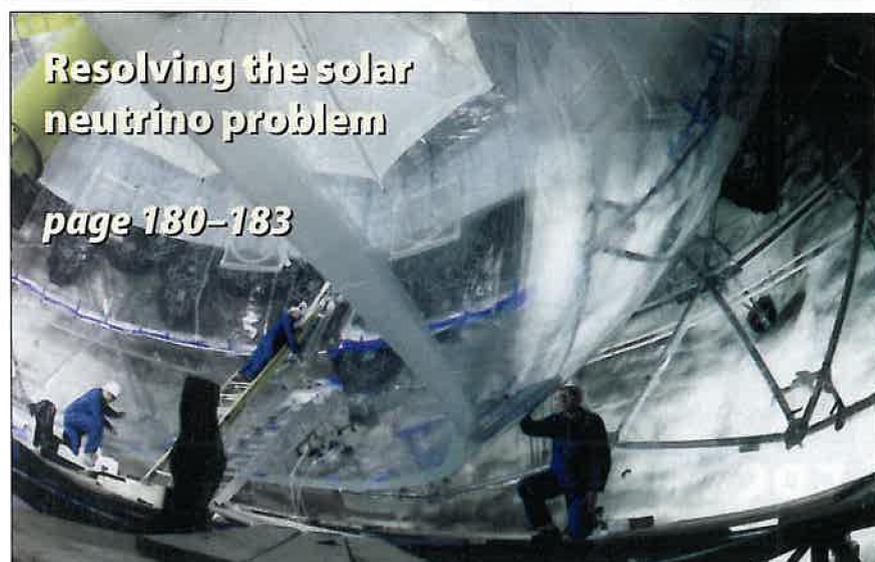
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EPS-12

The 12th general conference of the European Physical Society, "Trends in Physics" will be held in Budapest, from Monday 26 to Friday 30 August 2002. The conference venue will be the Physics Building of the Eötvös University located in South Buda, situated along the banks of the Danube river.

The programme of EPS-12 will follow the traditional scheme of the series consisting of plenary talks, parallel symposia with invited presentations and posters.

In 2002, there will be a common programme with the International Conference of Physics Students that will be held at the same place from 21 to 27 August.

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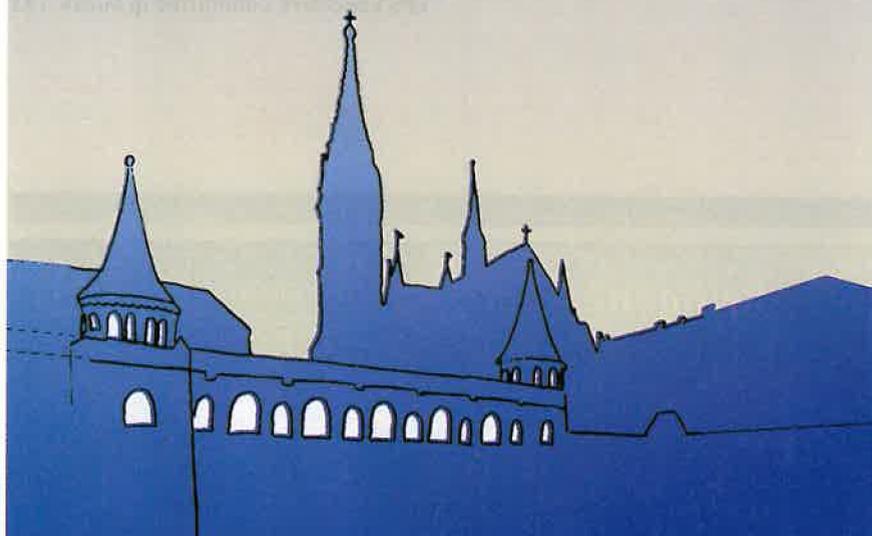
New information will be posted on the conference web site (<http://www.eps12.kfki.hu/>). Please check this site regularly. It will also be used for online registration and abstract submission. In matters of the scientific programme please contact the Programme Committee at eps12@rmki.kfki.hu

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EPS-12: Trends in Physics

first announcement

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The magnetic moment of the muon worries theorists

Francis J.M. Farley

Last February the Brookhaven muon ($g-2$) collaboration [1] announced a new measurement of the muon g -factor, disagreeing with theory by 2.6 standard deviations. Either some term in the theory has been wrongly calculated or this could be the first sign of physics beyond the standard model. To see why this matters let us look back at the electron.

The magnetic moment of the electron is g times the natural unit which is its angular momentum $\hbar/4\pi$ multiplied by the Larmor ratio $e/2mc$. Dirac theory predicted $g = 2$ but we now realise that this is modified by quantum fluctuations. In quantum field theory the electron is surrounded by a thin soup of evanescent particles which wink in and out of existence in fractions of a second. This soup is slightly magnetic so it increases the magnetic moment to $g = 2(1 + a)$. The small correction a (about 0.12%), called the anomalous moment, but often referred to as " $g-2$ " is a pure quantum effect entirely due to the soup of virtual particles around the electron. Its detection and measurement with gradually increasing accuracy inspired the theory of quantum electrodynamics (QED) and the present spectacular agreement [2] with calculation to 24 parts per billion (ppb) in is one of the main pillars of the theory. (The measurement is more accurate, but independent knowledge of the fine structure constant α limits the comparison).

The muon is 206 times heavier than the electron so its magnetic moment is 206 times smaller, but the virtual particles in the quantum soup can be more massive. As a result the anomalous moment is 40,000 times more sensitive to undiscovered particles and new physics at short distances,

$$\Delta a/a \sim (m/M)^2 \tag{1}$$

where m is the mass of the muon (or electron) and M is the mass scale of some new process. The present accuracy in the muon anomaly a_μ is 1.3 parts per million (ppm). In comparing with theory the error is 50 times larger than for the electron, but this makes it 800 times more sensitive to new effects. The agreement to 4 ppm must be regarded as the best test of the theory, but there is a small discrepancy that needs to be explained.

How can one measure a_μ ? When longitudinally polarised muons are trapped in a magnetic field B the orbit angular frequency is

$$\omega_c = eB/mc \tag{2}$$

where e is its electric charge, m its mass and c the velocity of light, while the spin frequency is

$$\omega_s = g(e/2mc)B \tag{3}$$

If $g = 2$ exactly these two frequencies are identical and the spin is always aligned with the velocity vector. But if $g > 2$, it turns faster and the angle between spin and momentum increases at angular frequency

$$\omega_a = (g/2 - 1)(eB/mc) = a_\mu (eB/mc) \tag{4}$$

It would be convenient to calibrate the magnetic field by measuring muon precession at rest, combining equations (3) and (4) to give

$$\omega_a/\omega_s = a_\mu / (1 + a_\mu) \tag{5}$$

Then (e/mc) for the muon need not be known. In practice one measures the field in terms of the proton precession (NMR) frequency ω_p and converts to ω_s using the ratio $\lambda = \omega_s/\omega_p = \mu_\mu/\mu_p$ where μ_μ and μ_p are the magnetic moments of the muon and proton. The value of λ is known to 26 ppb from the hyperfine structure of muonium [3].

In summary, one injects polarised muons into a magnetic field calibrated by proton NMR and measures the rate at which the spin turns relative to the momentum; this determines a_μ rather than g so it has come to be called the ($g-2$)-experiment. At low velocities the spin turns once relative to the velocity for every 800 turns in the field, so a good measurement requires many orbits. In a reasonable magnetic field (1.6 T) the ($g-2$) period (of spin relative to momentum) is 4 μ s, but the muon lifetime is only 2.2 μ s, so there are not many precession cycles to measure. The solution is to use highly relativistic muons so the lifetime is dilated (moving clocks run slow). Fortunately (for more complicated reasons) ω_a is not slowed down and equation (4) remains valid; in the latest experiments the muons are kept in the field for over 700 μ s giving hundreds of cycles to measure.

In 1956 ($g-2$) measurements for the electron were in progress and explained by QED; Berestetskii and colleagues derived equation (1) and called for a measurement of a_μ as a far better test of the theory. But in 1956 parity was conserved and muons were unpolarised, so there was no way to do the experiment.

In 1957 parity was violated and the muons from $\pi \rightarrow \mu + \nu$ decay were found to be longitudinally polarised. In a footnote to their first paper on muon precession Garwin, Lederman and Weinrich [4] invoked the ($g-2$) formula (4) to deduce that $g = 2$ to within 10%. Attempts to store muons in a magnet for many turns were initiated in several laboratories.

In 1960 muons from the CERN cyclotron were focused onto a beryllium block inside a long bending magnet, fig.1, so that they lost energy and were trapped in the field [5, 6]. A transverse gradient (high field at the bottom of fig.1, lower field at the top) made the orbits walk to the right, 2 cm per turn near the beryllium falling to 0.4 cm per turn in the middle of the magnet. When the muon reached the end it encountered a much steeper gradient, stepped along at 11 cm per turn, emerged from the field and was stopped in a field free absorber. After an average of 2.2 μ s it decayed, $\mu^+ \rightarrow e^+ + \nu + \bar{\nu}_\mu$, and the positrons were emitted preferentially in the direction of the muon spin. They were detected by scintillators in front of and behind the absorber so that over many events the average direction of the muon spin could be recorded. Fig.2 shows the transverse spin angle vs time spent in the magnet; a fit to this data determined a_μ to 0.4%. At the time the result was a surprise, it confirmed QED up to a mass scale of 1 GeV (while the pundits including R.P. Feynman had been anticipating a discrepancy) and it gave no sign of a new field postulated to explain the muon mass. Now the muon was accepted as a heavy electron and

features

nothing more, and this was confirmed by experiments at high energy, muon pair production by photons and the trident process (muon pairs produced by high energy muons), which showed that the muon obeys Fermi-Dirac statistics.

In 1962 the CERN proton synchrotron (PS) was running and high energy muons were available. Could we use them for $(g-2)$, dilating the lifetime to get more precession cycles? How to inject into a large ring magnet, and how to follow the spin direction vs time? On this occasion Nature was miraculously on our side! It is easy to inject, just put a target in the ring and hit it with high energy protons. Pions are produced and start to turn around the ring. In a few turns they decay to muons; the change of momentum in the decay shrinks the orbit so some muons forever miss the proton target and are permanently stored. They come from forward decay and are highly polarised.

When the muon decays some energy is lost to neutrinos, so the decay electron is bent to a smaller radius, emerges on the inside of the ring and hits a counter. By selecting large pulses from the lead/scintillator sandwich one can select high energy electrons and these must come from forward decay in the muon rest frame. Selecting energy in the laboratory selects angle in the moving frame. Therefore, as the muon spin rotates, the number of detected electrons is modulated. One sees an exponential decay with the dilated muon lifetime (27 μ s for 1.2 GeV muons) with the $(g-2)$ precession superimposed. Read off the frequency and you can measure ω_a . Fig.3 the precession curve [7] obtained in 1968.

To ensure vertical focusing, essential for storing muons for many turns, the field of the ring magnet had a radial gradient of 54 ppm/mm. So to determine the mean field and calculate a_μ one needed to know the radius of the stored muons. Fortunately the muons were bunched at injection and at early times the counting rate was modulated by the orbit frequency, (fig.3, lowest curve). From the record, the muon radius could be calculated to ± 3 mm. This experiment initially disagreed with theory by (450 ± 270) ppm, stimulating a reexamination by theorists of some $(\alpha/\pi)^3$ -terms in the QED expansion, connected theoretically with the scattering of light by light which has never been observed. They found a surprisingly large coefficient of 18.6, which brought the theory into agreement with the data.

In 1969 the main obstacle to further improvement was the radial magnetic gradient needed for vertical focusing. It was considered impossible to know the radius of the muons to better than 1 mm. So in the third CERN experiment the magnet had a uniform magnetic field with vertical focusing provided by electric quadrupoles. Positive plates above and below the orbit repelled the μ^+ back towards the centre. One can show that the effect on the orbits is equivalent

to a weak focusing system with magnetic gradient and surprisingly about 20 kV is sufficient to focus 3 GeV muons.

It is the vertical component of the electric field that does the focusing, but inevitably it is associated with a horizontal electric field that varies with radius. In general a radial electric field affects the spin motion, so it is still necessary to know the muon radius. Nothing is gained – unless one operates at a carefully chosen energy! If however $\gamma = E/mc^2 = \sqrt{1+1/a} = 29.3$ a radial electric field does not change the $(g-2)$ frequency; then one can use a uniform magnetic field with vertical focusing provided by electric quadrupoles; and the $(g-2)$ frequency will be the same all over the aperture. One does not need to know where the muons are! This so-called “magic” energy is 3.096 GeV, easily accessible with current accelerators.

In fact a correction is required for muons which are not exactly centred in the aperture; their momentum is not exactly magic and there is some radial electric field. On average this correction (calculated from the radial distribution of muons obtained from the orbit frequency data) is about 0.5 ppm.

The third CERN experiment [8] used a 14 m diameter storage ring operating at the magic energy. To gain beam intensity and

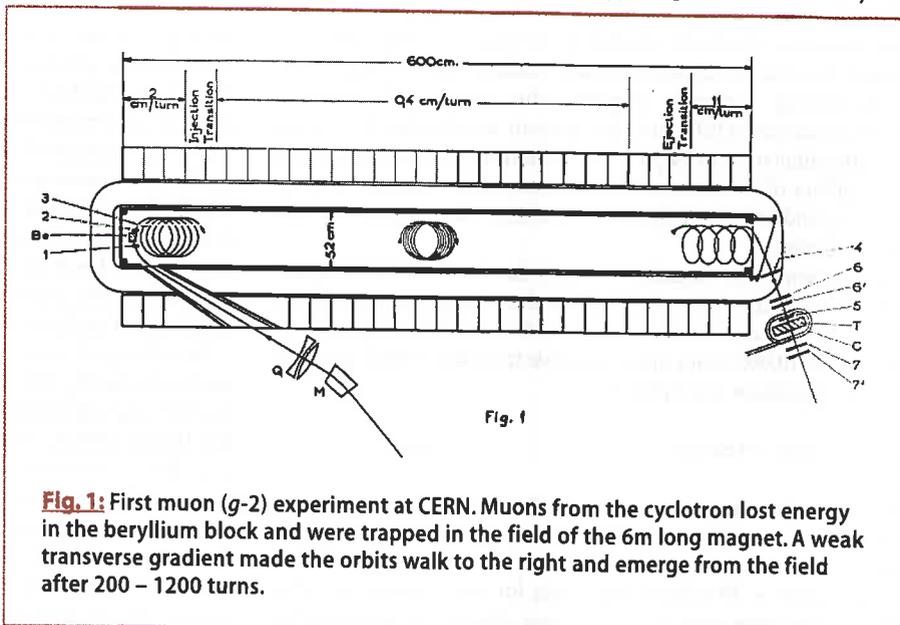


Fig. 1: First muon $(g-2)$ experiment at CERN. Muons from the cyclotron lost energy in the beryllium block and were trapped in the field of the 6m long magnet. A weak transverse gradient made the orbits walk to the right and emerge from the field after 200 – 1200 turns.

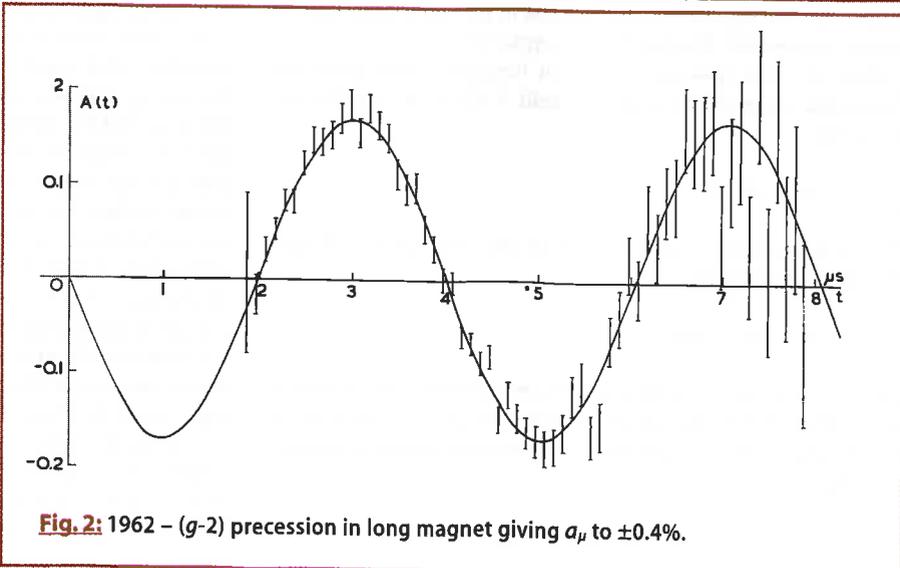


Fig. 2: 1962 – $(g-2)$ precession in long magnet giving a_μ to $\pm 0.4\%$.

reduce background, pions were injected (instead of protons). The magnetic field was stabilised at 40 points by feedback from NMR probes, and was very reproducible. The measurement to 7.3 ppm agreed with theory, and confirmed the existence of virtual hadrons in the quantum soup around the muon, calculated to contribute 58 ppm to the value of a_μ . Hadrons are not coupled directly to the muon, but a virtual photon in the soup can produce a virtual quark-antiquark pair. Once this happens the quarks interact strongly with each other, exchanging gluons and all the glory of the strong interaction comes into play, quark-antiquark convert to $\pi^+\pi^-$, ρ , ϕ , and ω resonances and all sorts of higher states. The equations which govern the strong interactions (quantum chromodynamics, QCD) are presumed known, but no one can solve them for the strongly coupled low energy states which contribute most to a_μ . How the effect is estimated is discussed below.

Also present in the soup are the intermediate bosons of the weak interaction, Z^0 and W^\pm , which couple directly to the muon and mediate its decay to $e^+\nu_\mu$. Their effect, calculated from the electroweak theory, is predicted to be 1.3 ppm in a_μ .

To see this effect was a primary objective of the new more accurate measurement of muon ($g-2$) initiated by Vernon Hughes of Yale in 1984. Improvements in the 33 GeV Brookhaven synchrotron (AGS) meant that many more muons could be available so the statistical error could be greatly reduced. He gradually assembled a large team of collaborators including, in addition to Brookhaven, groups from Boston University, Illinois, Minnesota, Germany, Japan and Russia and some of the old CERN team. It was decided to operate again at the magic energy with electric focusing, using a larger magnet aperture to give a more uniform field. Superconducting coils were used to excite an iron magnet with field 1.45 T and orbit diameter 14.22 m, fig. 4. Muons were collected from $\pi\text{-}\mu$ decay in a long focusing channel and separated from the undecayed particles by momentum selection. They were then injected into the storage ring and kicked onto the correct orbit with a pulsed magnetic field. Compared to pion injection this is more complex, but gives many more stored muons and a large reduction in background, essential for operation at the high beam intensities now available.

To measure the magnetic field a trolley, carrying NMR probes and a computer, was made to move round the ring inside the vacuum chamber and measure the field along the track of the muons at any moment. A single coaxial cable carried DC power to the electronics and a 62 MHz reference frequency and served to pull the trolley round the ring. It also carried output signals from the computer giving the results of the measurements.

During the muon storage runs the trolley was withdrawn into a special garage, (also under vacuum) and the field was monitored by 350 fixed NMR probes deployed above and below the vacuum chamber. The average field calculated from these fixed probes

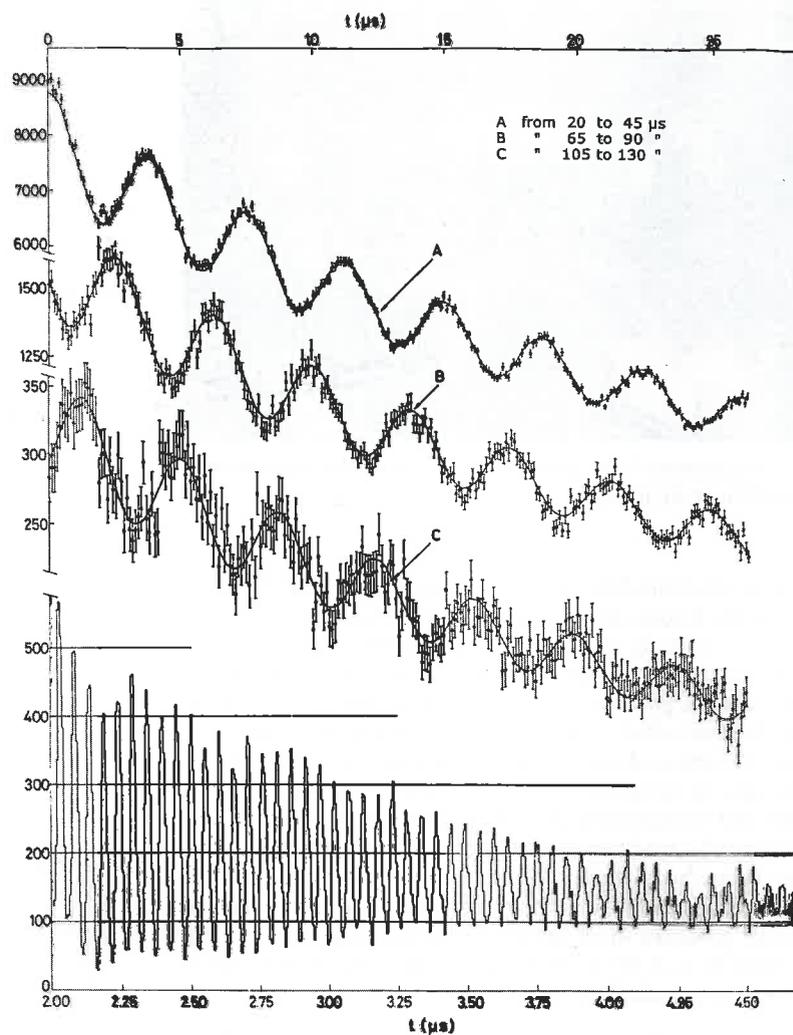


Fig. 3: 1969 – Relativistic muon decay in 5m storage ring showing 27 μs lifetime and ($g-2$) precession out to 130 μs (upper three curves with upper time scale); lower curve shows orbit frequency (lower time scale) from which orbit radius is calculated.

tracked with the average measured by the trolley to within ± 0.2 ppm.

A fit to the data taken in 1999, fig. 5, and published last February [1, 9] gave $a_\mu = 1,165,920.2 \times 10^{-9}$ with an error of 1.34 ppm. Combining with the previous measurements gives the best experimental value $a_\mu = 1,165,920.3 \times 10^{-9}$ with an error of 1.27 ppm compared to the theoretical prediction $a_\mu = 1,165,916.0 \times 10^{-9}$ with an error of 0.57 ppm [10]. The discrepancy of (3.7 ± 1.4) ppm warrants some discussion.

It could be a statistical fluke but that is unlikely. It could be a “harbinger for new physics” [10]. In particular the theory of Supersymmetry [11] (which has many adjustable parameters) predicts a new contribution to a_μ and can easily accommodate our value. In this theory every known boson is matched by a supersymmetric fermion, and vice versa, so many new particles would be there awaiting discovery as soon we can reach sufficient energy; and the theory gets rid of some mathematical infinities that plague the standard model.



Fig. 4: Brookhaven 14m diameter superferric storage ring with some of the $(g-2)$ group.

On the other hand the current standard model (renormalisable electroweak theory, plus quantum chromodynamics) may not have been correctly evaluated. No one doubts the main terms derived from QED and the weak interaction, but the calculation of the hadronic part of a_μ is complex and in some parts approximate. The main effect (one virtual hadron in the soup converting to a quark-antiquark pair) is related by dispersion theory to the probability of creating hadrons in electron-positron colliding beams, and this has been carefully measured in Novosibirsk and Beijing and discussed by many theorists. There is currently a consensus about this part of a_μ but new experimental data could still change the value. On the other hand there are more complex hadronic processes involving several virtual photons and these contribute to a_μ at the level of 1 ppm and in this area no one is quite sure of the calculation.

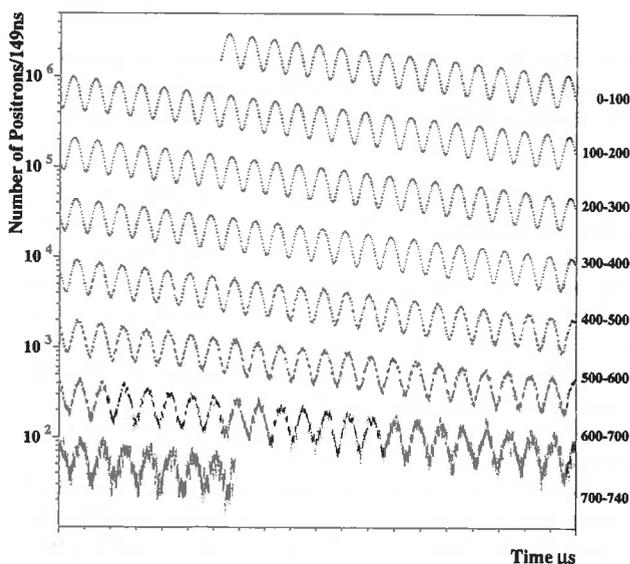


Fig. 5: 1999 muon $(g-2)$ precession measured out to 740 ms at Brookhaven with lifetime dilated to $64 \mu\text{s}$, giving a_μ to ± 1.3 ppm, 2.6σ above theory; it could be a "harbinger for new physics" [10].

So in summary the new muon $(g-2)$ result from Brookhaven cannot at present be explained by the established theory. A more accurate measurement, based on data taken in the years 2000 and 2001 should be available by the end of the year. Meanwhile theorists are looking for flaws in the argument and more measurements on the production of hadrons by e^+e^- colliding beams are underway. If all this fails, Supersymmetry can explain the data, but we would need other experiments to show that the postulated particles can exist in the real world, as well as in the evanescent quantum soup around the muon.

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PHYSICS LETTERS A

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Granular community goes to the desert

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The physics of granular media is an ancient science. It is present in practically all fields of applied physical sciences. At a fundamental level, models of hard spheres or disks have been used from the early times of classical Greece to nowadays investigations to characterize the microscopic states of organisation of matter. Conversely, in the last two decades, a large community of physicists has made use of what had been acquired in the microscopic physics world to try to enrich our understanding of the science of "real grains". In the eighties, as we were testing percolation ideas by mixing conducting and insulating otherwise identical grains in various concentrations [1], we realized then that the way the packings were built had a strong influence on the result of the experiments. Replacing a single conducting grain by an insulating one tells one in particular how many good electrical contacts this grain had, and this varies with filling conditions and packing pressure. The question led us to be acquainted with the British school which since Bernal [2] had studied arrangements of packings in connection with the structure of the liquid state. But probably the most spectacular finding for us was that of a photoelastic experiment by P. Dantu [3] on compressed arrays of parallel aligned photoelastic cylinders which clearly showed that the stresses propagated along continuous chains of cylinders leaving a lot of them practically free of stress due to arching (similar work had been done independently by Josselin de Jong in Holland). This result was not well recognized at this time partly because of a prevalent dogma in mechanics based on homogenization procedures which use phenomenological local constitutive laws to evaluate global properties of heterogeneous - generally periodic - structures. Clearly this can not apply in the granular case of a granular assembly; because of the very large distribution of local forces a global geometrical description is needed [4]. Percolation ideas have been applied to the problem taking into account the asymmetry between presence or absence of inter-grain forces when the grains are either pressed together or pulled apart, like a network of fuses or of diodes and unlike a mechanical spring lattice. Such models can account for the fact that the value of the exponent x of the force F - deformation D law, $F = D^x$, is much larger than that of an individual contact (given by Hertz law $f = d^{3/2}$) due to the increase of active mechanical contacts where forces increase. More recent results have been obtained to describe propagation laws of forces from a point force applied at the top surface of a packing of grains. They were stimulated by the observation that, in some cases, the load exerted at the bottom of a conical heap of grain has a minimum below the tip [5]. Another very active subject is how to obtain an optimal compact disordered system as well as its long time evolution (which is not far from aging in glasses) [6].

The rediscovery of the heaps, which had been first observed by Faraday when vibrating vertically a thin horizontal bed of grains, has initiated the modern research activity on grains in motion. Regular periodic patterns can be produced as well as soliton structures [7]. The main mechanism is the appearance of circula-

tion flows, where the grains are lifted upwards in the core of conical heaps during the downward plate motion, and of avalanches which descend along the surface of the cones. This convective motion grossly evokes that of the fluid within a Bénard cell, and dynamic structure concepts have been applied to this problem.

The dynamics of avalanches is of practical and environmental interest. The results obtained over the last 10 years are important and have contributed to the recent interest in sand dunes. We know from C. A. Coulomb's work, who was at the time of his finding a civil engineer working on fortifications, that there is a maximum angle of stability of a cone given by $\tan \theta_M = \mu$, where μ is a friction parameter depending on the nature of grains and of their interaction. When an avalanche starts, it will usually stop at a slightly smaller angle of repose θ_m ; the difference between these two values comes from the fact that, in order to flow, a dense packing of grains has to expand a little, a classical phenomenon in granular physics known as Reynold's dilatancy. The self-organized criticality concept promoted by Per Bak neglected this hysteretic effect: this permitted him to associate with the existence of the Coulomb critical angle a particular class of critical effects where fluctuations (here avalanches) of all sizes would maintain the cone angle at this fixed value when the size of the cone varies. In fact, between θ_M and θ_m local avalanches can be triggered artificially. Their structure is a well defined function of the angle and the layer thickness [8]. Several theoretical treatments have been proposed in the recent years [9] to describe the flow of sand in avalanches. They use a two-phase description with an upper thin layer flowing and exchanging matter with the lower fixed phase and are tested experimentally in many groups.

A new partner in the problem is wind which transports sand, shapes and causes the dunes to move. We consider one-directional



Fig. 1: Computer simulation of the evolution of a granular surface starting from an artificial random configuration at $t = 0$, $t = 180$ days and $t = 470$ days.

wind, such as provided by the NW-SE wind due to the trade winds in West Sahara, which gives rise to so called "Barchans" dunes that have crescent-like shape. However, in conditions of seasonal winds having two main possible directions at an angle, elongated – "longitudinal" – dunes will form along the bisector of this angle.

Depending on their size, the grains carried by the wind will roll along the surface (reptation), will be lifted in the air by hydrodynamic forces (saltation), or be suspended for the smallest ones. The saltation process is dominant for dune formation and will act within a limited range of grain sizes (typically between 100 μm and 300 μm), as larger grains will not have enough momentum to get them off the ground. The grains are accelerated by the wind along their trajectories; when they hit again the granular bed, they eject new grains due to the impact. This chain reaction increases the surface flux until it saturates because the air cannot carry more particles. The exponential increase in the flux and its subsequent saturation can be described by the logistic equation coupled to the shear stress of the wind on the ground. The latter one can be obtained by integrating over the logarithmic turbulent velocity profile of the wind; it depends, of course, on the topography which itself is modified by the surface flux thus closing the iterative scheme: topography \rightarrow wind field \rightarrow surface flux. Recently, software doing exactly this has been developed and applied mostly to Barchan fields [10]. In the figure, we see a computer simulation of the temporal evolution of a set of Gaussian hills into a Barchan field as it is typically observed in nature.

Among the most recent results obtained, we should mention the quantitative description of the shape of a Barchan dune and the understanding of its stability and shape invariance. Today, we have a clear criterion for the minimum size of such a dune and for the formation of its crest. But Barchans are only a very specific type of dunes and there is still much work to be done to understand the other ones, over one hundred observed dune morphologies! In the future, it should also be possible to study numerically techniques to destroy dunes in particular using appropriate obstacles.

Concerning the flow of air and grains which experience mid air collisions and the turbulent flow profile being modified by the grain dynamics, much work remains to be done on this subject, after the theoretical contributions of Sørensen [11] and Jenkins [12], both in field experiments and air tunnels. In particular, it seems of importance to get beyond the statistically averaged description of turbulence and to introduce fluctuations and eddies of different size.

Another important issue is water. Dunes are a potential reservoir of water at a certain depth where water does not evaporate. This is clear from the growth of very long rooted plants (up to 30 meters deep) on dunes. This is also a crucial parameter for keeping the dunes fixed. How we can keep and use the water stored in sand is another vital issue for millions of people.

Collaboration with those concerned mostly with the problems of moving dunes seems very important at this stage. Our studies on sand dunes have shown us the multiplicity of required competences: physicists, fluid mechanics, geomorphologists and geologists, naturalists, but also social scientists which deal with anthropic parameters, are the first partners in coping with the increasing risk of dune formation in a mushroom city like Nouakchott (Mauritania) whose population grew by a factor of nearly 1000 in less than half a century! We held there a one-week meeting last March with the support of the EPS and with a large participation of scientists and engineers of the country. Several important and urgent issues were addressed, one of which dealing with the "route de l'espoir" between Nouakchott and Bamako, the capital

of Mali. This east-west road being constantly covered by sand moving from north to south has become a test ground for dune-breaking and sand flux controlling techniques. But the new harbor of Nouakchott raises also vital problems for the city due to underwater uncontrolled sand transport induced by the large dike whose construction twenty years ago had not been correctly planned, leading to the sanding of the harbor and as well as creating a serious threat of submerging the city built below sea level

The Nouakchott meeting was part of an international program that we have initiated and has had the support of the EPS from its beginning, three years ago. It involves European physicists (mostly from France, Germany, Denmark) as well as from concerned countries (at the present time, Tunisia, Mauritania, Morocco and Algeria) and with the appreciated contribution of the U. S. A. (the support of NASA was justified by the dunes observed on Mars!). The progress from the first meeting two years ago in Tunisia to the recent one in Nouakchott is spectacular and shows much common interest in this typical "physics for development" project such as the EPS wishes it to develop. On the aspect of education and technical formation, we are establishing, in partnership with the Ministry of Education of Mauritania and, hopefully, other countries, original programs for doctorate studies which combine disciplines much broader than our classical curricula, with combined studies followed in Europe and Africa.

The research project is going to be pursued on a regional scale with a next meeting in Agadir (Morocco), planned in two years where we expect to maintain a participation of the EPS. Meanwhile we will strengthen the exchange in coupled experimental work, numerical and theoretical models and studies in the field, using it as an observation site as well as a large scale wind tunnel! This empirical activity must be accompanied by a deeper understanding of grain transport and of the coupling between changing winds and changing topography with the hope to better control the motion of dunes and, more generally, the progress of desertification.

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Imaging atom sites with near node photoelectron holography

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Recent photoelectron diffraction experiments at the synchrotron ELETTRA (Trieste) demonstrated a strong suppression of forward scattering in aluminium for Al 2s photoelectrons ($E_{kin} \approx 1$ keV) that are measured at an angle near the nodal plane of the outgoing p-wave [1]. This use of the selection rules for photoemission considerably improves the holographic reconstructions of real space from photoelectron diffraction data. These holographic reconstructions provide 3 dimensional images of atomic sites in unit cells with an extension of more than 10 Å.

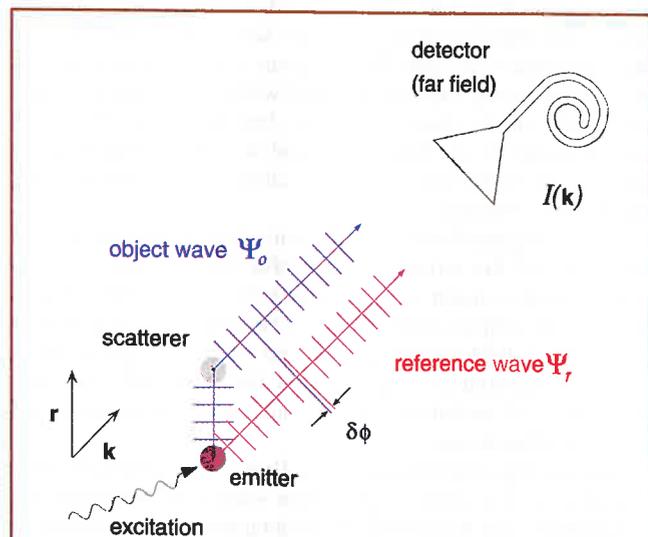
Structure determination on the atomic level is of key importance for the understanding of physical and chemical processes. At surfaces low-energy electron diffraction (LEED) with kinetic energies between 20 and 500 eV is the most successful technique for this purpose [2]. For real space structure determination LEED suffers, in spite of its obvious advantages, from three problems: It is not chemically sensitive, i.e. the individual atomic species cannot be identified directly, the electron scattering cross sections are large, and the phase information of the scattered wave is lost. In principle, photoelectron diffraction circumvents these problems. Core level photoemission is chemically sensitive, and in going to higher kinetic energies multiple scattering decreases roughly proportionally to the wavelength of the electrons. The phase problem, however, is common to all diffraction techniques, and most structure determination schemes are based on trial and error methods. If the phase of the scattered wave is known and the scattering can be treated in the kinematic approximation, i.e. without multiple scattering, the positions of the individual scatterers in real space may be recovered directly by Fourier transform.

Gabor's idea of holography is a way of recovering the phase information and gives, in principle, access to the full three dimensional structure [3]. Szöke extended holography to X-ray and electron diffraction experiments. His "inside source" concept (see Box 1) proposes that the X-rays or electrons which are created at atomic sites form a hologram in Gabor's sense [4]. After the emission process, the "coherent beam" splits into an unscattered reference wave Ψ_r and a scattered object wave Ψ_o that interfere in the detector. The measured intensity $I(\mathbf{k})$ can thus be written as:

$$I(\mathbf{k}) = |\Psi_r + \Psi_o|^2 = \Psi_r\Psi_r^* + \Psi_r\Psi_o^* + \Psi_o\Psi_r^* + \Psi_o\Psi_o^*, \quad (1)$$

where \mathbf{k} is the wave vector of the reference and the object waves. The intensities of a large set of \mathbf{k} vectors constitute a hologram and permit the reconstruction of an image $U(\mathbf{r})$ in real space. If \mathbf{r} is known and the object self interference term $\Psi_o\Psi_o^*$ is small, $U(\mathbf{r})$ is determined by the Fourier transform of $I(\mathbf{k})$, i.e. from the interference terms $\Psi_r\Psi_o^* + \Psi_o\Psi_r^*$. These interference terms contain an image and a twin image, and methods exist to distinguish the two [5]. For three dimensional images, the \mathbf{k} -space sample has to span three dimensions. This is achieved by scanning two emission angles and/or $|\mathbf{k}|$ (multiple energy sampling).

Inside source holography with X-rays [6] and its time reversed sister with γ -rays [7] have been demonstrated. These kinds of holography apply for heavy elements as scatterers and emitters and for a probed volume which is fairly large. Inside source holography with electrons is more sensitive, in particular to light elements, and applications with particular emitter geometries have been reported [8]. However, several problems are encountered: In the relevant electron kinetic energy range, the scattering cross section of electrons is of the order of 1 Å² and highly anisotropic. Therefore, multiple scattering is important and the scattering amplitudes and phase shifts are not isotropic. The dominant feature of this anisotropy is forward scattering, which is a consequence of the focusing by the attractive ion cores of an incoming electron wave along its \mathbf{k} -vector [9]. Forward scattering is a zero order diffraction feature that contains no holographic information, i.e. information on the path length differences



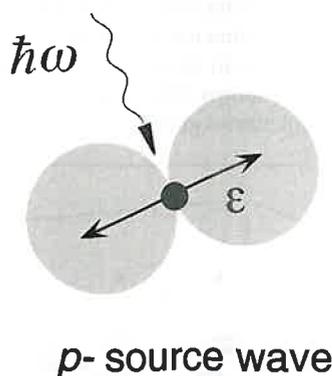
Box 1: Concept of inside source holography as proposed by Szöke [4]. The excitation of an atom triggers the propagation of a coherent wave centered at the site of the emitting atom. The wave may be a photoelectron, an Auger electron or a photon from a uorescent relaxation process. \mathbf{k} is the wave vector of the detected wave and \mathbf{r} is the position of the scatterer (object) relative to the emitter. The phaseshift $\delta\phi$ between Ψ_r and Ψ_o depends on $\mathbf{k}\mathbf{r}$ and contains the information on the object coordinates. The intensity $I(\mathbf{k})$ is the coherent superposition of the scattered object wave Ψ_o and the unscattered reference wave Ψ_r in the far field. A large set of $I(\mathbf{k})$'s which spans a three dimensional section in \mathbf{k} -space is a hologram in Gabor's sense. If the scattering is not too strong, $\pm\mathbf{r}$ is directly found by Fourier transform of $I(\mathbf{k})$.

between the scattered and the unscattered waves. The application of Fourier transforms to recover the real space structure from photoelectron or Auger electron diffraction data is thus not straightforward.

At a first glance, forward scattering seems to be an intrinsic feature of photoelectron diffraction, at least if the emitter does not lie in the top layer. There is, however a twist around this problem if the anisotropic nature of the photoelectron source wave (see Box 2) is exploited [10]. In a single scattering picture, the photoelectron diffraction intensity $I(\mathbf{k})$ (Equation 1) may be written as:

$$I(\mathbf{k}) = |\Psi_{source}(\vartheta=0, \mathbf{R}) + \sum_i \frac{f(\vartheta_i)}{|\mathbf{R} - \mathbf{r}_i|} \Psi_{source}(\vartheta_i, \mathbf{r}_i)|^2, \quad (2)$$

where the emitter (source) sits at the origin, \mathbf{R} is the position of the detector (in the direction of \mathbf{k}), and \mathbf{r}_i the location of the scatterer (object). $f(\vartheta_i)$ is the complex scattering amplitude, where ϑ_i is the angle between \mathbf{r}_i and \mathbf{R} . $\Psi_{source}(\vartheta=0, \mathbf{R})$ is the reference wave Ψ_r . It can be seen that the importance of forward scattering $\vartheta_i=0$ scales with the intensity of the reference wave. Therefore the Fraunhofer condition $|\Psi_r| \gg |\Psi_o|$ can generally not be optimized in electron holography since it would cause strong forward scattering. If the source wave is isotropic the relative weight of the forward scattering is constant. For anisotropic source waves, such as a p -wave that is created by the photo-excitation of an s -level, the relative importance of the reference wave and thus the weight of forward scattering can be tuned. If for example the electron emission direction lies on a node of the photoemission source wave, *no* forward scattering is expected. However, within the single scattering picture, such photoelectron diffraction patterns cannot be considered as holograms, since the reference wave is missing in this geometry. For 1 keV electrons it was shown by scattering calculations that there is an optimum angle of about 10° near the nodal plane of an outgoing p -wave, where the holographic reconstructions are best [10]. This angle is a compromise between the



Box 2: Photoemission from a core level of an atom provides a highly coherent electron source wave that is localized on the emitting atom. The incoming photon breaks the spherical symmetry of the atom and creates an anisotropic electron source wave. The dipole selection rules dictate a change in angular momentum $\hbar\Delta l$ between the initial state and the photoemission final state (source wave) of $\pm\hbar$. For the excitation of a s -core level ($l=0$) this results in the creation of a pure p -wave ($l=1$) with a node. The emission from other levels than s -levels generally produces no nodes. The picture shows a p -wave as generated by light that is linearly polarized along the electric field vector ϵ .

effect of the disturbing object self interference term $\Psi_o\Psi_o^*$ and that of the forward scattering. In Figure 1, the *far node* geometry is compared with the *near node* geometry. The Figure shows simulated photoelectron diffraction patterns and the corresponding holographic reconstructions for a single emitter and a single scatterer. In the near node geometry, the relative weight of the interference pattern is strongly enhanced compared to the forward scattering. The holographic reconstructions from the diffraction pattern in the far node geometry show “fingers” that correspond to the forward scattering cone in the photoelectron diffraction near field. On the other hand, the diffraction data in the near node geometry show “droplet”-features near the atomic site

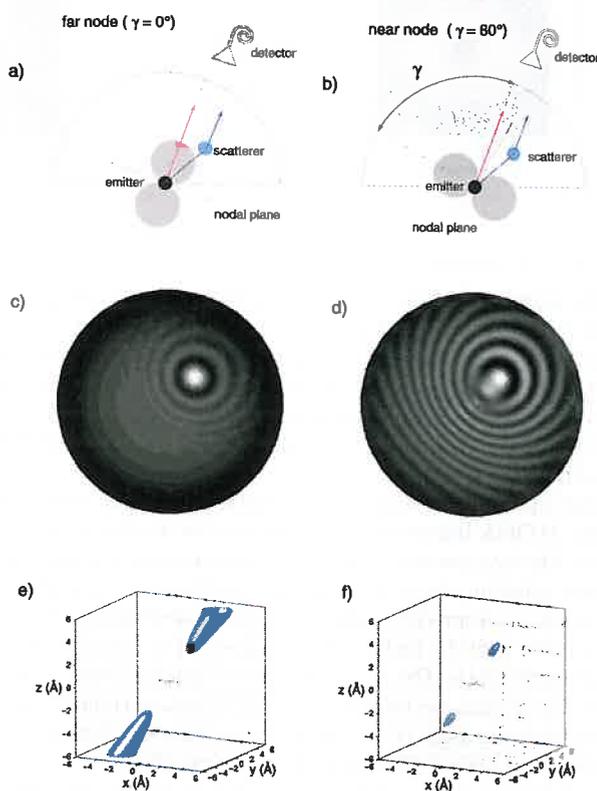


Fig. 1: Photoelectron holography for the far- and near node geometries. γ is the angle between the light polarization and the electron detector. Two configurations of a p -source wave are indicated in a) for the far node ($\gamma = 0^\circ$) and in b) for the near node geometry ($\gamma = 80^\circ$). The Al 2s emitter (inside source) ($\lambda = 0.4 \text{ \AA}$) is 2.86 \AA away from the Al scatterer. The diffraction patterns in c) and d) are simulated with single scattering calculations: They show the stereographically projected photoelectron diffraction intensity into the hemisphere above the surface with γ kept constant. In c) the forward scattering along the emitter scatterer axis (bright spot) clearly dominates. In d) the higher order diffraction fringes are strongly enhanced compared to the forward scattering. In e) and f) the corresponding holographic reconstructions $|\mathbf{r}\mathbf{U}(\mathbf{r})|^2$ are shown in three dimensional isointensity representation. While the reconstruction from far node diffraction shows “finger” like forward scattering cones, the near node reconstruction indicates the atomic site \mathbf{r} at and its twin at $-\mathbf{r}$.

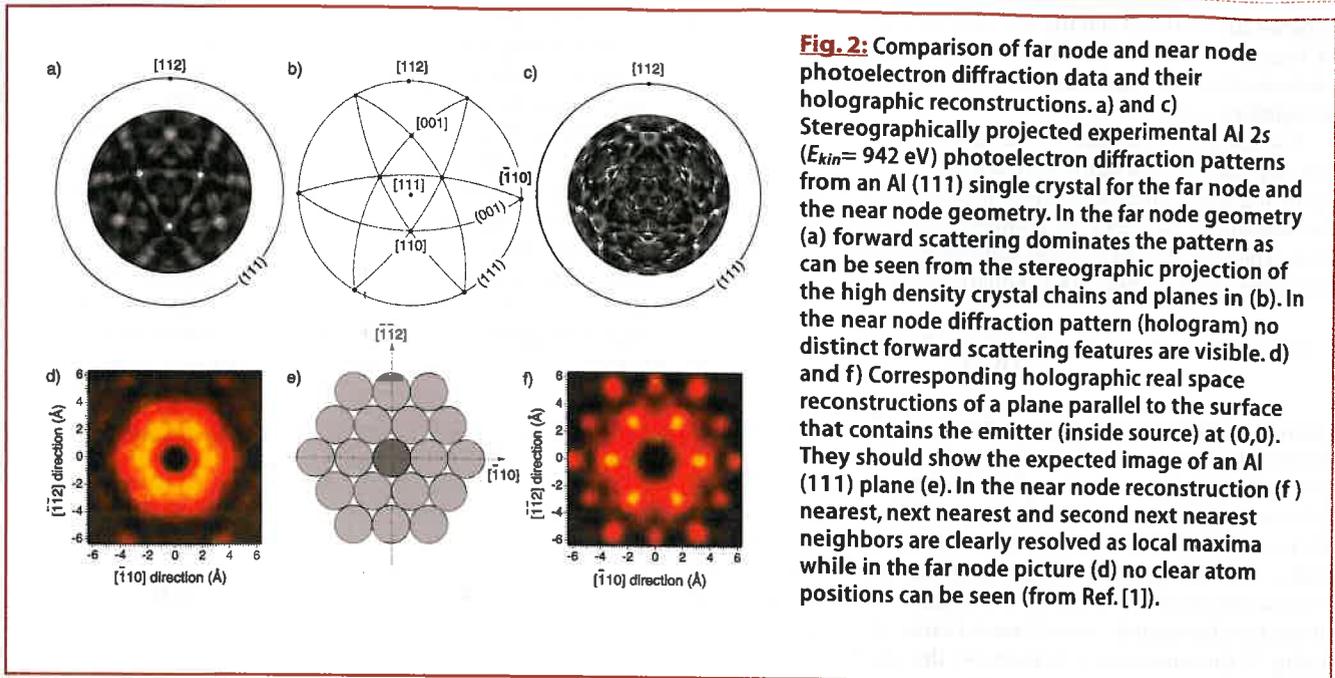


Fig. 2: Comparison of far node and near node photoelectron diffraction data and their holographic reconstructions. a) and c) Stereographically projected experimental Al 2s ($E_{kin}= 942$ eV) photoelectron diffraction patterns from an Al (111) single crystal for the far node and the near node geometry. In the far node geometry (a) forward scattering dominates the pattern as can be seen from the stereographic projection of the high density crystal chains and planes in (b). In the near node diffraction pattern (hologram) no distinct forward scattering features are visible. (d) and (f) Corresponding holographic real space reconstructions of a plane parallel to the surface that contains the emitter (inside source) at (0,0). They should show the expected image of an Al (111) plane (e). In the near node reconstruction (f) nearest, next nearest and second next nearest neighbors are clearly resolved as local maxima while in the far node picture (d) no clear atom positions can be seen (from Ref. [1]).

of the scatterer and its twin image. It has to be noted that near node photoelectron holography, requires a constant angle γ between the detector and the light polarization. Otherwise the near node condition is not fulfilled for all emission directions. Therefore, in this kind of experiment, the sample has to be rotated with respect to the reference frame of the light source and the detector.

The experiments on the Al(111) surface have been performed at the ALOISA beamline at the synchrotron facility ELETTRA [1,11]. The face centered cubic (*fcc*) structure of aluminium with a nearest neighbor distance of 2.86 Å, is well known. Furthermore, the inversion symmetry of the *fcc* structure causes the twin image to coincide with the image. The experiments were performed at room temperature. The Al 2s diffraction data sets contain about 1600 data points evenly spaced in $2\pi/3$ from normal emission down to a polar angle of 70° and are recorded with a high angular resolution of $\Delta\Omega \approx 1^\circ$. With the photon energy of 1070 eV and the 118 eV binding energy of the Al 2s core level, the electron wavelength becomes 0.4 Å. Two orientations of the linear light polarization were used. In the *near node* geometry the angle γ between the detector and the polarization was set to 80° and in the *far node* geometry to 0° . The far node geometry data serve for comparison and an absolute determination of the crystal orientation. In order to remove the polar angle dependence of the instrumental response function, the azimuthal data sets (Fig. 2a and c) are normalized for every polar emission angle.

Figure 2 demonstrates near node photoelectron diffraction (and holography) with experimental data [1]. The angle-dependent Al 2s photoemission intensities for the far node and the near node geometry are stereographically projected in Figures 2a) and c). White corresponds to highest and black to lowest intensity. From comparison with Figure 2b) which shows the corresponding real space projection of an *fcc* crystal onto the (111) plane, it is seen that the far node diffraction pattern can be regarded as a projection of nuclear charge along the nearest neighbour directions. The forward scattering focuses intensity along nearest neighbor directions and thus causes high intensity along low index atomic chains and planes [9]. This correspondence is not seen in the near node diffraction pattern (Figure 2c) and thus indicates suppres-

sion of forward scattering. In order to get real space images of the emitter's environment, the diffraction patterns are holographically interpreted [12]. The image function $|r U(x)|^2$ is shown after a convolution with a Gaussian with 1 Å full width at half maximum, without any low intensity cut-off. In the near node geometry, the holographic reconstruction of real space around the emitter in the (111) plane clearly reveals the positions of the surrounding atoms. In Figure 2f) nearest, next nearest and even second next nearest neighbor positions are resolved as local maxima in the image. This is not the case for the far node geometry data, where instead of distinct atomic positions a "nearest neighbor belt" is found. As usual with inside source holography, the emitter sits at the origin of the image and is not reproduced since.

In Figure 3, a three dimensional image of the holographic reconstruction of the data in Figure 2c) is displayed. The convoluted image function is shown within a sphere around the emitter with 8 Å diameter. Intensities greater than 83% of the maximum

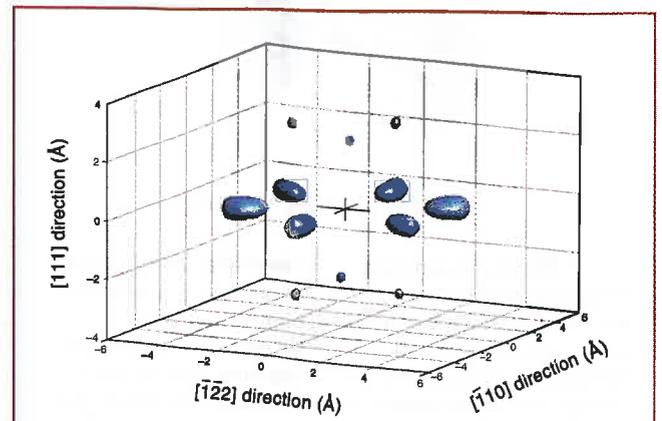


Fig. 3: Three dimensional isointensity representation of the holographic image as reconstructed from the photoelectron diffraction data in Figure 2c). The atomic environment of an Al 2s photoemitter at (0,0,0) in Al (111) is shown inside a shell with 4 Å radius (from Ref. [1]).

intensity are displayed opaque. The image quality in the [111] direction, normal to the surface, is not as good as in the (111) plane. This can be partly understood by considering that the emitters in the top layers see truncated neighbor shells and that the thermal smearing is more pronounced normal to the surface. Furthermore, the $k_{[111]}$ sampling is more limited in our experimental setup. However, from the data in Figure 2c) the three dimensional structure of the twelve nearest neighbors around the emitter is recovered. In Figure 3, the expected ABC stacking of subsequent (111) planes in the *fcc* structure is correctly reproduced. The holographic image is, however, not very precise with respect to the absolute length. This is caused by the atomic scattering phase shifts that imply larger and anisotropic "effective" scattering paths. All nearest neighbor distances in Figure 3 are overestimated by about one wavelength, but in a fairly isotropic way. The twelve emitter-nearest neighbor distances scatter by 0.1 Å around the mean value of 3.4 Å (instead of the 2.86 Å expected from the *fcc* structure of aluminium).

These findings demonstrate that the atomic structure of molecular objects with a size of the order of 10 Å can be explored with near node photoelectron holography. The chemical sensitivity of core level photoemission and the exploitation of the anisotropy of its source wave present an opportunity for structure determination in large unit cells with complicated molecular structures.

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Symmetry-induced vortex patterns

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For about 15 years, that is since the discovery of high temperature superconductivity in the cuprates perovskites by Mueller and Bednorz, many breakthroughs have been reported, the last one being the observation of superconductivity in MgB2 around 40 K. Perhaps less publicized are the spectacular progress made during this period in the fabrication of superconducting nanostructures and their regular arrays to understand new quantum effects. With respect to the phenomenology of superconductors described by the Ginzburg-Landau theory, a particular interesting question to address is the influence of sample size and geometry on the confinement of superconducting vortices. It is like the well known quantum mechanical problem of a particle in a box: different boxes having different quantum levels [1].

The fabrication of such nanostructures (including different regular pinning arrays) with sizes ranging from $1\mu\text{m}$ to $10\mu\text{m}$ can be made by photolithography and electron beam lithography, and down to 0.1 nm by single atom manipulation. This progress has strongly stimulated the experimental and theoretical studies of nanostructured systems, including superconductors. This is one of the main research topics in the framework of the ongoing European Science Foundation Programme "Vortex Matter in Superconductors at Extreme Scales and Conditions" -VORTEX [2]. In contrast to the conventional approach, which relied upon the search for new bulk materials each time a new specific combination of physical properties was required, the modern trend in condensed matter physics is to modify the properties of the same material through its nanostructuring and the optimization of the confinement potential and topology (concept of "quantum design").

One of the main objectives of the ESF Programme VORTEX is to investigate the role of the vortex confinement in the evolution of the properties of the vortex matter at extreme length scales and conditions. The main envisaged achievement of the program will be the (hopefully positive) answer to the following fundamental question: can the quantum design of the vortex confinement in superconductors result in the optimization of their critical currents and fields? By optimizing the vortex confinement, we shall be able to increase these two fundamental parameters of any given superconductor up to their theoretical limits, which is of course very important for applications.

Three main classes of nanoengineered superconducting materials are interesting to investigate in that respect: (i) individual nanoplaquettes of different geometry, (ii) clusters of them and (iii) large arrays. For individual nanoplaquettes a very straightforward fundamental question arises: to what extent are the properties of the confined vortices affected by the imposed discrete symmetry of the sample? This important question has been recently addressed by the two teams at the Katholieke Universiteit Leuven (Laboratories of Solid State Physics and Magnetism, and Quantum Chemistry) [3,4]. In disks and cylinders, for example, a big single whirl in the center ("giant vortex state") is compatible with the symmetry of the boundary conditions. In superconducting equilateral triangles, squares, etc, however, a very different situation arises. For example, it is quite easy to keep the imposed symmetry trying to put three vortices into a triangle or four into a

square. But what about "less lucky" numbers, like two vortices in a triangle or three vortices in a square (see the Figure)? The latter is like "...pushing a triangular peg into a square hole" [5]. Seemingly the only possible solution of this puzzle is to "merge" single quantum vortices into a single "giant" vortex and to place it in the center. In the language of numbers it is like presenting the number of applied flux quanta through the sample $2 = 2+0$ instead of $2 = 1+1$ for two vortices in triangle or, similarly, $3 = 3+0$ instead of $3 = 1+1+1$ for three vortices in a square. But such a "merger" costs too much energy in triangles and squares, although is possible in a disc or a cylinder. If the formation of the giant vortex state is excluded, then it looks like there is no solution of the puzzle. Remarkably, spontaneous formation of the vortex - antivortex pair saves the whole scheme. Indeed, using the same symbolic language of numbers, we can claim that not only $2 = 2+0$ but also $2 = 3-1$, meaning three vortices in three corners of a triangle and one

Schematic presentation of the vortex patterns in mesoscopic superconducting triangles and squares for the applied magnetic field generating two flux quanta through a triangle (top panel) or three flux quanta through a square (bottom panel). The spontaneous generation of the vortex-antivortex pair keeps the applied vorticity ($1-1 = 0$) and at the same time solves the puzzle how to find the symmetry-consistent vortex configurations, corresponding to $2 = 3-1$ (triangle) and $3 = 4-1$ (square).

antivortex in the center (fully symmetry consistent!) or, for a square, instead of $3 = 3+0$, we can use $3 = 4-1$, thus making it possible to put comfortably four vortices into four corners and one antivortex into the center. It looks like a "discovery" of negative numbers (antivortices, in our case) provides the necessary means for the vortex system to comply with the imposed boundary conditions. Note, that these symmetry-induced antivortices are qualitatively different from the ones related to the Kosterlitz-Thouless transition in two-dimensional superconductors.

The first experimental evidence supporting the existence of the symmetry induced antivortices in mesoscopic superconducting triangles and squares has been found in measurements of the phase boundary defined by the field dependence of the superconducting critical temperature $T_c(H)$. These measurements revealed a very good agreement between the boundary calculated from the linearised Ginzburg-Landau equation (LGLE) taking into account the formation of antivortices, and the experimental $T_c(H)$ line [3,4]. More experimental work is under the way to use the vortex imaging techniques, such as scanning SQUID, Lorentz or Hall microscopes, to visualize directly the symmetry-induced vortex patterns. Theoretically, the effects of the non-linear terms in the GLE should be also considered in order to find out which vortex configurations survive when one moves deeper into the superconducting state.

These new ideas about the spontaneous formation of the vortex-antivortex pairs are applicable to other types of the symmetrically confined vortex matter, like superfluid helium rotated in a triangular or square vessel, or Bose-Einstein condensate confined in a trap with a well defined discrete symmetry and certain vorticity imposed by the rotated laser beam. Future experimental and theoretical efforts in this area will lead to a better understanding of the fundamental physics behind puzzling questions about interplay between the discrete symmetry of the sample and the vortex patterns consistent with it.

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Radiation pressure induced EPR paradox

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The debate between Einstein and Bohr about the interpretation of Quantum Mechanics, initiated at the end of the twenties and formalized in the Einstein, Podolski and Rosen paper of 1935 [1], left both contenders with his own opinion. As is well known, Einstein and coworkers showed that, in a system formed by two spatially separated but physically correlated particles A and B, the possibility of determining indirectly (at the experimenter's choice) the value of one or the other of two canonically conjugate variables (e.g. x and p) of B by measuring the corresponding variable of A implied one of these two alternatives: (a) the two incompatible (according to QM) variables of each particle, contrary to the fundamental uncertainty established by the Heisenberg principle, possess simultaneously well defined, even if unknowable, values; (b) the result of the measurement performed on A is instantaneously transmitted to B whose corresponding variable, uncertain until that moment, acquires the value required by the correlation's constraint. Einstein rejected (b) and deduced from (a) that QM was an incomplete theory, while Bohr eliminated the problem by denying the possibility of speaking of the values of the variables of B not directly measured. Since no means seemed to exist to decide who was right, because the issue was a counterfactual statement, the question remained open for almost thirty years.

It was John Bell [2] who, in 1964, found a way to test whether Einstein was right or wrong. Instead of discussing about the unknowable values of unmeasured quantities he suggested to compare the values of measured quantities. Bell showed in fact that, when the variables of the two particles are only partially correlated, their experimentally measurable correlation coefficient is different if the incompatible variables of each particle actually do

possess well defined simultaneous values, as Einstein believed, or not. In the former case a set of inequalities were satisfied; in the latter, violated. The first reliable evidence that the correlation coefficient between the polarizations of two photons is indeed inconsistent with Einstein's choice was performed by Aspect, Granger and Roger in 1981.

This introduction, which will sound trivial to the readers who have already read these things many times, is useful not only in order to explain to newcomers the essence of this still open fundamental issue but also to provide the context in which the paper *Radiation Pressure Induced Einstein-Podolski-Rosen Paradox* by V. Giovannetti, S. Mancini and P. Tombesi (GMT) recently published in EPL [3] should be placed. The line of research to which the paper discussed here belongs, in fact, is not the same as Bell's. Its purpose is not to test once again whether Einstein was right or wrong. It is rather to deepen our knowledge of the various aspects of the fundamental, but counterintuitive, quantum property called *entanglement*, which is an essential ingredient of the EPR paradox.

Very briefly I recall its definition. Suppose that ψ_A^r ($r=1,2,\dots$) is the wave function of A in a state labelled by the eigenvalue r of a variable σ_A and ψ_B^r is the wave function of B in the corresponding state r of the correlated variable σ_B . Then the wave function Ψ for the total system, describing a state in which *either* A and B are both in state r or A and B are both in an other state s , is given by:

$$\Psi = c_r \psi_A^r \psi_B^r + c_s \psi_A^s \psi_B^s \quad (1)$$

This quantum state does *not* describe a statistical ensemble of N pairs AB in which $N_r = N|c_r|^2$ pairs are in state r and $N_s = N|c_s|^2$

pairs are in state s as Einstein maintained. It describes an ensemble in which each pair has probabilities $P_r=|c_r|^2$ and $P_s=|c_s|^2$ ($P_r+P_s=1$) for the two alternatives. The difference between these two ensembles arises when one considers the measurement of variables τ_A and τ_B which are incompatible with σ_A and σ_B respectively. The expression for the mean value of $\tau_A\tau_B$ contains in fact non vanishing interference terms of the form

$$(\psi_A^r \tau_A \psi_A^s)(\psi_B^r \tau_B \psi_B^s) + \text{compl. conj.} \quad (2)$$

The presence of these terms is at the origin of all the strange properties of two (or more) components systems [4, 5, 6] usually attributed to what is called the *spooky action-at-a-distance* of QM.

The proposal of GMT follows the avenue suggested by Reid and Drummond [7]. These authors consider two distinct light modes A and B in a cavity spatially separated but strongly correlated by a nondegenerate optical parametric oscillator. Each mode is characterized by two conjugate quadratures whose phase differs by $\pi/2$. These quadratures $X_A(0)$, $X_A(\pi/2)$ and $X_B(0)$, $X_B(\pi/2)$ play the role of the conjugate variables x and p of the two particles A and B of EPR. Since each mode of A is correlated with the corresponding mode of B one can infer the values of $X_A(0)$, $X_A(\pi/2)$ by measuring $X_B(0)$ or $X_B(\pi/2)$. The errors of these inferences can be quantified by the variances $\Delta_{\text{inf}}^2 X_A(0)$ and $\Delta_{\text{inf}}^2 X_A(\pi/2)$ between the "true" values and the "inferred" values of $X_A(0)$, $X_A(\pi/2)$. The EPR paradox arises if the correlation is high enough that one can reduce the values of the variances to an extent that

$$\Delta_{\text{inf}}^2 X_A(0) \Delta_{\text{inf}}^2 X_A(\pi/2) < 1 \quad (3)$$

because, according to quantum mechanics, the two conjugate variables must satisfy the Heisenberg principle

$$\Delta X_A(0) \Delta X_A(\pi/2) > 1 \quad (4)$$

Of course QM predicts that, as a result of entanglement, both inequalities should be satisfied. They are not contradictory. The variances appearing in inequality (2) in fact refer to values of $X_A(0)$, $X_A(\pi/2)$ inferred by *different* measurements ($X_B(0)$ or $X_B(\pi/2)$) performed on B. The prediction (3) has been experimentally realized [8].

The interest of the GMT paper arises from the fact, up to now, the production of entangled states has been generally considered as the result of quantum dynamics at the microscopic level. These authors, instead, suggest that "entanglement can be obtained via a classical force acting on a macroscopic object." To this purpose, they "consider the radiation field having a macroscopic number of photons and impinging on a completely reflecting and oscillating mirror in an optical cavity". By studying the properties of the output field they demonstrate that the state of the radiation field can become non-classical, giving rise to the appearance of the EPR paradox on its continuous variables.

In the proposed experiment, in fact, the two input modes in the cavity interact by means of the radiation pressure force by which each of them acts on the mirror. The entanglement of the two output field quadratures arises from the reaction of the mirror displacement quantum fluctuations. The Hamiltonian assumed to describe the system allows the calculation of the left hand side of (2) as a function of the input power and the temperature. Its value turns out to be about 0.7 for values of these parameters within the possibilities of the available technology.

In conclusion, the proposed scheme achieves the goal of obtaining the entanglement of radiation fields with a macroscopic number of photons, by means of a classical ponderomotive force on a macroscopic object. This work offers therefore new prospects for the investigation of the tricky borderline between the quantum and the classical world.

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Resolving the solar neutrino problem:

Evidence for massive neutrinos in the Sudbury Neutrino Observatory

Karsten M. Heeger
for the SNO collaboration

The solar neutrino problem

For more than 30 years, experiments have detected neutrinos produced in the thermonuclear fusion reactions which power the Sun. These reactions fuse protons into helium and release neutrinos with an energy of up to 15 MeV. Data from these solar neutrino experiments were found to be incompatible with the predictions of solar models. More precisely, the flux of neutrinos detected on Earth was less than expected, and the relative intensities of the sources of neutrinos in the sun was incompatible with those predicted by solar models. By the mid-1990's the data were beginning to suggest that one could not even in principle adjust solar models sufficiently to account for the effects. Novel properties of neutrinos seemed to be called for. With the recent measurements of the Sudbury Neutrino Observatory (SNO), it has finally become possible to test the solar model predictions and the particle properties of neutrinos independently.

Solar models that simulate the interior of the Sun and explain stellar evolution have been developed using experimental and theoretical inputs from nuclear physics, astrophysics, and particle physics. These models are based on the assumption of light element fusion in the Sun. As more and more astrophysical data have become available, solar models were tested through a variety of observables and found to be successful in many respects.

A variety of hypotheses that require new particle physics have been postulated to explain the discrepancy between the solar model expectations and the apparent deficit of solar neutrinos detected on Earth. In the Standard Model, neutrinos belong to the family of leptons. Neutrinos were believed to be massless particles with three distinct flavors (electron, muon, and tau) depending on the weak interaction process that created them. One flavor could not transform into another.

All three types of neutrinos have been directly detected experimentally, the tau neutrino only in the last year. In the light element fusion processes in the Sun, only electron type neutrinos are created.

As early as 1969, Bruno Pontecorvo proposed that neutrinos might oscillate between the electron and muon flavor states (the only ones known then). Like the $K^0-\bar{K}^0$ mixing phenomenon, neutrino oscillations are a quantum effect. Oscillations can occur if the physical neutrinos are actually particles with different masses but not unique flavors. Neutrino mass and flavor mixing

are not features of the Standard Model of particle physics. In quantum mechanics, an initially pure flavor (e.g. electron) can change as neutrinos propagate because the mass components that made up that pure flavor get out of phase. The probability for neutrino oscillations to occur may even be enhanced in the Sun in an energy-dependent and resonant manner as neutrinos emerge from the dense core of the Sun. This effect of matter-enhanced neutrino oscillations was suggested by Mikheyev, Smirnov, and Wolfenstein (MSW) and is one of the most promising explanations of the solar neutrino problem.

The measurements at the Sudbury Neutrino Observatory (SNO) show that the neutrino flux produced in the ${}^8\text{B}\rightarrow 2({}^4\text{He}) + e^+ + \nu_e$ beta decay reaction in the Sun contains a significant non-electron type component when measured on Earth [1]. This measurement is the first strong indication for the oscillation of solar neutrinos! This in itself is evidence that neutrinos have mass. Together with the oscillation signature in atmospheric neutrino studies, these results are strong evidence for physics beyond the Standard Model. It is also interesting that most theories that attempt to unify the description of all forces between elementary particles already permit non-zero neutrino masses. As for the cosmological implications, the measurements of SNO, combined with the results from other experiments, set an upper limit on the total mass of electron, muon, and taus neutrinos in the Universe.

The Sudbury Neutrino Observatory

Located 2 km underground in an active nickel mine in Sudbury, Ontario, the Sudbury Neutrino Observatory is an imaging water Cherenkov detector specifically designed to study the properties

of solar neutrinos. It consists of a spherical acrylic tank filled with 1000 tonnes of heavy water and surrounded by 7000 tonnes of light water to shield it from backgrounds (Figure 1). The choice of D_2O as a target material makes the SNO detector unique in comparison with other solar neutrino detectors. It allows SNO to measure both the total flux of solar neutrinos as well as the electron-type component of the neutrino flux produced in the Sun. Almost 10,000 photomultiplier tubes (PMT) are used to record flashes of Cherenkov light from the heavy water.

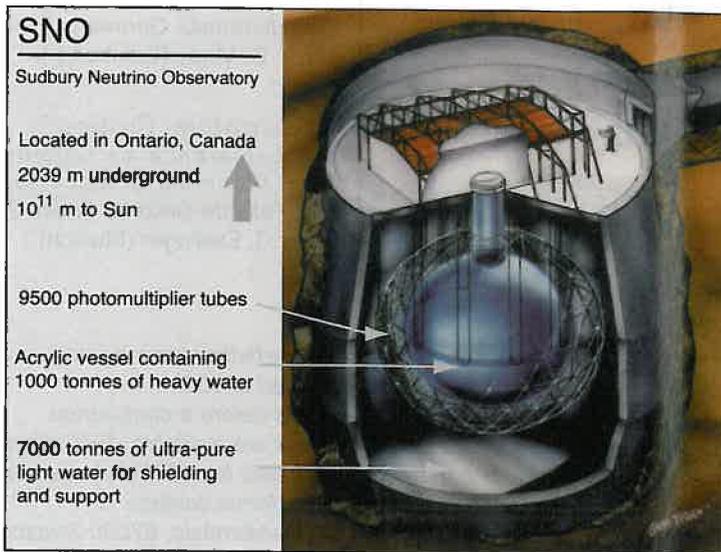


Fig. 1: Artist's conception of the Sudbury Neutrino Observatory. Shown are the acrylic vessel, the photomultiplier support structure, the water-filled cavity, and the deck of the detector where the electronic resides.

Solar neutrinos from the decay of ${}^8\text{B}$ are detected via the charged-current reaction on deuterium ($\nu_e + d \rightarrow p + p + e^-$) and by elastic scattering off electrons ($\nu_x + e^- \rightarrow \nu_x + e^-$). The charged-current reaction is sensitive exclusively to ν_e while the elastic-scattering reaction also has a small sensitivity to ν_μ and ν_τ . Neutrinos also interact through the neutral-current reaction ($\nu_x + d \rightarrow p + n + \nu_x$) which dissociates the deuterium and liberates a neutron that quickly thermalizes in the heavy water. Both the charged-current and elastic scattering interaction rates have been measured at SNO. The determination of the neutral-current interaction rate is under way and results will be reported in the near future.

Measurement of charged-current interactions of ${}^8\text{B}$ neutrinos

The data reported by the SNO collaboration was taken between November 1, 1999 and January 15, 2001 and corresponds to a live time of 241 days. Events are defined by a multiplicity trigger counting the number of hit PMTs above channel threshold. For every event trigger, the time and charge response of each participating PMT are recorded. Electronic pulsers and pulsed light sources are used for the calibration of the PMT timing and charge response. Optical calibration of the detector response is obtained using a diffuse source of pulsed laser light. The absolute energy scale and uncertainties are established with a triggered ${}^{16}\text{N}$ source (predominantly 6.13-MeV γ) deployed in the D_2O and H_2O . The detector response is tested using neutrons from ${}^{252}\text{Cf}$, the electron spectrum from ${}^8\text{Li}$, and a 19.8 MeV γ calibration source.

Instrumental backgrounds are eliminated from the raw data based on the timing and charge of hit PMTs in comparison with Cherenkov light. In addition, a set of high level cuts is applied to test the hypothesis that each neutrino event has the characteristics of single electron Cherenkov light.

For each neutrino event, an effective kinetic energy is calculated using prompt, unscattered Cherenkov photons, and the position and direction of the event. As an independent verification of the energy scale, the total number of triggered PMTs (which corresponds to the total light generated by the Cherenkov electron) is used to calculate the energy of every event.

Possible backgrounds from radioactivity in the D_2O and H_2O are measured by regular low level radio-assays of uranium and thorium decay chain products in these regions. Low-energy radioactivity backgrounds are removed by the high 6.75 MeV threshold, as are most neutron capture events. High energy gamma rays from the cavity are also attenuated by the H_2O shield. A fiducial volume cut is applied at $R=550$ cm (from the center of the detector) to reduce backgrounds from regions exterior to the heavy water volume and to minimize systematic uncertainties associated with optics and reconstruction of events near the acrylic vessel.

Results from SNO

The final data set contains 1169 neutrino events after the fiducial volume and energy threshold cuts. Figure 3a displays the solar angle distribution in $\cos\theta_{\odot}$, that is the angle between the reconstructed direction of the event and instantaneous direction from the Sun to the Earth. The forward peak in this distribution arises from the kinematics of the elastic scattering reaction and points away from the Sun.

Neutrino Reactions on Deuterium

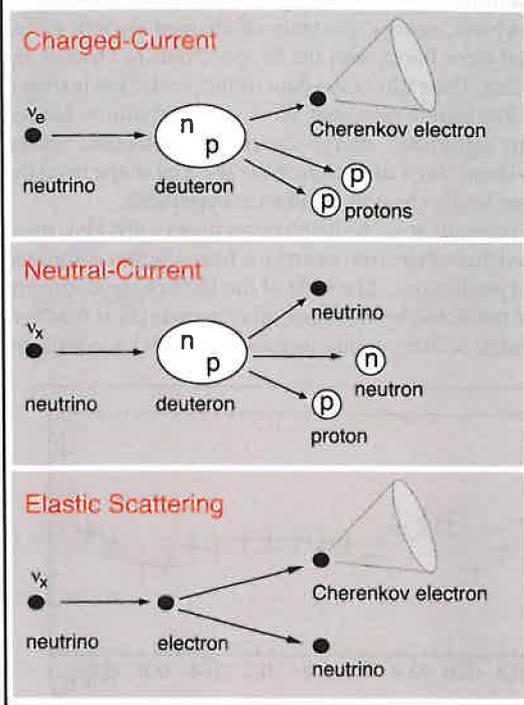


Fig. 2: Neutrino interactions with deuterium in the SNO detector: Both the elastic scattering and neutral-current reaction are sensitive to all neutrino flavors while the charged-current reaction is sensitive exclusively to ν_e . Solar neutrinos interacting via the the charged-current or elastic scattering reaction are detected by the light emitted from Cherenkov electrons.



Picture 1 and 2

Construction of the Sudbury Neutrino Observatory in 1997: The photomultiplier support structure and installation of the photomultiplier tubes is half complete.

features

The data are then resolved into contributions from charged-current interactions, elastic scattering, and neutron events. Figure 3b shows the kinetic energy spectrum of charged-current events (with statistical error bars), with the ^8B spectrum (of Ortiz *et al.*) scaled to the data. The ratio of the data to the prediction is shown in Figure 3c. The bands represent the 1σ uncertainties derived from the most significant energy-dependent systematic errors. There is no evidence for a deviation of the spectral shape from the predicted shape under the non-oscillation hypothesis.

As have all previous solar neutrino experiments, SNO has measured a reduced flux of electron neutrinos from the Sun compared to solar model predictions. The ratio of the SNO charged-current ^8B flux to that predicted by standard solar models [2] is 0.347 ± 0.029 . The elastic scattering flux measured by SNO is consistent

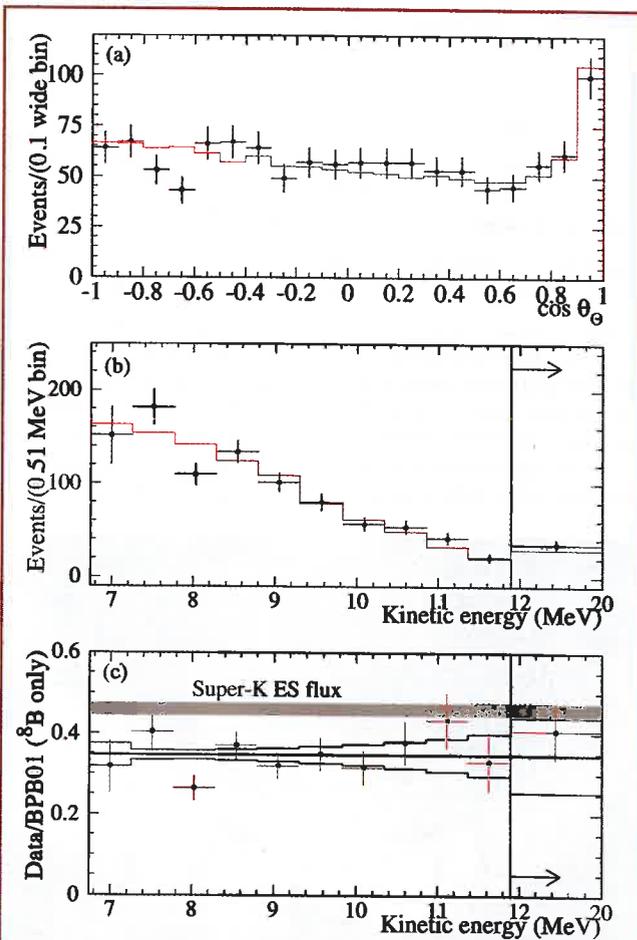


Fig. 3a: displays the solar angle distribution in $\cos\theta_0$, that is the angle between the reconstructed direction of the event and instantaneous direction from the Sun to the Earth. The forward peak in this distribution arises from the kinematics of neutrino elastic scattering off electrons and points away from the position of the Sun. Cherenkov electrons from the charged-current reaction on deuterium have a distribution which is $(1-0.340 \cos\theta_0)$ before detector response. **Fig. 3b:** shows the kinetic energy spectrum of charged-current events (with statistical error bars), with the ^8B spectrum (of Ortiz *et al.*) scaled to the data. The ratio of the data to the prediction is shown in **Fig. 3c**. The bands represent the 1σ uncertainties derived from the most significant energy-dependent systematic errors. There is no evidence for any spectral distortion.

with the high-precision measurement performed at Super-Kamiokande [3], a light water Cherenkov detector located in Kamioka, Japan. It is particularly interesting to compare SNO's charged-current flux to the elastic-scattering measurement at Super-Kamiokande. The charged-current reaction on deuterium is sensitive exclusively to ν_e 's while the elastic scattering off electrons also has a small sensitivity to ν_μ 's and ν_τ 's. The difference between the charged-current and elastic scattering interaction rates is more than 3σ . This is an indication of the non-electron flavor component of the solar neutrino flux. The total flux of active ^8B neutrinos is the sum of the electron and non-electron flavors, and it is in good agreement with solar model predictions.

The difference between the elastic scattering and charged-current interaction rate (normalized to the standard solar model predictions) disfavors the oscillations of ν_e 's to sterile neutrinos, which would lead to a reduced flux of electron neutrinos but equal charged-current and elastic scattering rates. (Sterile neutrinos might be, for example, right-handed neutrinos or left-handed antineutrinos which do not interact through Standard Model interactions.) On the other hand, the different interaction rates are consistent with oscillations of ν_e 's into active ν_μ 's and ν_τ 's. SNO's result is consistent with both the hypothesis that electron neutrinos from the Sun oscillate into other active flavors, and with the standard solar model prediction for the total number of neutrinos released in the solar fusion reactions.

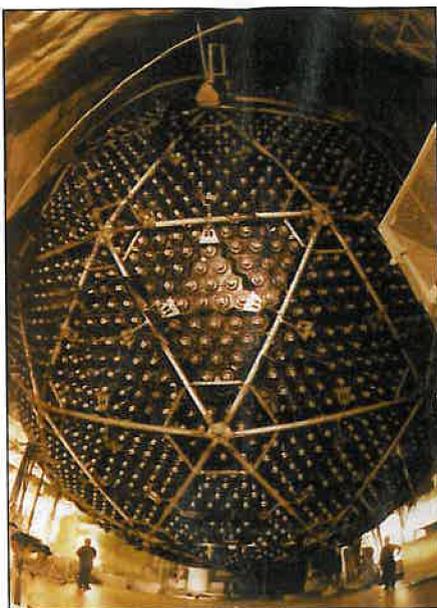
Implications of the SNO Result

Phenomenological studies have analyzed the recent SNO result in terms of 2, 3, and even 4-flavor neutrino oscillation scenarios [4] and determined the favored oscillation parameters, i.e. the most likely values for the mixing angle and the splitting of the neutrino mass eigenstates. A 2-flavor analysis finds that only the solutions with large mixing angles survive at the 3σ level, with a slight preference for the one with the larger mass splitting. This is the so-called large mixing angle solution. Global analyses with 3 and more neutrino species find that additional active and sterile neutrino oscillations solutions are currently allowed at 3σ . Interestingly, all favored solutions involve large, but not necessarily maximal, mixing angles. In summary, the recent SNO result disfavors complete conversion of electron neutrinos into sterile neutrinos and appears to favor large mixing angles.

Even without knowing the exact oscillation parameters this result already has theoretical implications for neutrino masses and high energy theories. Theoretical frameworks which invoke large extra dimensions with right-handed neutrinos in the bulk to explain the small neutrino masses tend to resemble neutrino oscillations into sterile neutrinos and also involve small-mixing angles. In contrast, some *see-saw* type mechanisms readily yield solutions with large mixing angles. A *see-saw* solution would imply a large mass scale in physics associated with right-handed neutrinos. This large mass scale may be the scale at which the forces (except gravity) are unified, and hence may affect our predictions for supersymmetry (SUSY).

Summary and Outlook

The data from SNO, taken together with that from Super-Kamiokande, have provided clear evidence for neutrino flavor conversion. It is very likely that the conversion mechanism is neutrino oscillations, although other non-Standard-Model processes have also been suggested. Recent analyses have shown that small mixing angles are disfavored in solar neutrino oscillations but not ruled out. Even if the small mixing angle solution is discarded there are several allowed regions of oscillation parameter space



Picture 3
View of the SNO detector after installation of the bottom PMT panels, but before cabling. Photo courtesy of Ernest Orlando Lawrence Berkeley National Laboratory.

which fit all the data. At present, it is not clear whether the oscillation occurs only between active neutrino species or with an admixture of a sterile component. Pure $\nu_e \rightarrow \nu_s$ oscillations, however, are ruled out by the current data.

At the beginning of June, SNO started the second phase of its scientific operation. Using NaCl as an additive to the heavy water enhances the capture efficiency of neutrons produced in the neutral-current dissociation of deuterium. This enables SNO to make a precision measurement of the neutral-current interaction rate of ^8B neutrinos with deuterium. The comparison of the neutral-current and charged-current rates gives a very precise measure of the extent of flavor conversion. In combination with analyses of the day-night asymmetry in the neutrino rate and the shape of the charged-current spectrum, SNO may also be able to distinguish the various oscillation scenarios and determine the generic oscil-



Picture 4
View from the bottom of the SNO acrylic vessel and PMT array with a fish-eye lens. This photo was taken immediately before the final, bottom-most panel of PMTs was installed. Photo courtesy of Ernest Orlando Lawrence Berkeley National Laboratory.

lation parameters for solar neutrinos.

The Sudbury Neutrino Observatory is a collaboration of about 100 scientists from 11 universities and laboratories in Canada, the US, and the UK. More information on the SNO project can be found on the SNO web site at <http://www.sno.phy.queensu.ca>.

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CERN signs draft Memorandum of Understanding with Iran

Iranian Minister for Science, Research and Technology, Dr Mostafa Moin, and CERN Director-General, Professor Luciano Maiani, today signed a draft Memorandum of Understanding concerning the participation of Iranian universities in the Laboratory's scientific programme. Under this agreement, one Iranian researcher and three students will come to CERN to participate in the CMS experiment, with Iranian industry contributing to the experiment's construction. The Memorandum also paves the way for possible further Iranian involvement with experiments at CERN.

The Iranian researchers, from the Sharif University of Technology in Teheran, the Beheshti University in Teheran, the University of Mashad, and the Institute for Physics and Mathematics in Teheran will be joining the 1800-strong CMS collaboration, which already numbers 145 collaborating institutes. CMS is currently preparing a particle detector to study high energy collisions between protons in CERN's new research machine, the Large Hadron Collider (LHC). Among the experiment's research goals are understanding why fundamental particles have mass, developing a unified picture of these particles and the forces that act between them, and investigating why nature has provided two copies of the family of particles that make up matter as we know it. The answers to these questions will have a profound impact on our understanding of the universe, its origins, and its future.

In signing this draft Memorandum of Understanding, CERN recognises the excellence of scientific talent in Iran. "We warmly welcome the researchers from Iranian universities," said Professor Maiani, "and look forward to a fruitful collaboration developing over the coming years." With many of the foundations of mathematics being laid in Persia, it is no less than appropriate that scientists from modern-day Iran should participate in the programme of one of the world's leading fundamental research organizations.

Pure science has always brought together scientists united by a common desire to learn more about their universe, and nowhere is this more apparent than at CERN. Since the Laboratory's inception in the 1950s, scientists from around the world have come to CERN to perform their research. Today, the Laboratory's experimental programme embraces some 7000 researchers from over 500 institutes in 80 countries. In keeping with CERN's convention, all results are openly published.

EU proposal for the VI Framework Programme

EPS Position Paper – September 2001

1. The European Physical Society and its roles

The European Physical Society (EPS) is an independent body, established as a union of 38 National Physical Societies of European countries, individual physicists, research institutions and industries. It includes as members all EU countries and has strong links to Central and Eastern European physicists.

The EPS represents over 80.000 physicists in Europe and can call on expertise in all areas where physics is involved.

The EPS is the only body at the European level that brings together and represents working physicists in research and education, with as a priority to have close relations with physicists working in all sectors of activity, including research, industry, commerce, public service and education.

The role of the EPS is clearly summarized by the items identified in its Strategy Plan: Scientific Issues in Physics, Physics in Profession, Physics Education, East-West Cooperation and Physics for Development, Public Awareness and Information Dissemination. This Strategy Plan was approved by the EPS Council of March 2001 and a short version has been published in the May/June issue of *Europhysics News* 32 (2001) p. 108.

Within the physics community, the activities of the EPS include the publication of scientific journals, the organisation of forefront international physics conferences and schools and contributes to worldwide recognition of outstanding achievement in physics by awarding prizes. Outside the physics community, The EPS has a major role in the promotion of physical sciences and the public understanding of physics.

The declared aim of the EPS is to promote Physics and help physicists in Europe.

2. Aims of this Position Paper

The EPS is the major European body in physics and, as such, welcomes with enthusiasm the EU proposal to establish a European Research Area (ERA). Physics is a rigorous theoretical and experimental discipline that plays a fundamental role in all natural sciences and constitutes the basis for the development of new technology. Therefore, we believe that Physics will be crucial to the ERA, in particular by its contributions to interdisciplinary and new emergent fields of research.

With this position paper the EPS wishes to offer its assistance and to join the EU efforts in the creation of the ERA.

The EPS is convinced that a close collaboration with the EU will help to extend its own running initiatives for the benefit of all. For this purpose it is willing to propose the EPS infrastructure (Divisions, Executive Committee, Secretariat), and its publication network for reaching the 80.000 physicists who are potential members of the ERA.

This paper is addressed to both those in authority and the General Public.

3. The European Research Area

The EPS has appreciated the previous EU Framework Programmes that have promoted cooperation and have supported collaboration among research institutions and industries across Europe. The establishment of a European Research Area is the natural follow-up towards European scientific and technical development throughout the continent.

The EPS welcomes the proposal of infrastructure and research centres in the ERA Programme. The success of these initiatives, however, will strongly depend on the national consensus and the access conditions to these research centres. The EPS will support actions toward an integration of national research programmes with these European research centres.

The EPS has no doubts that quality should remain the principal funding criteria of scientific research. One crucial issue is the methodology for defining Centres of Excellence. Since excellence is not necessarily restricted to large institutions, criteria must be defined also bearing in mind the importance of small enterprises, both in the academic and industrial world.

The EPS shares the view of the EU on the equal importance of fundamental and applied research. Europe is at the forefront in many areas of research in physics and the EPS is a natural vehicle to widely disseminate novel results. All the existing links established inside the EPS and mentioned in section 1, can be easily used to promote the ERA. The EPS can offer to collect views from its members via the National Physical Societies, Divisions, Action Committees, etc. and transfer them to the EU Commission, and act as a communication channel in return. The EPS is also willing to work towards the creation of an ad hoc European Science Council, capable of giving top-level, independent advice on major scientific issues within Europe to the national funding agencies and to the EU, when requested.

The EPS acknowledges the wisdom of the EU to select 7 high priority areas. It recommends however to better motivate the choices in order to meet possible criticisms.

4. The EPS contribution

Within Framework Programme VI, the EPS is ready to contribute at three levels:

- Science policy making
- Scientific and technical assessments
- Evaluation process within the EU Framework Programme VI

The first issue is currently being addressed by the EPS, which is expanding its Division structure to enhance the role of specific areas to which the EU has given priority. In particular, the EPS has decided to open two new Divisions for Nano-Physics and Biological Physics. These two topics are strongly connected. Nanoscience and nanotechnology are at the interface between physics, chemistry, engineering and, most importantly, biology. The fundamental processes of living matter occur at the nanometer scale. Micro-electrical mechanical systems are approaching the dimensions of biological cells, opening up the possibility of connecting machines to individual cells. These issues are well inside the priority areas set by the EU for the ERA and obviously they cannot do without Physics. Even more, Physics might play the role of "incubator" for new emerging cross-disciplines in at least six of the seven the ERA priority areas. The EPS can make contacts with other learned societies or bodies (Biology, Chemistry, Engineering, Economics, etc.) to generate synergies and move towards the creation of the mentioned European Science Council. The EPS has launched the project of "The World Year of Physics" in 2005 and will act as the co-ordinator. This worldwide promotion of physics can be seen as a contribution to the ERA. Common strategies are easily foreseen.

The EPS can effectively contribute on the technical level to the creation of the ERA simply by following its strategy plan in a professional way. Indeed, the EPS strategy plan includes explicitly:

- information service – preferentially in electronic form, and the creation of databases;

- analysis of needs and status of science;
- information to the public and the visibility of science;
- contacts to and knowledge about third countries;
- concerns about ethics, brain-drain and several other subjects touched in position papers and more.

Additional resources to enhance activity in these fields would be most welcome.

The third issue will be addressed, as in the past programmes, by individual members of the EPS who serve for the evaluation of assigned projects, according to the rules set by the EU. If of inter-

est to the EU, the EPS could select and call on famous and influential physicists to help set up top-level evaluation panels. Since evaluation criteria and formats are of primary importance, the EPS is ready, if necessary, to suggest such criteria. The EPS recommends further that, inside the ERA, the mobility of researchers should be extended to all ages and stages in their career.

In summary, the EPS welcomes the ERA proposals. They will stimulate high-level research in Europe and beyond and will help forge links across sciences. The EPS, as one of the leading European scientific organisations is ready to play its role.

The future of nuclear energy

EPS Position Paper – June 2001

The European Physical Society (EPS) is an independent body funded by contributions from National Physical Societies, other bodies and individual members. It has over 80,000 members and can call on expertise in all areas where Physics is involved.

The declared aim of the EPS is to help Physics and Physicists in Europe.

1. The aim of this Position Paper

Although 'Nuclear Energy' has had a bad press, not least because of wartime applications and accidents with nuclear power stations, there is a positive aspect. Both pluses and minuses are discussed in this Position Paper.

The Paper is aimed at both those in authority and the General Public.

2. Energy Consumption

A considerable increase in world-wide energy consumption is expected over the next decades, especially in third-world countries, but there is also the necessity to cut down on the use of fossil fuel in the near future, not least because of the greenhouse effect. Although strenuous efforts must be made to improve the efficiency of power generation, and to make progress with energy conservation and "renewable" energy sources (like wind, water and solar devices), it is doubtful that they will reduce the future long-term demand for large-scale energy consumption. Thus, the option of large-scale energy production by nuclear processes using innovative concepts should remain open, while public confidence in this option needs to be restored.

3. Current numbers of nuclear power plants

At the end of 1999, a total number of 436 nuclear power plants were in operation world-wide, producing 17% of the world electricity generation. In Western Europe, 151 reactors provide 43% of energy production. There are 37 new units under construction, mostly in the Eastern European and Asian countries.

4. Reduction in Global CO₂ emission

In the last 20 years the amount of CO₂ emission saved by nuclear energy production corresponds to 9% of the total amount of gases containing carbon emitted for energy generation (and 28% as referred to electricity generation). The issue of reaching further savings is widely discussed. Natural resources for energy production using nuclear processes are very large and may become practically unlimited if nuclear fusion can also be exploited, although it is true to say that progress in this area has been slower than expected.

5. Open Questions

As remarked already, there is opposition to nuclear energy in some countries — because of its association with nuclear weapons and for concerns about safety. Furthermore, there is the problem of the long term storage of the radioactive by-products of nuclear reactors. The opposition is not irrational in principle because of both very long term as well as short term health hazards. However, the problems need to be put into perspective.

All energy sources involve hazards, whether it be in the extraction and transport of the fuel or in the by-products in the form of obnoxious emissions. The case for nuclear energy must be won by those who support this source by way of demonstrating that the gains outweigh the losses.

Similarly, the opponents need to propose practicable alternative, safer sources of power which can satisfy future demands. A common goal is nevertheless to influence governments of all countries to develop and support energy savings programmes and viable alternative energy sources.

6. Improved nuclear reactors

New scenarios for large-scale energy production by fission are currently being explored. They include new types of reactors based on the use of thorium rather than uranium fuel in which the production of long-lived wastes and plutonium would be at least a factor 1000 smaller than in current methods. Novel accelerator driven fission reactors are being studied in both Europe and the United States. These use the thorium cycle and sub-critical reactors, which are predicted to be intrinsically safe. The option of new hybrid systems offers the possibility to partly incinerate and transmute nuclear waste.

7. The need for further research

To ensure a sufficient supply of energy for future generations, an extensive and long term research and development programme (R&D) is needed, which should include all possible options for sustainable energy production, including the option for energy production by nuclear fission and fusion processes. The problems connected with sustainable and large-scale nuclear energy production go well beyond national frontiers. Therefore R&D work should be performed on an international (European) scale, through a European Institute.

8. The need for public debate

If nuclear technology is to contribute to the problem of meeting future energy needs and help to ameliorate the severe environmental effects of other energy sources presently used, it is essential to obtain public support. Thus, it is necessary to have the views of the public and engage in dialogue with them. Only if the public can be honestly persuaded that the benefits outweigh the risks will nuclear energy be accepted.

NANO-2001

Andrey Bychkov, St. John's College, Oxford, United Kingdom

In the EPN 31/5 issue we wrote about the International Symposium on Nanostructures held in St. Petersburg in the end of June every year since 1993. This year has brought about some changes to the traditional scheme. The organizer and permanent co-chair of the Symposium, Professor Zhores Alferov, was awarded the Nobel Prize in Physics 2000 for developing semiconductor heterostructures in high-speed and optoelectronics. Given that his counterpart Professor Leo Esaki had received the Nobel Prize in Physics 1973 for the discovery of tunneling phenomena in semiconductors, from now on the Symposium is proud to be co-chaired by two Nobel Prize winners. Another good news is, the participants were welcomed in the brand new Educational Centre of the Ioffe Institute. Built in 1999 to foster interaction between students and researchers, the Centre comprises experimental facilities and seminar rooms, along with a swimming pool and a spacious lecture theatre where the Opening Session took place.

At the Opening Session, Leo Esaki provided an insight into how nanotechnology, or 'modern alchemy', was originated. Zhores Alferov reviewed the development of 'man-made' - as opposed to 'god-made' - nanostructures. Federico Capasso from Bell Labs introduced the micro- and nano Electro Mechanical Systems (MEMS and NEMS), a new frontier of nanotechnology. The form of his talk, a Powerpoint presentation recorded on video, sent over the Internet and overhead-projected, was itself a direct evidence that technology is going in the right way.

Technology and applications of nanostructures, rather than basic physics, dominated at this Symposium more than ever before. That's fair enough, since on one hand, it indicates nanotechnology has become mature, and what used to be science fiction ten years ago now is a well-developed process, as e.g. in the case of quantum dots. Russell Dupuis from Univ. of Texas delivered a comprehensive overview of InP self-assembled quantum dots (QDs) grown by metalorganic chemical vapor deposition. By varying growth conditions it is possible not only to change the size and density of these artificial atoms, but also to engineer reliably their band structure and photoluminescence spectrum. On the other hand, nanotechnology has reached so high a level at which it can be called nanoscience or even nanoart having to do with the most delicate effects of quantum physics. Alfred Cho from Bell Labs demonstrated this in his talk on molecular beam epitaxy of quantum devices, namely quantum cascade lasers, composed of hundreds of atomically precise layers to achieve emission of the right wavelength.

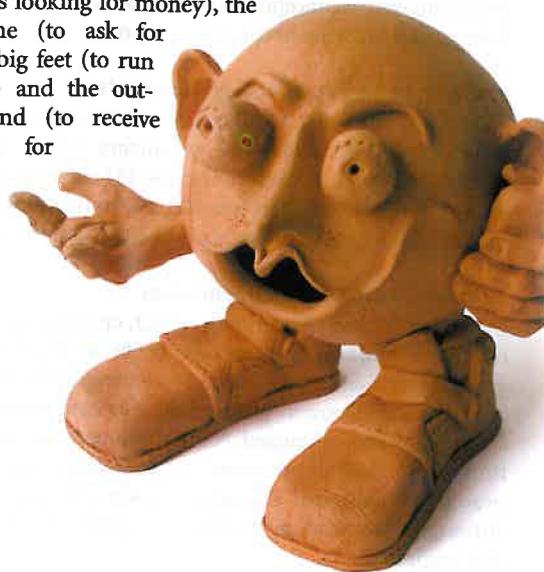
Nonetheless, we had a pleasure to listen to some beautiful physics talks too. Xavier Marie from INSA-CNRS Toulouse presented a work on spin coherence in semiconductor nanostructures. If excited resonantly, i.e. exactly at the frequency of ground state transition, excitons in InAs/GaAs QDs preserve their spin quantum state unchanged until they recombine. Moreover, the inferred exciton spin relaxation time of 20 ns is orders of magnitude larger than other relevant decoherence times, which makes it attractive for such exotic applications as quantum computing. Mats-Erik Pistol from Lund Univ. talked about random telegraph noise in photoluminescence of InGaAs QDs. Some individual dots exhibit blinking, or changing the emission intensity randomly on the scale of seconds. This effect may be common in

III-V semiconductors, and a model involving a mobile defect that captures carriers from the dot was proposed, which triggered discussions among the audience. We should expect further news on the topic in the nearest future. Eugenij Vdovin from IMT-RAS Chernogolovka reported on the spatial mapping of electron wavefunctions in InAs QDs. Conventional spectroscopy techniques enable the measurement of quantum dot energy eigenstates fairly easily, which is not the case with the eigenfunctions. That is what Vdovin *et al.* have achieved using magnetotunneling spectroscopy. By applying the magnetic field perpendicular to the tunneling current through the dot, it is possible to trace the Fourier transform of the electron probability density. Rotating the magnetic field parallel to the growth plane and performing conductance measurements for each direction of the field, one then restores information on the wavefunction distribution in the *k*-space. Karl-Fredrik Berggren from Linköping Univ. presented work on quantum chaos in ballistic electron transport through quantum dots. Quantum flows simulated on a supercomputer show rich and sometimes counterintuitive behavior, which strongly depends on the shape of the dot. It would be very helpful to test this in experiment.

There were many other interesting reports and two poster sessions, which the space limitations do not allow me to touch upon. At the Closing Session, Leonid Keldysh from Lebedev Institute gave a talk on dynamic Stark effect for excitons, and Robert Suris from Ioffe Institute presented work on Bloch oscillations in quantum dot superlattices. An overview of nanoelectronics by Raphael Tsu from Univ. of North Carolina ended the scientific programme. Professor Alferov closed the Symposium by giving the Aixtron Young Scientist Award to Ivan Shorubalko from Lund Univ. for implementation of GaInAs/InP ballistic rectifiers working at room temperature. He also suggested, subject to sufficient interest from the participants, to carry out the 10th Symposium next summer on the boat going down the rivers and canals of Russia. Maybe see you on board then!

A model approach

The Physicist as seen by Prof. S. Bagaev. Presented to the EPS at the meeting in Minsk (see special report, page 193) the physicist can be recognised by his harassed expression (because he is looking for money), the mobile phone (to ask for money), the big feet (to run after money) and the outstretched hand (to receive money). All for research, naturally.



How to present R&D activities to non-technical audiences

Sean McCarthy

Research groups rely on public and private funding to finance their research work. The different people involved in the financing of R&D are the public officials who administer the funding programmes, the technical experts who evaluate the 'scientific excellence' of the research, the business executives who require new technologies and the politicians who prepare economic and social policy. Researchers are under more and more pressure to present their activities to a wide range of audiences. Many books and courses exist on presentation skills. This article concentrates on the skills that are specific to the needs of researchers. The article is based on twenty years of presenting R&D activities at technical conferences, business conferences, contractors' meeting and at public events. The article is also based on a training course developed by the author.

Problems encountered by researchers presenting their work.

The most common presentation problems quoted by researchers include the following:

- Getting to the point;
- Having time to prepare the presentation (either due to short notice or trying to be perfect);
- Tailoring the presentation to the audience;
- Knowing how much detail is required.

Other problems include nervousness and technical problems with equipment (especially the LCD projectors for PowerPoint presentations). Speaking in another language is quoted as a major problem.

When researchers present their activities to non-technical audiences the following problems are observed:

Researchers use presentations to demonstrate that they know their subject and that they work hard!

These two problems consume over 50% of the time in technical presentations. Researchers use public presentations to demonstrate their depth of knowledge in their field and the complexity, intensity and sophistication of their work. If a researcher can avoid the above they can save 50% of the available presentation time.

Researchers tell us what they do NOT why they do it!

In a presentation the researcher must first educate the audience on why the topic is important. At the beginning of every presentation the researcher must answer the following questions: Why bother with this type of work? Why not purchase the solution on the market? If it is so important, why wait until now (and not 5 years ago)? Is this totally new or are you building on other peoples work?

Jargon, buzz words, terminology

This problem is common to all professions but science seems to generate acronyms and buzz words at a faster rate. Examples include acronyms such as IPR (Intellectual Property Rights), SME (Small and Medium Sized Enterprises) and WP (work plan). These acronyms should be avoided in presentations. Use the full words rather than the acronyms.

Researchers focus on their activities rather than on their results

Most organisations and individual describe what they do based on what they produce e.g. Microsoft produce Excel, PowerPoint, etc. Siemens produce computers, controllers etc. Researchers, on the other hand, are often content to describe what they do solely on their activities. Researchers claim that they undertake research on nanotechnology, biotechnology etc. But what do researchers produce? Researchers produce new knowledge, prototypes, documents, software, data, transgenic mice, new materials, etc. In presentations researchers must focus on their activities AND on their results.

It is also essential that the results must be expressed in the words of the user. Some examples are shown below in Table 1.

How to Prepare a Technical Presentation

The following emotional phases are common to all IMPORTANT presentations.

- Phase 1: Privileged to be asked
- Phase 2: Realisation of work involved
- Phase 3: Start planning (*Sorry you agreed*)
- Phase 4: Preparation of talk (*Really sorry you agreed*)
- Phase 5: Before presentation (*Panic!*)
- Phase 6: Presentation (*I feel great*)
- Phase 7: Audience applauds (*All the effort was worth it*)
- Phase 8: Asked to give another talk (*Go to phase 1*)

The important message here is that presentations have three very distinct phases: (1) The Planning Phase (2) The Preparation Phase (3) The Presentation Phase. The following section summarises what is required in each phase.

Table 1: Translation of research language into user language

Scientific Result	User of the Result	What the User Calls It
Report on the system	Design Engineer	Design Specification
Performance Improvement	Production Manager	Process Improvement
Instrument Data	Instrument Designer	Calibration Curve
Engine Data	Engine Designer	Performance Data
Results of tests	Medical Personnel	Screening Criteria
Data	Policy Maker	Environmental Indicators
CD ROM	Trainer	Training Material
Database	Researcher	Search Engine
New Knowledge	Researcher	Scientific Publications

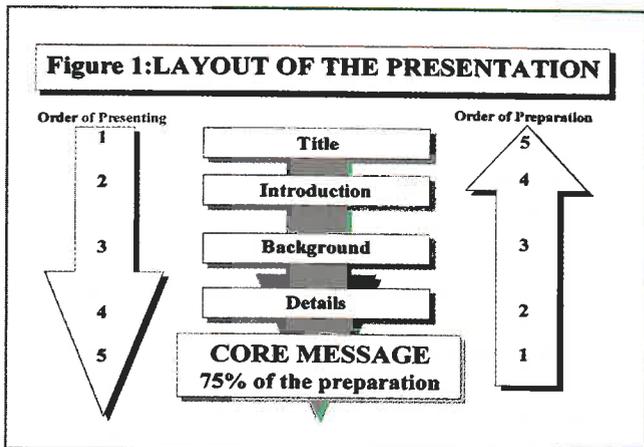
NB: In a presentaion the researcher would present column 2 and column 3 e.g. "a design specification for a design engineer" or "a calibration curve for an instrument designer".

Sample Presentation

A researcher, specialising in nanocomposites, has been asked to make a presentation at a conference organised by the European Plastics Industry Association.

The Planning Phase

All presentations have a generic format and this is summarised in Figure 1.



The important message here is that 75% of the planning consists of defining the *core message*. This is the most important issue in any presentation. The core message will depend on the audience. For example if we use the case of the researcher making the nanocomposites presentation the core message could vary in the ways shown below in Table 2.

When you identify the core message everything else must lead up to this. The best way to test a core message is to imagine if someone woke up at the end of the presentation they would have a clear understanding of the presentation. The core message should also be structured so that it can be discussed after the presentation.

Table 2: How the core message depends on the audience

EXAMPLES OF DIFFERENT AUDIENCES	POSSIBLE CORE MESSAGE
Business Enterprises funding the development of a new nanocomposite process.	"The system works"
Funding Agency who is providing funding to the researcher.	"The work is on schedule"
Business Enterprises interested in funding a pilot process.	"We have the technical solution. It is working in the laboratory and we need funding to demonstrate it at a pilot scale".
Presentation to a multinational company interested in funding the activities of the researcher.	"We already work with companies like yours"

Table 3: Improved performance of plastics with a 3-5% weight nanocomposite loading

Performance Properties	Improvement over existing products
Tensile Strength	100-700 %
Flexural Modulus	50-300 %
Thermal Stability	30-80%
Gas Permeability Reduction	100-400%
Heat Release Rate Reduction	60-80%

To find the core message the presenter must first understand how the presentation will be judged (a) by the audience (b) by the researcher's organisation and (c) by the presenter themselves.

In the cases of the researcher preparing the presentation for the Plastics Industry Association the core message would be identified in the following way:

- a) *The Plastics Industry will say the presentation was brilliant if:*
 They understand the relevance of nanocomposites to their business.
 They have facts and figures to compare nanocomposites with their existing products.
 They receive a roadmap on how to incorporate nanocomposites into their business.
 They identify funding to support the above.
- b) *The researcher's organisation will say the presentation was brilliant if:*
 The industries were interested in funding R&D activities.
 Meetings were requested to discuss cooperation.
- c) *The researcher (the individual) will say the presentation was brilliant if:*
 The researcher is respected by the industry as an expert in the field.
 The researcher is requested to submit proposals for R&D funding.

The core message?

- Nanocomposites market estimated at 10 billion € by 2010
- First markets for nanocomposites: Aerospace, automotive, packaging, computers.
- We are one of the European Leaders in this field.
- Funding is available in European Union R&D Programmes (CRAFT).

(This was actually a real case. The researchers submitted a proposal based on the above and received a score of 5/5 for economic relevance of their proposal. They also received the full amount of funding they requested. The presentation was later published in the Plastics Industry Yearbook 2000)

Preparing the content

Title: This should be based on the core message e.g.

The Importance of Nanocomposites to the European Plastics Industry over the Next 10 Years.

Background:

Educate the audience with facts and figures that support the core message. For example in the above presentation Table 3 (shown on the left) was presented.

Details of the presentation:

This section should only contain details you need to support the core message.

In the above example the presenter would demonstrate the samples of products made using nanocomposites, list industries already active in this area (Toyota Central R&D Labs, Inc) and would describe the changes that would have to be made to the industrial processes. The presenter would also provide an overview of the European Union R&D programmes and the programme that would support this type of project.

What different audiences love/hate to hear

The following table summarises how different audiences judge presentations.

Audience	What they like to hear	What they hate to hear
Business Executives	Commercial awareness of their needs Business Arguments Facts and figures relevant to their business Technical competence in the subject Professional image Ability to communicate ideas	Lectures Theories Jargon Pet Projects
Public Officials (Funding Agency)	Relevance to their policies Serious scientists Respect for deadlines/paperwork Real successes	Money hunters (with no science) Contractual Problems Problems without solutions Surprises
Politicians	Issues which support their ideas Image and public relations for themselves Success Stories Slogans e.g. 'The future is nano'	Controversial issues Complex issues
Other Scientists	Latest breakthroughs Sources of information (websites) Relevant conferences/seminars Sources of funding Technical leaders in the field	Old stories

Tips during presentations

Many books have been written on this subject. Here we will simply include the most important points that should be remembered by researchers:

1. When you stand up on the podium everyone is with you! This should help you overcome any nervousness you may have.
2. DO NOT EXPECT A REACTION FROM THE AUDIENCE
This is the most important point I have learned over 20 years. If people are genuinely interested in your presentation all their brain cells are used to concentrate on your presentation and very few brain cells are left to control their facial expressions.
3. Speak slowly and clearly. People speaking in their non-native language have a major advantage here – they have no option but to speak slowly and clearly.
4. How to deal with interruptions (e.g. your notes falling on the floor) Pause, Correct, Continue. It looks very professional.
5. Adopt a confident poise, have a simple plan for your hands and scan the audience.
6. How to finish You must have your own closing line. For example "Thank you for your attention and if you have any questions I would be delighted to answer them. THANK YOU VERY MUCH."

Conclusion

When you make a professional presentation the experience can be magic. All the planning, all the preparation and all the practice is worth the effort. Next to science, the ability to communicate your ideas to any audience is the most important skill for a researcher. The important point to remember is that when you are planning the presentation start with the core message, then identify the details you need to support the core message and finally include background information to educate the audience on issues which

will help them understand the core message. You make the presentation in the reverse order i.e. background, details and then the core message. To perfect your presentation skills you must practice, observe, refine, practice, observe, refine....

About the author

Dr. Sean McCarthy (sean.mccarthy@hyperion.ie) is Managing Director of Hyperion Ltd. Hyperion specialises in the development of training course for research managers. Full details of their training courses can be found on www.hyperion.ie. Hyperion's clients can be seen on www.hyperion.ie/hyperionclients.htm

Nobel Laureates meet in Lindau

Simon Newman

At the end of June the 51st Meeting of Nobel laureates, the 17th dedicated to physics, was held in Lindau on Lake Constance. Under the presidency of Countess Sonja Bernadotte, wife of their founder and first patron Count Lennart, these reunions have attracted ever wider audiences. Over 600 students and young researchers, not only from Europe but also from the USA and India, came eager to encounter the 18 Laureates attending. They listened to lectures on topics such as heterostructures presented by the latest prizewinners Herbert Kroemer and Zhores Alferov and pioneers in the field Klaus von Klitzing and Leo Esaki. Round-table discussions engaged Laureates and students in lively debates on basic research and resultant applications, or on the role of physics in the life sciences. There were many opportunities of conversing with the Laureates of one's choice, not least on the last day during the boat trip to the island of Mainau, seat of the Bernadottes.

Once again hundreds of young scientists, selected by their university or institution with financial support through sponsorship or public and private funding, departed to continue their careers inspired by the contact with the eminent.

Further details on www.lindau-noble.de



Photograph: The podium of a round-table discussion facing hundreds of students and other Laureates at Lindau. Chaired by Anders Bárányi (centre) of the Nobel Committee for Physics, from left to right: William Phillips, Douglas Osheroff, Herbert Kroemer, Klaus von Klitzing, Zhores Alferov, Leo Esaki.

The word from Brussels

Tom Elsworth

The regularity of these messages from Brussels certainly seems to make time move along quickly. We are already well into the Belgium Presidency of the Council that should we hope, see an acceleration and a focusing towards a culmination, of activities related to Framework Programme 6.

We all of course, have our own personal timetables. As I write this we have just returned from an excellent summer vacation in the USA, inspired as always by the magnificence of the country, its continuing spirit of "can-do" and the gigantic benefits of a sound federal government. There are many points of view on this one but for science in general there surely can be no doubt that a fully developed EU having similar structures to the USA would be quite literally, the best news since sliced bread.

Having nailed my flag firmly to the mast let us get back to the key issue for us at the moment - the continuing saga of the development of Framework Programme 6 and the European Research Area. From the start of their Presidency, Belgium has adopted a positive stance. François-Xavier de Donnea as early as mid June, set out his intention "to bring closer closure on FP6 and ERA" and "to make a decisive contribution". There is to be a Belgium Presidency organised conference on 17th/18th September with a key theme of success of European Research on the global stage. If this can indeed be achieved in full so as to gain leadership, we will have succeeded in turning the clock back 100 years or more - so perhaps unrealistic but it is certainly where the EU should be aiming.

Many of the EU's institutions have taken a hand in developments in the Framework Programme and the ERA since I wrote the previous article in this series. There is not room to set out the whole story, nor would it make fascinating reading. Nevertheless it is important to pick out some of the highlights. Firstly our Parliament; the Industry Committee held a public hearing on 26th June at which the rapporteur Gérard Caudron (French, PES) commented in particular on the need for the transition from the present programme to the 6th to be "seamless". This has not always been the case in the past as many readers will know to their cost! Gérard Caudron's report is likely to be adopted by the committee in September/October and put to the vote in plenary in October/November. This is of course, very far from the end of the co-decision story but it is far better to influence matters early. We can be sure that M. Caudron is being lobbied heavily by a range of well organised interest groups. Perhaps EPS members would agree with much of this lobbying, but if members do not make their own voice heard either directly or through official or political or association representatives then they can hardly complain about the outcome.

On the same day 26th June, the research council met in Luxembourg under the Presidency of Mr Östros of Sweden (Minister for Education). Here is a test of our involvement in the process, how many of us can name the person who would have represented our own countries? In my case it was Lord Sainsbury of Turville (Minister for Science in the UK government).

The Council held a "first orientation debate" on the Commission's proposals for the Framework Programme. They reached a fairly substantial set of agreed views, too long to be quoted in full here. The key points seems to me to be the following:

- Broadly supported the Commission's choice of scientific priorities and their aim of focusing on a limited number of such areas.
- Supported the Commissions' intention to use integrated projects and networks of excellence to achieve effectiveness and efficiency in assembling a critical mass of scientific expertise.
- But a significant minority (I would guess the smaller countries) considered that these new instruments should be used alongside existing ones so as to ensure a smooth transition between the 5th and 6th Programmes.

This latter point is somewhat concerning, it smacks of the development of a political compromise quite likely to result in the structures and processes of the 6th Programme being even more complex and impenetrable than those of the 5th!

Returning to the Council's discussions, I was glad to see their explicit welcome for the inclusion of Science and Society as a priority area. They went so far as to consider development of a specific European initiative on "scientific and technological culture" and the promotion of "regular events of high visibility and quality presenting important topics of scientific and technological research and exploring scientific and technological issues of interest to the public at large". The Commission was asked to prepare an action plan on "science and society". Speaking to MEPs, Mr de Donnea the current President of the Research Council said "this will prepare the way for a definition of concrete measures aiming to reduce the gulf which seems to separate the scientific world from the citizen".

Moving along the list of European Institutions we should all raise a cheer for the Economic and Social Committee that has called for a 50% increase in community RTD & D budget. They also very sensibly in my view, called for the strengthening of the EURATOM programme. Unsurprisingly, given the ESC's structure and role, these sensible points were matched by caution and muddying of the water on the question of the new instruments and the use of Article 169 (see the last edition of Europhysics News).

What then of the timetable for events on development of the Framework Programme? Mr de Donnea has set out his views, "we would like to be able to bring a common position to the council of October. In effect, this timetable which presents all the guarantees for the Sixth Framework programme could be adopted under the Spanish presidency, beginning on 1 January, 2002. This is really about avoiding a hiatus between the Fifth and the Sixth Framework programmes." He said this to MEPs on 11th July; all previous experience of the workings of our Parliament indicate that the chances of them being ready for this tight deadline are minimal. By the time this article is published we shall know the position. I should love to be proved wrong.

Events

Opening up European research to the world: excellency, mobility and exchanges 17-18 September Brussels

COST 30th anniversary celebration 10 October Brussels

The European Initiative "Global Monitoring for Environment and Security (GMES): towards implementation" 15 October Brussels

Research Council 18 October Luxembourg

1st Annual European Energy & Transport Summit 18-19 October Barcelona

Unity and diversity: the contribution of the social sciences and the humanities to the European Research Area 29-30 October Bruges

European Week of Science & Technology 4-10 November Various

International best practices in evaluation of research in public institutes and universities 12-13 November Brussels

The place of the SMEs in the European Research Area and the new Framework Programme 19 November Liège

Descartes Prize 27 November Brussels

European Biodiversity Platform, Scientific tools for biodiversity conservation (models, monitoring and experiments) 2-4 December Brussels

Research Council 10 December Brussels

Public awareness of science and technology in Europe and its regions. Building bridges with society: best practice, benchmarking and regional diversity 17-18 December Brussels

3rd Science Centre World Congress 11-15 February 2002 Canberra, Australia

Calls for Proposals

Calls published on 7 August 2001

Energy, Environment and Sustainable Development (Part A)

- Call for proposals to extend existing contracts to include partners from the newly associated States (NAS)
- Opening date: 07.08.2001
- Closing dates: 15.02.2002

Calls published on 24 July 2001

Improving Human Research Potential and the Socio-economic Knowledge Base

- Third Call for proposals for Key Action "Socio-economic Research"
- Opening date: 24.07.2001
- Closing dates: 15.02.2002

Calls published on 13 July 2001

Promotion of Innovation and Encouragement of SME Participation SME Specific Measures

- Call for Collective Research Pilot Action
- Opening date: 13.07.2001
- Closing dates: See Call text

Calls published on 7 July 2001

Promoting a User-Friendly Information Society

- 7th IST Call for proposals
- Opening date: 07.07.2001
- Closing dates: See Call text

Calls published on 1 June 2001

Competitive and Sustainable Growth

- Fixed deadline call - Call for proposals for indirect RTD actions
- (Growth June 2001)
- Opening date: 01.06.2001
- Closing dates: See Call text

Tailpiece

I like to include in this article a couple of other points of more general interest that have emerged in Brussels.

The Cost of Electricity

EU funded research over the last 10 years has pinned down the external, environmental costs of electricity production. The answer appears to be rather shockingly, that the true total cost of electricity production from coal or oil is double what we had thought it was and that from gas 30% higher. These are very significant members economically (1-2% of EU GDP) and do not even include the costs of global warming! Nuclear, wind and hydro seem to be the winning technologies - at least from this point of view.

From the Web to the Grid

Confirming "Moore's law", formulated 35 years ago, the power of computers doubles virtually every 18 months. Computational performances have increased a million times over in the space of 15 years. The Cray 1, the leading supercomputer in the late 1970s, pales into insignificance today, when compared with even the most modest laptop.

The challenge has been taken up today by scientific bodies such as CERN (the European Organisation for Nuclear Research), whose new particle accelerator, the Large Hadron Collider (LHC), is due to enter service in 2005. The particle bunches colliding in this device at the rate of 40 million times a second will generate a volume of data equivalent to that of 20 telephone conversations conducted simultaneously by every inhabitant on the planet.

This makes it timely to look at the Grid concept developed a few years ago by Ian Foster, professor of computer science at the University of Chicago. The principle is to decentralise computing resources by using a high speed network linking supercomputers, batteries of processors, disks, databases, computer systems, tools and, of course, users, in a kind of "worldwide virtual laboratory". CERN is heading the so called DataGrid project, with financial backing of nearly EURO10 million from the FP5 Information Society Technologies (IST) research programme.

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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noticeboard

Nominations to CMD Board

The Condensed Matter Division will organize elections to replace three outgoing members, whose terms expire on 31 December, 2001. Nominations are invited from members of the Division. Nominations including a 1/2 page cv, as well as a statement from the candidate should be addressed to David Lee, EPS, B.P. 2136 34, rue Marc Seguin F - 68060 Mulhouse, France. The deadline for receipt of nominations is 30 November 2001. The resulting list of candidates and ballot papers will be mailed to Section Members who will be invited to vote by the deadline of 31 January 2002.

New Section

A new section of the Plasma Physics Division in Beam Plasma and Inertial Physics was created at the Funchal meeting of the PPD. The interim board consists of Professors Lefebvre (France), Meyer-ter-Vehn (Germany, chairman) Atzeni (Italy), Wolowski (Poland), Sharkov (Russia) Honrubia (Spain), Norreys (UK).

One of the goals of the new section is to bring the European Beam Plasma & Inertial Fusion community into closer contact with magnetic fusion and other branches of plasma physics in Europe. First steps in this direction will be to organize topical satellite meetings within the annual EPS plasma conferences.

New Officers

Statistical and Non linear Physics Division

Dr. Marcel Ausloos (Université de Liège, Belgium) has been co-opted as a member of the EPS-SNP board, as the representative of the APFA action committee.

High Energy and Particle Physics Division

Dr. Michel Spiro (CEA Saclay, France) is the new Chairman of the EPS-HEPP Board.

Interdivisional Group on Accelerators

Dr. Lenny Rivkin (Pe Chairman elect of the IGA and will take up office in 2002.

University Section

Dr. Urbaan Titulaer (Johannes Kepler Universitaet Linz, Austria) is the Chairman of the University Section of the Physics Education Division

Pre-University Section

Dr. Gunnar Tibell (Uppsala University, Sweden) is the Chairman of the Pre University Section of the Physics Education Division

Long-term archiving conference

The IUPAP will organise a meeting to discuss the issues of long term archiving. The meeting, which will take place on November 5 and 6, Lyon (France), will address, among other, the Commitments by publishers to maintain the readability of their electronic archives, and the future viability of reference links, and the establishment of backup mirrors at institutions which would commit to updating the archives in the event that publishers fail to do so. More information can be found at <http://www.IUPAP.org/>

Nominations to QEOD Board

The Quantum Electronics and Optics Division will organize elections to replace outgoing members, whose terms expire on 31 December, 2001. Nominations are invited from members of the Division. Nominations including a 1/2 page cv, as well as a statement from the candidate should be addressed to David Lee, EPS, B.P. 2136 34, rue Marc Seguin F - 68060 Mulhouse, France. The deadline for receipt of nominations is 30 November 2001. The resulting list of candidates and ballot papers will be mailed to Section Members who will be invited to vote by the deadline of 31 January 2002.

Agilent Technologies Europhysics Prize

Nominations are invited from members of the EPS and the European Physics Community for the Agilent Technologies Europhysics Prize for Outstanding Achievement in Condensed Matter Physics. The award is given in recognition of a recent work (completed within the last 5 years) by one or more individuals in the area of physics of condensed matter, specifically work leading to advances in the fields of electronic, electrical and materials engineering. The award may be given for either pure or applied research.

Only complete nominations will be considered. For a nomination to be complete, the must include:

- a complete CV
- a publication list (not to exceed 5 pages)
- an indication of the three most relevant papers to the nomination
- a description of the work justifying the nomination (up to 2 A4 sheets)
- a suggested short citation

The deadline for the receipt of nominations is 20 November 2001. Nominations should be sent to David LEE, EPS, 34 rue Marc Seguin, BP 2136, 68060 Mulhouse Cedex, France, to the attention of the Agilent Technologies Europhysics Prize Selection Committee. All nominations will be acknowledged.

Errata

On page 90 of EPN vol. 32 no. 3 an incorrect figure caption was used. The correct caption for figure 9 should have read: High-resolution transmission electron microscopy image of bundles of SWNTs filled with C₆₀ molecules (Courtesy of S. Iijima).

EPS Executive Committee in Minsk

On 29-30 June 2001, the EPS Executive Committee met with Presidents and representatives of the Belarusian Physical Society (BPS), the United Physical Society of the Russian Federation (UPSRF) and the Lithuanian (LPS) and Polish (PPS) Physical Societies. The purpose of the meeting, as stated by M. Ducloy, EPS President was to learn more about the activities and issues of concern to EPS members. This is an essential step in coordinating EPS activities and in implementing the Strategy Plan. The personal contact also shows that EPS is not a virtual society. The strength and impact of the EPS cannot be measured by its financial resources. The network of physicists and physical societies from industry, research and education constitutes a tool that all EPS members are encouraged to use.

The European Physical Society would like to thank our hosts of the BPS particularly the President, P. A. Apanasevich and the vice-presidents V. A. Tolkachev and F. F. Komarov for the extremely warm welcome and interesting discussions.

Presentations were made by Professors S. Bagaev (Vice President, UPSRF), S. Bausch (PPS), and Z. Rudzikas (President, LPS) about the situation of physics in Russia, Poland and Lithuania, and the actions of their physical societies. Below is summarized the content of the contribution prepared by Professors P. A. Apanasevich and F. F. Komarov.

Created in 1990, and a member of the EPS since 1993, the aim of the BPS is to provide a forum for physicists and to develop physics in the Republic of Belarus. The economic difficulties that plague the country have also been a source of trouble for the BPS. The BPS has become much more active since the society was reorganised in 1996. Since that time, the Society has organised many major international conferences and now counts 200 members from 30 institutions around the country. More about the BPS can be found on their home page at <http://imaph.bas-net.by/BPS>

Physics, mathematics and information science receive special attention in the Belarus education system. This stems from the important role played by micro and opto electronics, optical instrument making and the medical and chemical industry in Belarus. The country has made the choice to concentrate on these sectors of activity due to the absence of raw materials and the long lasting effects of the Chernobyl accident that has had a negative effect on agricultural production.

Currently physics is taught at seven universities and one pedagogical institute in Belarus. In 2001, a total of 683 students will graduate with degrees in physics, of which 321 are trained to work in research and/or industry, and 321 as teachers in secondary and special schools. All institutions teaching physics have international contacts with other countries, including France, Germany and the US. The quality of physics teaching in Belarus is very good. Most universities begin training future



The EPS Executive Committee meeting with representatives of the BPS, LPS, PPS, and the UPSRF.

The Republic of Belarus is an independent state originating from one of the 15 Union Republics of the former Soviet Union. The territory covers an area of 208000 km² populated with more than 10 millions inhabitants. It share borders with the Russian Federation, Ukraine, Poland, Lithuania and Latvia. The country is divided in 6 regions and 118 districts and its capital is Minsk with a population over 1.7 million inhabitants.

students in special classes taught at the 10th and 11th grade taught by university professors, where students average 6 hours of physics a week. Physics studies are also encouraged through summer schools and physics competitions.

Belarusian physics graduates generally have very good basic and theoretical training. However, they are less experienced in practical work as compared with graduates in Western Europe and the USA. In order to meet these shortcomings, as well as to bring the Belarusian university system into line with European system of higher education, the Belarusian State University is piloting a vast reform programme.

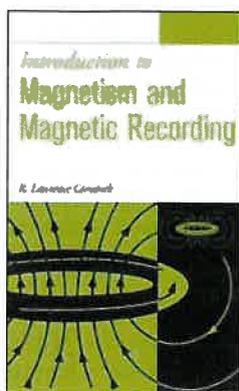
The Belarusian educational system is however, encountering serious problems. There is a real lack of research equipment, foreign language journals in physics and personal computers. The funding level is also extremely low, the average research project receiving around 3500 Euro for this year 2001

Other serious problems are the brain drain, as well as the absence of economic and social motivation for graduates to continue their activity in universities either as research or teaching staff. Many of the best students have left to take up positions in universities or companies in Western Europe and the USA. This has caused a dramatic increase in the average age of research and teaching staff in Belarus, and the formation of a gap between the senior generation of highly qualified physicists and the young specialists planning their careers in the educational system.

Areas where the EPS may be effective:

- Broadening EU support for international training to allow Ph. D. students to spend time in Western Universities
- Work with companies and others to supply PCs
- Provide free or low cost access to European Journals like EPL, EPJ and others
- Encourage EPS Divisions and Groups to organise conferences in Eastern and Central Europe
- Encourage EPS Divisions and Groups to integrate physicists from Eastern and Central Europe on their boards
- Organise joint meetings of the Executive Committee
- Award joint prizes
- Encourage the integration of Eastern and Central European Journals into other European joint ventures
- Invite physicists from Eastern and Central European countries to participate on the EPJ Scientific Advisory Committee, and editorial boards
- Determine the possibility of providing funds through the East West Task Force that could account for the aging of the population of active physicists in Eastern and Central European Countries
- Publish Position Papers on issues of importance for Eastern and Central European Countries and support actions at the political level

BOOK REVIEWS



Introduction to Magnetism and Magnetic Recording

R. Lawrence Comstock
Wiley Interscience, 1999
487 pages

The discovery about 20 years ago of new high-energy product permanent magnets based on the $\text{Nd}_2\text{Fe}_{14}\text{B}$ intermetallic compound and, more recently, of giant and colossal magnetoresistance, has led to a renaissance in the search for new magnetic materials, the search for new preparative routes to recording media, the design of new, highly efficient, recording devices, and research into the fundamentals of magnetism. Although there have been several recent useful monographs on applied magnetism, strangely this renewed research activity has led to rather few new textbooks in this field. Further, it is the experience of this reviewer that the recent books which are available are far from "student-friendly" and do not replace the earlier excellent, but now dated, textbooks such as those by Cullity or Morrish. Thus there is a real need for a new textbook directed towards applied magnetism. Sadly, in the view of this reviewer, this book does not fill the gap.

This textbook originated in the graduate courses on magnetism and magnetic recording taught by the author at Santa Clara, Stanford, and San Jose State Universities in California. The author's stated goal was to fill the above noted gap in the textbook market. Hence among eight chapters, the first four are devoted to detailed basic material on magnetism and the final four are devoted to applications of the basic material to magnetic recording. This structure immediately directs this book towards engineering and, to a lesser extent, towards materials science students rather than towards physics students.

The first four chapters include an introduction to magneto-statics, a short description of the types of magnetism, and magnetic measurements, a quantum mechanical description of paramagnetism, ferromagnetism, antiferromagnetism, and ferrimagnetism, and a discussion of magnetocrystalline anisotropy and magnetostriction.

Throughout the book, the author has, by choice, mixed SI and CGS units. The reviewer finds this a serious source of confusion especially for students who may approach applied magnetism for the first time in the first four chapters of the book. Further, the author should know that the MKS system has been renamed in 1960 the SI system of units and he definitely should have abandoned the use of the MKS name. A good example of the confusion which arises from this mixture of units is found in Figure 1.20 in which the load line is in SI units and the axes are in CGS units. Another perturbing example is at the top of page 359 where the unit system is changed between the first and second equation. Probably because this book represents "improved" lecture notes for engineering students, the writing lacks the fluency that should be expected in a textbook. For instance, in some sentences, the

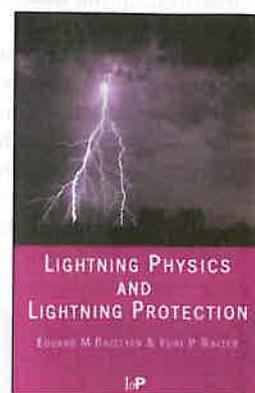
verb is replaced by the equal sign in an equation. Some other sentences are rather absurd, such as that on page 39 which states "Magnetic materials are magnetic because the atoms of which they are made are magnetic." Further, the entire book, and especially the first two chapters, should have been more carefully proofread; there is, on average, at least one typographical error per page in the first chapters. The reviewer finds this very distracting and imagines that students may find it extremely annoying. Sometimes these errors are minor, but sometimes they are more important, for instance "electron frequency" rather than "photon frequency" in the description of the photoelectric effect on page 68, or "The angular momentum vector processes ..." instead of "precesses", on page 69. There are also problems with mathematical notation, such as a change in notation between an equation, a figure, and the text or, sadly, undefined notation, such as v_n on page 71. Finally, there are also errors in the figures, such as in Fig. 2.10 in which the projection of μ has been drawn incorrectly. All these minor and sometimes less than minor errors will make it difficult to use this book as a textbook. In the least, students will need to be forewarned of the problems.

The last four chapters deal with applications of the basic magnetic concepts to magnetic recording and discusses in detail the processing of thin films, magnetic recording systems, magnetoresistive and giant magnetoresistive heads, and magnetic recording media. This portion of the book reads more fluently and, apparently, contains fewer annoying errors. I still noticed some strange sentences, such as the one on page 359 which states that "...the slope of the $\cos^2\theta$ is linear". In the last four chapters there are many practical experimental numbers, plots, and technological details which a teacher and/or an engineer may find most useful in illustrating a lecture or in designing a new or improved magnetic recording device. The students and teachers who use this book will be pleased to find several excellent questions and problems at the end of each chapter.

Prof. Fernande Grandjean, University of Liège, Belgium

Lightning Physics and Lightning Protection

Eduard M. Bazelyan & Yuri P. Raizer
IOP Publishing, 2000
325 pages



With this book the authors put their emphasis on the second part of the title. They present an overview of up-to-date physical concepts of lightning development as a basis for researchers and engineers to judge the properties of this gas discharge phenomenon. In discussing the nature of various manifestations of lightning, the authors focus on the mechanisms of interaction between lightning and different structures. Based on these considerations, the effectiveness of various protective measures and possible improvements are discussed. Therefore this book can serve as an ideal introduction for those interested in the basic physics and the engineering aspects of lightning protection.

The first chapter provides a nice overview, introducing all types of lightning discharges, their basic components and the different possible hazards of a lightning strike. Some numerical estimates for simple examples help the reader to become familiar with and to develop a better feeling for this subject. The next chapter discusses the physics of spark discharges in a long air gap. Because the physical processes in lightning occurring in nature are not easily accessible, it is these phenomena studied in high voltage laboratories that have provided scientists with the knowledge on details of the physical processes in lightning. Then a detailed overview on the available lightning data is given. Here also very recent data have been included. Based on these data and the laboratory measurements, the next chapter discusses the physical processes in different types of lightning discharges. Turning to the applications of such research, the last two chapters discuss the lightning attraction of objects (which is the principal issue for lightning protection technology) and the lightning effects on modern structures (e.g. planes and underground communication cables).

This book does not discuss in detail all available information on lightning, but it is intended to provide the basis thereof as far as it is necessary to understand protection measures and to improve them. Therefore it is well suited for engineers and scientists interested in this type of applied physics, and it provides a basic and understandable introduction for students. Unfortunately, the English translation of this book has not been performed - or checked - by a native speaker. At some places this would have improved the readability of the book, but otherwise this book can be regarded as a very good textbook on applied lightning research.

Hans-Stephan Bosch

Max-Planck-Institut für Plasmaphysik, Garching/Greifswald

into the eigenfunction corresponding to the measurement outcome. The difficulty is that nowhere is the concept of 'measurement' objectively defined. This 'measurement problem' has been known about for nearly three-quarters of a century, but has still not been resolved to general satisfaction.

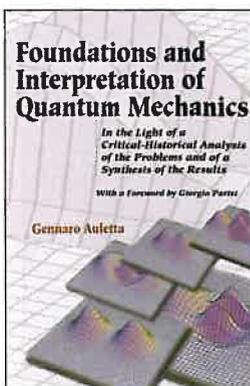
Gennaro Auletta believes that the historical context should form a vital part of our understanding of the foundations of quantum physics, and this approach is embedded in this book, which reviews the whole subject from its inception until the end of the twentieth century. This is a huge project and the result is a very big book (nearly 1000 pages). With over 500 references, it will be an invaluable asset for students and established workers in the field.

Despite its length, several topics are treated very cursorily and one sometimes wonders what the point of their inclusion is. For example, anyone who knew nothing about the Dirac equation would have great difficulty understanding this treatment, which covers less than two pages. The author might have used the space better by expanding those sections that were particularly relevant to the foundations and interpretation.

The section on the Copenhagen interpretation is particularly interesting from an historical point of view. Throughout, the ideas are compared with the results of experiments conducted over the years. For example, Auletta shows how recent observations on single particles falsify statistical interpretations, particularly of the type first proposed by Einstein. The debate between Einstein and Bohr is well-trodden ground clearly recounted, but less familiar are the distinctions Auletta is careful to make between the work that originated from the different schools of thought operating at the time. Thus Bohr and the Copenhagen group placed great emphasis on complementarity, Heisenberg developed the uncertainty principle, and Von Neumann developed the formalism that underpins most of the teaching of quantum mechanics today. Although many today look back on this as progression to a single theory called the Copenhagen interpretation, Auletta believes (p230) that 'von Neumann's quantum mechanical treatment...is absolutely contrary to the spirit of Bohr's philosophy'. The nub of the disagreement is whether, as Bohr believed, the essential feature of measurement is the presence of macroscopic apparatus (however defined) or whether (following von Neumann) a conscious observer is essential.

Most modern views would go along with von Neumann's formalism, but be very reluctant to go down the consciousness road. This is the core of the measurement problem and a central part of this book. Three possible alternative ways forward are explored: the Many Worlds Interpretation, Semiclassical Apparatus, and Decoherence. The Many Worlds Interpretation essentially assumes that unitary evolution continues even through the measurement process. A necessary consequence of this is the branching of the wavefunction into a superposition of all possible measurement outcomes - i.e. 'worlds' - which persist for ever while being unaware of each other's existence. This chapter is surprisingly short considering how many people take this approach seriously today and how often it is referred to in the later chapters of this book. Auletta's criticism of the Many Worlds Interpretation is largely founded on the difficulty of defining objectively the set of worlds that will evolve from a measurement (the 'preferred basis' problem) and he does not consider to what extent this has been overcome by the work on decoherence. The real problem for the Many Worlds Theory is how it can be meaningful to define relative probabilities for events if they are all occurring simultaneously; this is mentioned, but given little emphasis.

The chapter on 'Semiclassical Apparatus' focuses on the idea of



Foundations and Interpretation of Quantum Mechanics

Gennaro Auletta
World Scientific Publishing Co., 2000
1000 pages

The present decade marks the centenary of the origins of quantum physics, beginning with Planck's quantum hypothesis early in the twentieth century. The outstanding success of the theoretical structure that emerged is, however, matched by the continuing problems of interpretation and understanding at a fundamental level. Quantum mechanics, as it is conventionally presented, provides a very powerful algorithm for making statistical predictions about the outcome of experiments, but no attempt to go beyond this and develop an 'ontology' that would explain the quantum world as it really is has yet succeeded in commanding general approval. Moreover, quantum mechanics contains two different descriptions for the time evolution of a quantum state. Between measurements, the wavefunction undergoes a 'unitary evolution' governed by the time-dependent Schrödinger equation, but when a measurement is made, the wavefunction 'collapses'

measurement being the result of the interaction between a quantum system and a classically unstable measuring apparatus. Auletta shows how the early work in this field was unsatisfactory, but surprisingly does not link this chapter to the later work of Tony Leggett and others that is featured later in the book.

Decoherence is perhaps the most significant step forward in our understanding of the basis of quantum mechanics in recent years. Essentially this has shown how the inevitable interaction of a quantum system with its environment removes the correlations that otherwise exist between the different quantum states. This is dramatically true as soon as any macroscopic measuring apparatus is involved, when these correlations are found to disappear with incredible rapidity. Auletta gives a full and clear description of this and concludes (p289): 'Decoherence is able to solve practically all the problems of measurement which have been discussed in the preceding chapters'. In the light of this quite remarkable statement, one wonders why the book has 600 more pages to go! In fact, it is clear from the body of the chapter, that Auletta knows that the essence of the measurement problem as requiring two types of time evolution is not solved by decoherence; so it is a pity that he propagates a misunderstanding that is all too common in the field.

The last section, apart from the Conclusions, is entitled 'Information and Quantum Mechanics'. This is an area in which there has been great progress during the last twenty or so years. The first chapter in the section contains a discussion of the idea of entropy in quantum mechanics; the second discusses developments in Quantum Cryptography and Teleportation, while the third and last describes the great effort that has gone into investigating the theoretical possibility of Quantum Computing. In principle, certain computational tasks could be performed simultaneously by processing a quantum state that is formed from a linear superposition of a number of components, each of which is performing a calculation. To retrieve any information about the outcome, a measurement must be made and this limits the amount of information that can be abstracted. In favourable cases, however, it is theoretically possible for a quantum computer to obtain results in a few hours that would take a conventional machine millions of years. It is generally agreed that any practical device would require huge technological advances and the value of this work is largely, that it has led to 'a better insight into the relationship between superposition and decoherence ...' (p781).

The Introduction promises a 'physical interpretation of QM' in the last chapter. I actually read this before anything else, but was not surprised to find that it meant little to me at that stage. I returned to it after I had read the rest of the book, but was disappointed that my comprehension had hardly increased. As far as I can make out, the fundamental dichotomy between unitary evolution and measurement collapse remains unresolved. Auletta claims (p796) that 'QM provides us with a new form of thinking that is neither "realistic"...nor "subjectivistic"'. This leads on to largely meaningless statements such as 'individuals are operations' (p796).

However, the fact that the author has not solved the problem that has been haunting quantum mechanics for so long should not blind us to the merits of this book. It is a tour de force that deserves to be treated as a definitive reference to the twentieth century's contribution to our understanding of quantum physics.

Alastair I M Rae

Reader in Quantum Physics, University of Birmingham, UK.

Books for review

Bose Einstein Correlations and Subatomic Interferometry
Richard M. Weiner
John Wiley & Sons, Ltd., 244 pp

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Richard Wigmans
Oxford University Press, 726 pp

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Trinh Xuan Thuan
Oxford University Press, 367 pp

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Gordon and Breach Science Publishers, 435 pp

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Letters

H. Nifenecker and E. Huffer, have given a comprehensive overview of decisive factors on the choice between "Global warming or nuclear waste" in EPN 32/2. Nuclear waste carries risks over thousands of years and the quantitative effect on the climate from anthropogenic discharges in the atmosphere is still subject to debate. That is no basis for substantial policy decisions. The forthcoming climatic instabilities require a strategy of survival. During more than two decades new measures have been stimulated, but there is no realistic perspective that the increase of the greenhouse effect will stop.

Nobody can tell when the identified changes in the climate will turn into an avalanche of synergetic effects. Threatening effects can be expected, e.g. from the methane gas hydrates (clathrates) in the cold parts of the oceans. These layers, between approximately 500 and 1000 metres below sea level, have an energy content equal to that of all other known fossil fuels resources. They are quite sensitive for a rise in temperature or a pressure drop. The 50 times larger greenhouse effect than CO₂, the 10 times shorter atmospheric half life, and their caloric value, the climatic effects of this methane will have quite a different character.

The precautionary principle justifies a rapid action in the reduction programmes for greenhouse gas emission. The current practice of changing from coal to natural gas burning will quite well offset the savings in CO₂ emission, due to losses of a few per cent during exploitation, and transportation. Lifetime-extension of nuclear power plants is more effective.

In fora like the recent climate conference in The Hague, and in the United Nations CSD (Commission on Sustainable Development) it appears to be still impossible to get nuclear energy classified as sustainable. Is the total CO₂ emission of the whole nuclear fuel cycle including waste and decommissioning really as low as expected?

One scientific background of this stance is a holistic approach to the entropy balance of the nuclear fuel cycle (see <http://home.trouwweb.nl/stormsmith> "Is Nuclear Power Sustainable; Would it Solve the CO₂-Emission Problem?"). The authors claim that in the end nuclear emits about as much CO₂ as the burning of natural gas for an equivalent amount of electricity production.

Such extreme controversies in the scientific world diminish the political viability of attempts to increase the contribution of nuclear energy. The development of sustainable, reliable, and affordable large scale electricity generation by wind-mills and photovoltaic cells will take some more decades. Stability of power supply requires also a base-load generation with minimum CO₂ emission. Only nuclear power can provide for this in the forthcoming decades.

At the final session of the International Panel on Climatic Change meeting in 1995, influential oil supplying states moderated the strong conclusion of the Working Groups on the anthropogenic influence to a vague formulation in the Final Document. Such national interests will prolong the political indecision.

The expansion of nuclear energy slowed down considerably. Therewith the perspectives for a nuclear career diminished. The average age of the workers is moving towards the age of retirement. Their experience and expertise supports the safe and reliable operation of the nuclear plants. The performance of nuclear power generation is still improving but gloomy perspectives endanger future possibilities.

Physicists could clarify scientific controversies. For a safe, secure, and responsible future thorough analyses should not only address nuclear but also the systemic controversies on the future share of other energy sources. Even with scientific consensus, the political, technical and economic follow up will require much time.

In preparation for the immanent instabilities in the atmospheric system and the concurrent delay in adaptations in power generation, much more effort should be given to assessment of consequences, development, and realisation of strategies to survive the changes. The logic discipline of physics could give a substantial contribution, which should not be limited to physical theories, but also used to assess the future consequences, and to develop new measures to mitigate the effects of the climate changes.

R. Joern S. Harry

In their feature "Applications of high temperature superconductors", EPN 32/3, T.M. Silver *et al.* write: "In a superconducting metal, such as niobium, ... the electrons no longer act as individuals, but merge into a collective entity ... This collective entity (is) often described as a Bose condensate...". Referring to the microscopic theory of Bardeen, Cooper and Schrieffer as an explanation of the condensate the authors continue: "Such a condensate requires that the particles composing it be bosons, that is, have integral spin.

Bosons obey Bose-Einstein statistics. Below the critical temperature the bosons in a superconductor can all gather together ... to form the condensate. ... Some of the electrons form the so-called Cooper pairs... Because the Cooper pairs have zero spin, they can participate in Bose condensation."

This is incorrect. Cooper pairs are NOT bosons, despite of what one can read frequently, because within the volume of one Cooper pair of a conventional superconductor there are about one million of mass centers of other Cooper pairs, their creation and destruction operators do not satisfy bosonic commutation relations, and their condensate wavefunction is antisymmetric; see, e.g., J. R. Schrieffer, "Theory of Superconductivity" (Benjamin, N.Y., 1964, pp. 32-42).

In BCS superconductors Cooper pairs can only exist within the condensate. They cannot be found in excited states according to the Bose-Einstein distribution function. This has important consequences for charge transport. The elementary excitations of BCS superconductors result from the "break-up" of Cooper pairs and obey Fermi-Dirac statistics.

Composite particles, consisting of an integer number of fermions, may be only considered as bosons in a many-body system, if the average distance between the composite particles is considerably larger than their spatial extension. Bosons may form phase-coherent condensates. But not all phase-coherent condensates must be formed by bosons: Cooper pairs are an example.

Otherwise, the article presents a very informative, comprehensive review of the problems and opportunities associated with large and small scale applications of high temperature and conventional superconductors.

Reiner Kuemmel

Letters, opinions, comments... please send them to:
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Call for proposals 2002

LURE : Synchrotron Radiation Laboratory - France

Description of the facility

LURE is one of the biggest European facilities dedicated to the use of Synchrotron Radiation (SR). It has two storage rings, DCI and SUPER-ACO and a linear accelerator which provides positron beams for filling both machines. DCI produces x-rays in the energy range 2-50 KeV, thanks in particular to a superconducting wiggler. In SUPER-ACO radiations are available from far infrared to soft x-rays (5 KeV).

Some 40 experimental stations, 20 on each ring, can be operated simultaneously. Most SR applications are possible with a special emphasis on molecular and atomic physics, surface sciences, absorption spectroscopy, diffraction and biology.

A special feature of LURE is the important use of the beam temporal structure at SUPER-ACO which operates 50% of the time in the two bunch mode.

SUPER-ACO operates in average 4 days a week with a total of about 165 days per year. The corresponding figures for DCI are 5 days a week, 170 days per year.

*Support of researchers from non French EU Member Countries and Associated States**

When a project has been accepted, the LURE, under the EC- program for the Access to Large Scale Facilities, can reimburse travel and per diem expenses under the following conditions : a researcher given access to the Facility is eligible to receive reimbursement of travel and expenses if he is normally working in one of the Member States of the Community or Associated States*.

Call for Proposals

Scientific experiment proposals are selected once per year by peer review panels (named programm committees by LURE) on the basis of scientific excellence.

For the experiments to be performed in 2001 proposals must be submitted by : **December 1st, 2001**

on forms which can be obtained (as well as general informations) from :

<http://www.lure.u-psud.fr>

Projets 2002

More information for applications can be obtained at

Laboratoire LURE

Centre Universitaire Paris-Sud

Bât. 209 D - B.P. 34

91898 ORSAY Cedex

Tel. 01 64 46 80 14 - Fax. 01 64 46 41 48

email. projets@lure.u-psud.fr

Overview

So far, and thanks to successive programs from the European Commission for the access to large scale facilities, scientists from the European Union (EU) Member States have completed more than 600 experiments at LURE.

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

The forthcoming deadline for applications for magnet time allocation (February to July 2002) at the

GRENOBLE HIGH MAGNETIC FIELD LABORATORY

is **October 31st, 2001.**

Scientists of EU countries and Associated States* are entitled to apply under the HPP 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 :

E. Mossang

Laboratoire des Champs

Magnétiques Intenses,

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Festkörperforschung et Centre

National de la Recherche

Scientifique

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Forschungszentrum Karlsruhe Technik und Umwelt

We are one of the biggest science and engineering research institutions within the association of national research centres "Hermann von Helmholtz-Gemeinschaft Deutscher Forschungszentren (HGE)". We are committed in the HGF research programmes on energy, environment, health, structure of matter and key technologies.

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"Head of the Nuclear Fusion Programme"

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For detailed information on the scope of the position, please contact Prof. Dr. Reinhard Maschuw (+49 7247 82-2007, e-mail: maschuw@vorstand.fzk.de).

Please send your application to Prof. Dr. Reinhard Maschuw before the end of September, 2001 (reference: 272/2001).

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You can find more information about Forschungszentrum Karlsruhe on the internet: <http://www.fzk.de>

Postdoctoral fellowships at the Niels Bohr Institute University of Copenhagen

The Niels Bohr Institute is part of the Physics Department of Copenhagen University (NBIfAFG) and has active theoretical and experimental research programs in particle physics, nuclear physics, and the physics of nonlinear and complex systems. The Institute shares building facilities with the independent Nordic research Institute, Nordita and there is considerable scientific collaboration with that Institute. More information about the Institute is available at <http://www.nbi.dk/>.

Applicants should submit a curriculum vitae, list of publications, a statement of their research interests and goals, and arrange for 2-3 letters of reference, to be sent to the following address:

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research for the future

The Laboratory for Neutron Scattering of the Paul Scherrer Institut in Villigen, Switzerland, has two openings for scientists to work in the field of neutron scattering at the spallation neutron source SINQ. The posts represent excellent opportunities for postdoctoral scientists to develop their expertise, broaden experience and interact with scientists from many countries.

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For further information please contact (A) Dr P. Fischer, phone +41 56 310 20 94, e-mail: peter.fischer@psi.ch and (B) Dr P. Allenspach, phone +41 56 310 25 27, e-mail: peter.allenspach@psi.ch.

Please send applications with C.V., a list of publications and the names of two academic referees quoting reference 3301A or 3301B, no later than by October 31, 2001 to: PAUL SCHERRER INSTITUT, Human Resources, CH-5232 Villigen, Switzerland.

**Berliner Elektronenspeicherring-Gesellschaft
für Synchrotronstrahlung mbH
EC-Human Potential Programme
Transnational Access to Major Research Infrastructures
EU Contract N° HPRI-CT-1999-00028**



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BESSY offers research groups in the European Union and Associated States access to the vacuum ultraviolet (VUV) and x-ray synchrotron radiation facility BESSY II in Berlin, Germany, under the Human Potential Programme of the European Commission. This offer also extends to Small and Medium size Enterprises (SMEs) registered in a Member State of the European Union or an Associated State for first time use.

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- pioneering and exploiting new technological applications utilizing synchrotron radiation,
- and training young scientists in this expanding field

are encouraged to send a 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 21 insertion device and 13 dipole beamlines are available at BESSY II for HPP projects. By 2002 further beamlines will be available for research in pure and applied sciences and technological applications. Experimental chambers and supplementary equipment maintained by BESSY are also available.

Proposals are selected on the basis of scientific merit by an independent peer review commission. Approved projects are granted access free of charge, including infrastructural, logistical, technical and scientific support. Travel and per diem expenses will be reimbursed to citizens of an EU Member State or an Associated State who work in an EU Member or Associated State but not in Germany.

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Beamtime Coordinator: Dr. Walter Braun, tel:++49(30) 6392-2927, e-mail: [Braun@bessy.de](mailto:braun@bessy.de)
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Fax: ++49(30) 6392-2989/-4673/-4980

BESSY Users' Office: e-mail: useroffice@bessy.de www address: <http://www.bessy.de>

Post Doctoral Positions

Experimental Fusion Plasma Physics

The Optics and Fluid Dynamics Department at Risø National Laboratory in Denmark has two openings for postdoctoral fellows in the field of experimental fusion plasma physics. The positions are in support of the fast ion collective Thomson scattering programme and entail:

- Design and implementation of diagnostic equipment.
- Data analysis and interpretation.
- Design and running of experiments.

The fellows will work in a multinational environment with our collaborators from MIT, the Max-Planck-Institute für Plasma-physik and the Trilateral-Euregio-Cluster (D, B, NL). Experiments will be conducted at the fusion facilities ASDEX Upgrade and TEXTOR.

Scientific environment

Magnetically confined fusion plasmas contain highly non-thermal populations of fast ions resulting from fusion reactions and plasma heating. The considerable free energy associated with these fast ions must be channelled into heating the bulk plasma, but is also available for mischief. By driving turbulence and instabilities, the fast ions can profoundly affect the plasma dynamics and stability, which in turn acts back on the fast ions. The recent breakthrough in experimental observation of the fast ion dynamics by collective Thomson scattering has opened this field for new scientific enquiry, permitting the extensive modelling efforts to be confronted in new ways. The fellows will join an expanding effort in collective Thomson scattering, working in close interaction with theorists.

Qualifications

- Ph.D. in plasma physics.
- Analytical, technical and organisational skills are all valued.
- Experience with fusion experiments is desirable.
- Ability to work as part of a large multinational team.

Terms of employment

Follow standard conditions for scientific staff at Risø National Laboratory. A scientific committee will consider all applications. The appointments will be for three years. The starting dates are negotiable. Risø seeks variety and supports equal opportunities irrespective of sex and ethnic background.

Further information

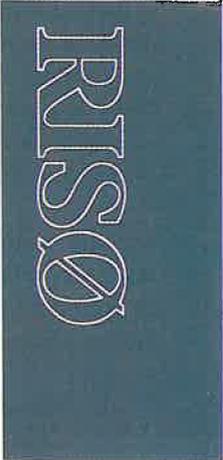
Can be found at <http://www.risoe.dk/euratom/cts> or obtained from Henrik Bindslev, Head of the Plasma and Fluid Dynamics Programme, e-mail: henrik.bindslev@risoe.dk. Information on the department is available at <http://www.risoe.dk/ofd/>.

Application

Marked "post doc 180/181-01", including CV, list of publications and reprints of maximum three representative publications should be sent in three copies to:

Risø National Laboratory
Personnel Office, Building 101
P.O. Box 49
DK-4000 Roskilde
Denmark

Deadline for application: 1 November 2001.



RISØ

Risø National Laboratory is the largest research institution in Denmark with about 950 employees. The main research areas are energy, environment and materials.

www.risoe.dk

10 Job opportunities

The *Laser Physics and Non-Linear Optics* group of the University of Twente has been operating at the frontier of laser physics since the late sixties. The research is mainly focussed on advanced laser systems for identifying novel applications and to employ these systems for fundamental research.

Nederlands Centrum voor Laser Research (NCLR) b.v. is a dynamic and innovative high-tech company whose mission is to research and develop advanced high power laser systems and to commercially exploit the results. NCLR is located on the premises of the University of Twente and closely collaborates with groups of the University of Twente for its basic research on lasers and applications. NCLR and the Laser Physics group employ a joint staff of 30 scientists in well equipped laboratories.

For the following applied and fundamental projects we are looking for young, enthusiastic *PhD students*, *Post Docs* and *Marie Curie Fellows*, who are willing to function in a multidisciplinary environment and are capable to contribute to the development of next generation laser systems and their applications.

- 1. Novel high performance gas and solid state laser systems with excellent beam quality**
This program involves research on a flexible diode pumped solid state MOPA laser system with phase conjugation and high power OPO's for wavelength tuning, long pulse VUV excimer lasers, a diode-fiber MOPA system and improving the beam quality of high power diode-laser stacks using a novel technology.
- 2. Fundamental physics with light**
One project involves research on certain media in which light can be slowed or frozen using electromagnetically induced transparency (EIT). New issues of frozen light, such as novel realisation schemes and the phase and quantum properties of the re-emitted radiation will be studied. Another project researches photonic bandgap materials using ultrashort IR pulses to demonstrate new types of solitons and of optical switching with femtosecond speed.
- 3. Electron sources and accelerators**
One project involves research on and development of large area electron-sources (emitting area of up to 100 cm²) and their applications as, e.g., X-ray pre-ionization source for kW excimer lasers and novel type of high power gas lasers. Another project studies the formation of a laser induced long plasma channel. This channel will be used to guide a TW femto-second laser pulse to accelerate electrons to ultra-relativistic speeds in the plasma wake of the laser pulse.
- 4. Continuous wave microwave free-electron laser for industrial applications**
In this project a compact cw free-electron laser will be developed in the frequency range from 20 – 100 GHz with an average power of more then 1 kW. Besides studying the physics of this oscillator, the device will also be used to research several applications.

We offer the candidates a stimulating environment and well equipped research facilities in which they can perform their challenging research.

If you are interested or if you want more information please contact

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PO Box 217, 7500 AE Enschede, NL
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 1 2 Conference program(s)

INDUSTRY YOU (one reply only):

- 1 User / User company
- 2 Design department, Independent engineering / Architect
- 3 Local government / organization
- 4 Builder / Equipment supplier
- 5 Distributor B to B / Reseller
- 6 Manufacturer
- 7 OEM's Integrator
- 8 Private Laboratorie
- 9 Operator
- 10 Consulting companies / financing
- 11 Systems integration



INDUSTRY YOU:

12 A Star-up

YOUR POSITION (one reply only):

- 1 President & CEO / CEO / Manager
- 2 Research Director / Researcher
- 3 Director / Department Head
- 4 Teacher / Trainer
- 5 Engineer / Manager
- 6 Project Manager
- 7 Consultant
- 8 Line Supervisor / Employee
- 9 Technician
- 10 Student / Doctoral student

YOUR BUSINESS SECTOR (one reply only):

- 1 Administration / Local government
- 2 Agri-food industry
- 3 Automobile
- 4 Banking / Finance / Insurance
- 5 Building / Civil engineering
- 6 Chemical / related chemical products / petrochemicals

YOUR BUSINESS SECTOR (contd):

- C13 Computer Systems/NTIC
- C6 Electrical engineering
- C7 Electronic engineering
- C8 Education, training
- C10 Environment
- C16 Health / pharmaceuticals
- C26 Metallurgical industry / transforming metal
- C14 Military / Defense
- C27 Multimedia
- C28 Normalization, certification
- C23 Optical engineering
- C15 Research / laboratories / research bodies
- C17 Services, consulting
- C11 Space / aeronautic
- C18 Telecommunications
- C19 Transportation / materials handling / logistics
- C20 Other Industries

YOUR DEPARTMENT (one reply only):

- D1 Corporate office
- D16 Technical management
- D2 Buying, general services
- D3 Engineering and design / process planning department
- D5 IT / IS
- D6 Measurement / Metrology
- D10 Networks and telecoms
- D12 Production / Operation
- D7 Quality / Control / Testing
- D8 R&D
- D13 Research
- D4 Sales / Marketing / Communication
- D11 Technical / engineering
- D17 Training

YOUR COMPANY FALLS INTO THE:

- E1 Public sector
- E2 Private sector

COMPANY SIZE IN NUMBER OF EMPLOYEES (one reply only):

- F1 1 to 10
- F2 11 to 50
- F3 51 to 100
- F4 101 to 500
- F5 501 to 2000
- F6 > 2000

TRADE SHOWS YOU WOULD LIKE TO ATTEND:

First choice: (only one reply, please)



Second choice: (multiple responses possible)



- G2 G12 Capteurs
- G3 G13 Exposition de Physique
- G4 G14 Opto
- H4 H14 Electronics Week
- M1 M11 Cabling Systems Europe
- M2 M12 Telecoms & Network Week

Other companies or associations may wish to contact you. If you would like your name to be withheld, simply write to us giving your contact details and the name of the exhibition. In accordance with article 27 of the French data protection act of 6/1/1978, you have the right to access and amend your data.

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