europhysicsnews

July/August 2001 32/4
Institutional subscription price: 91 euros per year
2001

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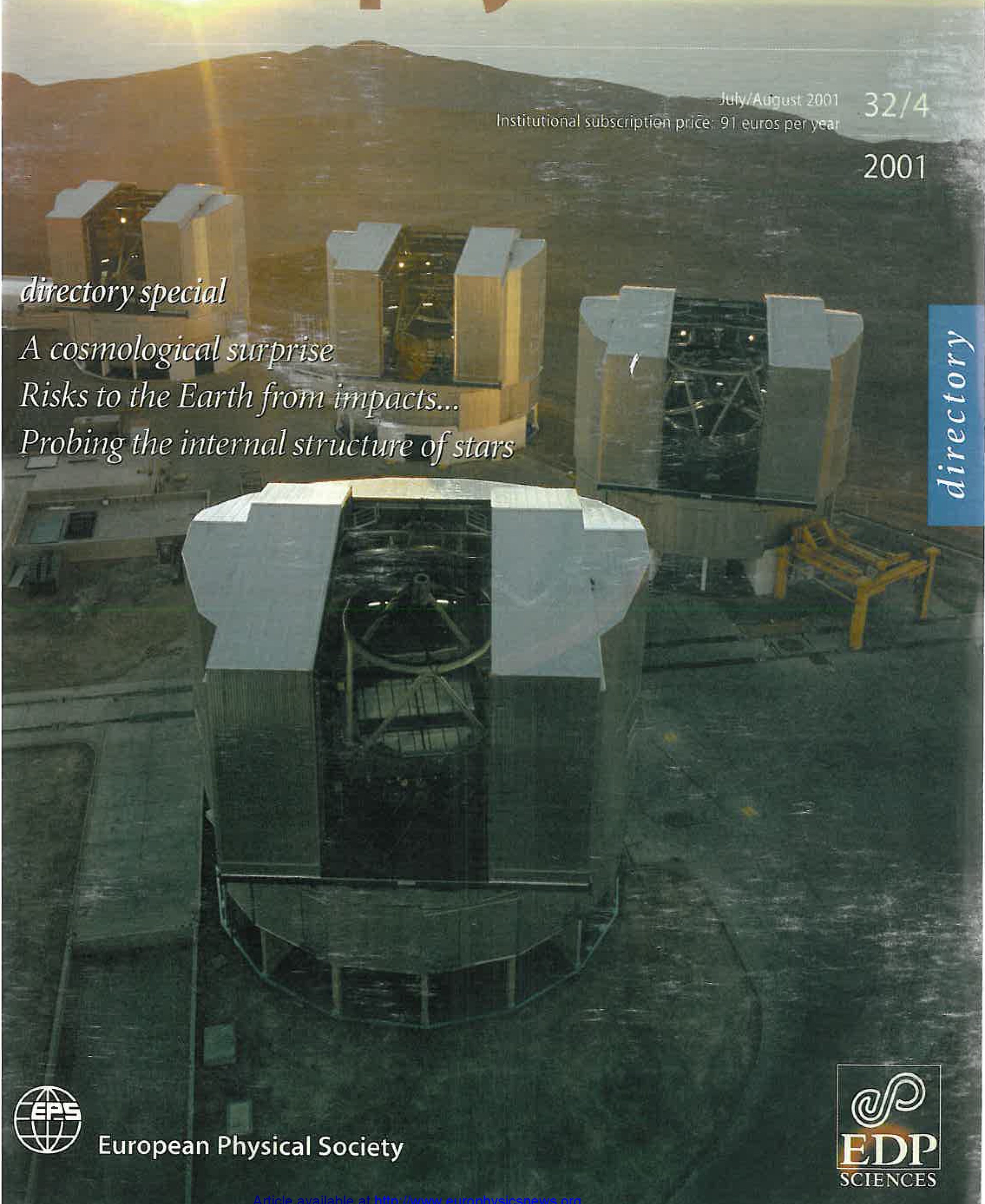
Probing the internal structure of stars



European Physical Society

EDP SCIENCES

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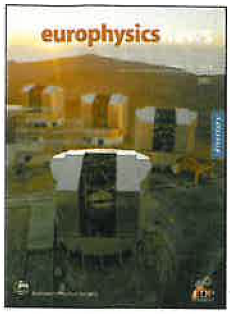
europhysics news
volume 32 • number 4
July/August 2001



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The ESO Very Large Telescope (VLT), Chile.
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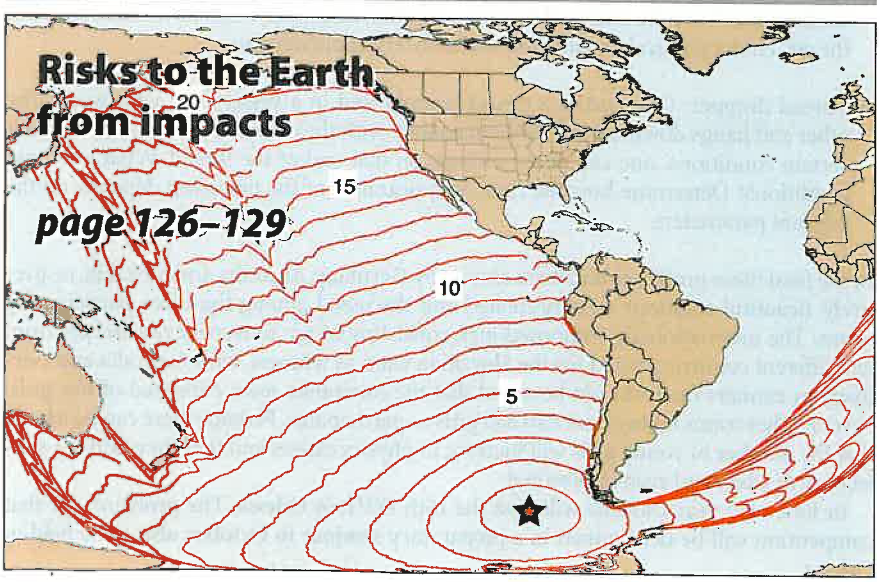

International young physicists

Gunnar Tibell, Chairman of the Pre-university Section of the EPS Division on Education President of IYPT

The 14th International Young Physicists' Tournament was arranged May 22 - 29, 2001 in Espoo, Finland, at Tapiola Upper Secondary School. The chairman of the Local organising committee was Matti Rajamäki, for the time being also serving as headmaster of the school. IYPT is a team competition in physics, for upper secondary school pupils, and this year 16 countries were represented among the 18 participating teams. Poland and Russia had two teams each.


The Tapiola Concert Hall, venue for the XIVth IYPT

The local organisers were congratulated for a superb planning which also included cultural events like visits to a national park, a science centre and the historically interesting fortress island Suomenlinna, built during the time when Finland was part of Sweden, and then called Sveaborg.

As has been described in previous reports of this annual team competition, the problems to be dealt with are published on the web, in advance. The participants have about six months to prepare their solutions. From this year, which has seen a change in the tournament regulations, there are five so called selective "fights" before the final. Three teams in each fight alternate in the roles as Reporter, Opponent and Reviewer. The Opponent challenges the Reporter team for one of the 17 problems available. After the report has been given, both Opponent and Reviewer make comments on the solution presented by the Reporter. An internationally composed jury judges the presentations. The three teams who reach the final after the qualifying rounds can choose their own problems among those on the list.

Some examples of problems, those discussed in the final, may help to understand that there are no simple and unique answers to the questions:

- Singing saw: Some people can play music on a handsaw. How do they get different pitches? Give a quantitative description of the phenomenon.

- Reaction: Make an aqueous solution of gelatine (10g gelatine in 90ml of water), heat it to 80 degrees C in a water bath and mix it with a solution of potassium iodide. Put the solution in a test tube and cool it. Pour a solution of copper sulphate on the surface of the gel. Find a physical explanation to the observed phenomena.

- Thread dropper: One end of a thread is immersed in a vessel filled with water. The other end hangs down outside without contact with the outer wall of the vessel. Under certain conditions, one can observe drops on that end of the thread. What are those conditions? Determine how the time of appearance of the first drop depends on the relevant parameters.

In the final these problems had been chosen by Germany, Australia and Slovakia, respectively. Beautiful solutions were presented and discussed among the three participating teams. The internationally composed jury, consisting of ten university researchers from ten different countries, voted for the Slovakian team as winners, with Australia and Germany as runners up. It should be noted that the Australian team consisted of five girls! Several other teams taking part also had girls as participants. Perhaps there can be a hope that the number of young girls will increase in physics classes and that they find the subject worth while and even interesting!

In June next year Ukraine will host the 15th IYPT, in Odessa. The problems for that competition will be determined in a preparatory seminar in October, also to be held in Odessa.

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Printer Rotofrance

Dépôt légal: juillet 2001

Schedule
Six issues will be published in 2001. The magazine is distributed in the second week of January, March, May, July, September, November. Meetings issues are published once a year (in September) and a directory issue with listings of all EPS officials is published once a year (in July).

Subscriptions
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ISSN 0531-7479
ISSN 1432-1092 (electronic edition)

A cosmological surprise: the universe accelerates

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Cosmology is in turmoil. The standard model of a few years ago has recently been abandoned and replaced by new ideas. The reasons for this dramatic change are new measurements of the geometry and the matter contents of the universe. The new model implies a dynamical age of the universe that accommodates the oldest known stellar objects, but raises the need for a dark energy component, which is not readily explained within the current particle physics theories.

Most current cosmological models are based on the Big Bang theory, in which the universe started in a hot and dense state. Since then, the cosmic expansion has led to adiabatic cooling, and the subsequent condensations of the matter have formed stars, galaxies and clusters of galaxies.

The Big Bang theory predicts not only the universal expansion, but also the baryonic matter content and a relic radiation from the original hot phase. All of these predictions have been observed. The detection of the cosmic microwave radiation and the tiny temperature fluctuations in it are often cited as the most spectacular success of this theory (e.g. Peebles 2001). An extension to the Big Bang theory is the proposed inflationary phase at the very earliest times of the expansion. The inflation would be driven by energy, which emerges from the decay of a particle field and produces a universe many times larger than a simple linear expansion. Inflation predicts the seeds for the growth of large-scale structure in the universe. Since the universe would be inflated several orders of magnitudes, it would essentially have a flat space geometry (Guth 1997). Among the open questions in this picture are the matter/energy content of this universe and its future.

The average energy density determines the fate of a homogeneous and isotropic universe governed by gravitational forces. It was thought that the matter content governs the expansion of the universe today, while at early phases radiation dominated. In this simple picture the geometry of the universe is directly coupled to the matter density. A flat universe implies an equivalent matter density of about $8 \cdot 10^{-27}$ kg m^{-3}, the critical density. For an average density below this value, the universe would be open and expand forever, while at a higher density it would be closed and eventually re-collapse.

Just a few years ago the total energy content of the universe was unknown. All indications were that baryonic matter makes up only about 5% of the critical density (Bahcall et al. 1999). To explain the kinematics of galaxies and clusters of galaxies an additional mass component often referred to as "missing" or "dark" mass had to be introduced. The search for direct evidence for the dark matter has, despite substantial efforts, been futile so far. Nevertheless, from observations of the evolution and mass determinations of clusters of galaxies, it appears that dark and baryonic matter could explain about 30% of the critical density. Should the universe be flat, as required if inflation is correct, then some other energy component must contribute to the average density.

For a cosmologist, there are only few parameters needed to describe the universe. All models are based on Einstein's theory of general relativity. The world models are characterized by two parameters: the current rate and the deceleration of the expansion. The first parameter is called the Hubble constant after Edwin Hubble, who discovered the cosmic expansion in 1929. The other parameter describes the change of the expansion and depends on the energy density and the curvature of the universe. The contributions to the density are expressed as fractions of the critical density and are denoted by the Greek letter Ω, e.g. Ω_M, for the matter density. The expansion itself is typically measured by the redshift. This is the ratio of the scale factor at two different times of the expansion and observed as a shift of spectral features to longer wavelengths. Hubble's law states that for small distances the redshift is proportional to the distance.

At large look-back times and distances the linearity of Hubble's law breaks down and the distances depend on the energy density of the universe. The various constituents, typically matter and

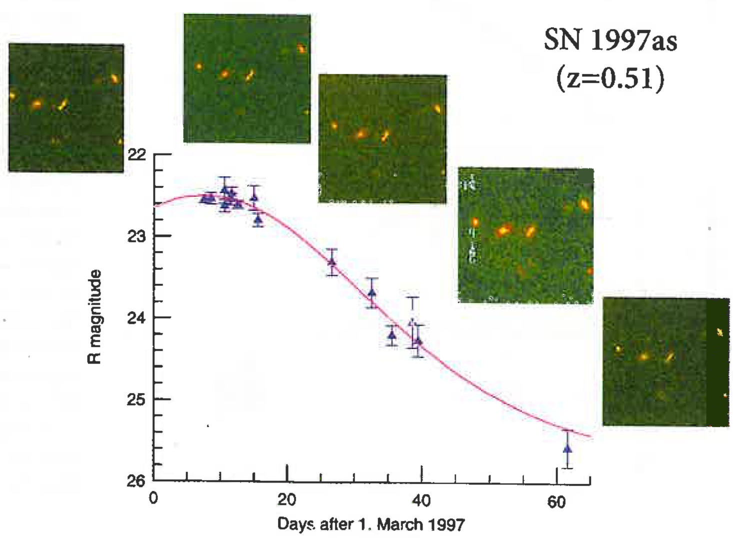

Fig. 1: A series of observations of a distant Type Ia Supernova. The object is located in a galaxy at a redshift of z=0.51 corresponding to a look back time of about 40% the age of the universe. The observations were obtained with the European Southern Observatory 3.5m diameter New Technology Telescope at the La Silla Observatory in Chile. The change in image sharpness is caused by the varying atmospheric conditions in the individual nights. The supernova at its brightest phase is about 15 million times fainter than what can be seen by naked eye.
The light curve of this object has been derived from the images. This diagram displays the rise and fall of the supernova brightness as a function of time. The red line indicates the evolution of a typical nearby Type Ia Supernova. Magnitudes are a logarithmic scale of observed energy flux.

radiation are considered, contribute in different ways to the energy density. Radiation ceased to be gravitationally important at a redshift of about z=1000, a time from which we can only measure the cosmic microwave background radiation. Another component is the famous cosmological constant introduced by Albert Einstein to reconcile the solutions of his equations with a static universe. He later abandoned this term, when Edwin Hubble discovered the general expansion of the universe. For many decades the cosmological constant was not considered in the world models as there was no obvious reason to include it and as it was not possible to connect it to any particle theory. In modern terms, it represents the contribution of the vacuum energy (Carroll et al. 1992).

The last three years have seen truly exciting progress in observational cosmology. The flat geometry of the universe has been confirmed by balloon-borne experiments that measured the fluctuations in the cosmic microwave background. The physical scale of these fluctuations can be determined from first principles and the measurement of their angular extend on the sky gives a direct indication of the geometry of the universe. All experiments agree that the universe is most likely flat (de Bernardis et al. 2000, Balbi et al. 2000).

A complementary approach to determine the geometry is through the measurement of distances. This approach actually measures the deceleration due to the gravitational attraction, which slows down the cosmic expansion. The amount of deceleration hence directly determines the average density.

Cosmological distances are, however, notoriously difficult to attain. The long and arduous history of the determination of the Hubble constant painfully reflects this difficulty. Even today, it appears that the value of the Hubble constant is uncertain to about 10%. The easiest way to measure distances is through standard candles, i.e. objects with identical absolute luminosity. Many candidates for standard candles have been proposed. Only few astronomical objects have turned out to be suitable.

A prime candidate for such a standard candle is a certain type of stellar explosions. Known to astronomers as Type Ia Supernovae these explosions occur at the end stages of stellar evolution, when low-mass stars exhaust their fuel and start to contract and cool down. The resulting white dwarfs are so compact and dense that they are supported by electron pressure. It can be shown that there is an upper limit to the mass supported by the pressure of the degenerate electrons. This Chandrasekhar limit, named after Subrahmanyan Chandrasekhar, is near 1.4 times the mass of the Sun. A single, isolated white dwarf will not change its mass, but a white dwarf in a double star system may acquire mass from its companion. If this process is efficient enough, the white dwarf will turn itself into a thermonuclear bomb that will burn carbon and oxygen explosively to nuclear statistical equilibrium. For the density and pressure in these explosions this is mostly a radioactive nickel isotope (^{56}Ni), which decays through γ-decay to ^{56}Co and further to stable ^{56}Fe. The energy is deposited in the star and blows it apart. Such an explosion can outshine the light of a whole galaxy made up of some 10^{10} stars (Figure 1). The Chandrasekhar mass is a natural limit and makes it conceivable that all Type Ia Supernovae are similar. Such a uniform constellation assures that there are only small differences between individual explosions, a prime condition for a standard candle.

Observing supernovae

Supernovae are extremely rare. A galaxy like our Milky Way may produce a Type Ia Supernova only every 400 years. Hence, one has to observe a large number of galaxies for quite some time to detect a supernova. The sample of nearby supernovae (out to a redshift of about z=0.1) is still rather limited. In fact, well-sampled light curves (e.g. Figure 1) are an exception and it has taken over a

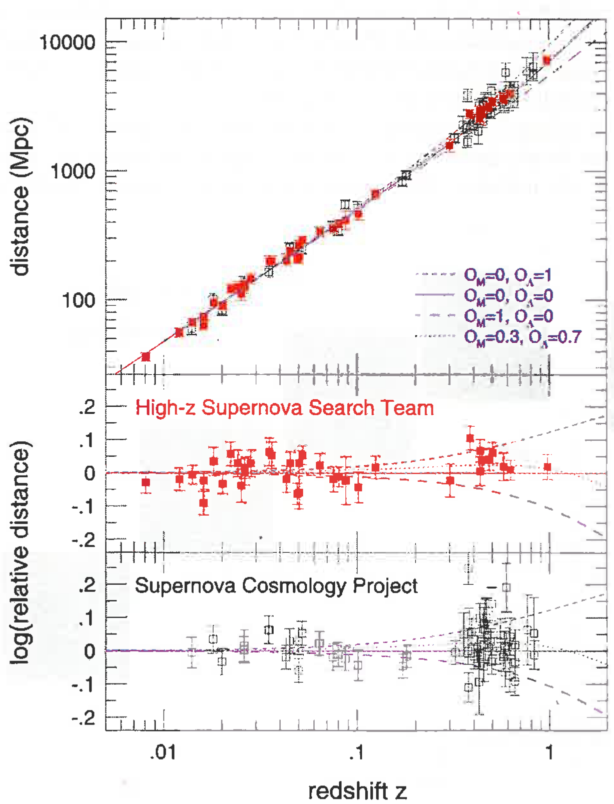

Fig. 2: Diagram displaying distance vs. redshift for Type Ia Supernovae. These diagrams are generally referred to as Hubble diagrams, as they are similar, but not identical to the original diagram showing the expansion of the universe. The upper panel shows the conventional form of this diagram. The points are the supernova measurements assembled by two independent groups, the High-z Supernova Search Team (Riess et al. 1998) and the Supernova Cosmology Project (Perlmutter et al. 1999). The nearby supernovae have been measured over about one decade, while the distant objects have been observed in short campaigns of a few months length. The lines represent the expectations for a standard candle in the specific world models. They represent an Einstein-de Sitter model in which the universe is completely dominated by matter (Ω_M=1.0, Ω_Λ=0.0), an empty universe (Ω_M=0.0, Ω_Λ=0.0) with nothing in it, and a universe dominated by the cosmological constant (Ω_M=0.0, Ω_Λ=1.0). The dotted line is a model which is consistent with all current data and has Ω_M=0.3 and Ω_Λ=0.7. The location of the model lines is set by the data for the nearby supernovae.
The lower panels show the same diagram normalised to the model of an empty universe. It is obvious that the distant supernovae lie above the line for an empty universe by about 20% in distance and require some contribution by the cosmological constant or quintessence. The favoured model predicts a non-monotonic behaviour of standard candles in this diagram.

Fig. 3: The ESO Very Large Telescope (VLT) on Cerro Paranal in Chile. This new array of four 8m telescopes is an example of what is required to observe the distant supernovae in detail. Only large telescopes, like the VLT, the 10m Keck telescopes on Mauna Kea in Hawaii and the Gemini 8m telescopes in Hawaii and Chile are capable to gather enough light for a detailed analysis.

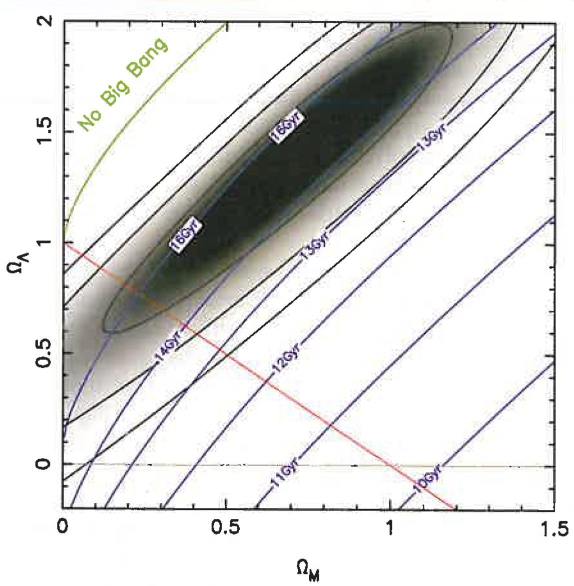

Fig. 4: Probability distribution of Ω_Λ vs. Ω_M from the supernova data. The greyscale gives the probability distribution as derived from the supernovae shown in Figure 2. The contours are drawn at 68.7%, 95.4% and 99.7% confidence level. The preference for a "dark energy" component is obvious. Ω_Λ=0 is excluded at the >95% level. The line for a flat universe as favoured by the cosmic microwave background is shown in red. The sloped blue lines indicate the age of the universe for these models assuming a Hubble constant of $H_0 = 65$ km s^{-1} Mpc^{-1}. The oldest stars have an age of about $13{\cdot}10^9$ years, which is consistent with the new supernova data but not with the Einstein-de Sitter model (Ω_M=1, Ω_Λ=0).

decade of dedicated effort to collect a significant sample of objects. In the process a lot has been learnt about Type Ia Supernovae and their physics (for a review see Leibundgut 2000).

Not all Type Ia Supernovae are identical. However, there is a way to normalise their peak luminosity according to their light curves. More luminous supernovae display a slower temporal evolution. In this way, it is possible to normalise all objects to the same peak luminosity and make them exquisite standard candles.

One way to empirically test the quality of a standard candle is to look at the distance vs. redshift diagram (Figure 2). For a redshift below z=0.1 the scatter around the line of linear expansion is extremely small and proves that, at least in the nearby universe, the supernovae can be used as distance indicators. Direct determination of the absolute luminosity of Type Ia Supernovae has recently been obtained for the 10 nearest supernovae which exploded within the last 60 years. The peak luminosity of these objects is indeed very uniform.

Distant supernovae, like the example in Figure 1, are more difficult to observe. Since supernovae are such rare events a large volume has to be surveyed to discover a sufficient number for coordinated follow-up observations. It was soon recognised that such a project would exceed the possibilities of a single observatory or group of astronomers. In fact, this experiment makes use of all the largest telescopes available. A typical campaign involves the European Southern Observatory VLT (Figure 3), the Keck telescopes, the Canada-France-Hawaii telescope, the Cerro Tololo Inter-American Observatory and the Hubble Space Telescope. The supernovae are observed for about two months with all available telescopes. The resulting light curves, like the one shown in Figure 1, are analysed to derive the peak brightness and plot them in diagrams like Figure 2.

With the model lines calibrated by the nearby supernovae the distant explosions tell us how much the universe has expanded between then and now. From Figure 2 it is obvious that the distances are larger than what would be expected in a freely coasting, i.e. empty, universe. Even worse would be a fit for a flat and matter-filled Einstein-de Sitter model. The distant supernovae are simply too faint, i.e. too distant to be compatible with the old paradigm of a universe filled with matter and radiation only. There has to be a component to the energy density that has accelerated the expansion over the last $\sim 6{\cdot}10^9$ years (Riess et al. 1998, Perlmutter et al. 1999, Hogan et al. 1999, Riess 2000).

An obvious candidate is the cosmological constant. With the supernova result it appears that it should be re-introduced to explain the data. Another possibility is that the cosmological constant is indeed zero, but that there is a particle field that through its decay acts like a cosmological constant. It has now come to be known as 'quintessence' (Ostriker and Steinhardt 2001). Independent of which explanation is correct we can designate the energy density of this "dark energy" as Ω_Λ. Figure 4 shows the probability distribution between the matter density Ω_M and Ω_Λ as the supernova distances define them. It is obvious that models with Ω_Λ=0 are excluded at the >95% level for all models with a positive matter content. This comes from the fact that an accelerating, negative-pressure component is required, which can not be achieved with matter or radiation.

A nice feature of world models with these parameters would be that the dynamical age of the universe is no longer in conflict with the ages of the oldest stars in our Milky Way. We have marked the isochrones of the dynamical age for the combination of Ω_M and Ω_Λ in Figure 4.

The result from the distant supernovae that the expansion of the universe is not decelerating but in fact accelerates is certainly

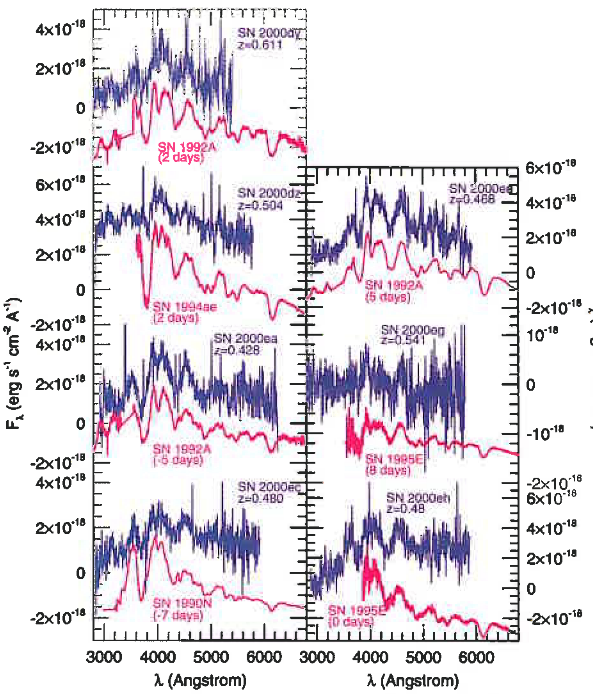

Fig. 5: Comparison of spectra of nearby and distant supernovae. Spectra of seven distant Type Ia Supernovae observed with the VLT (blue) are compared with nearby objects (red) at the same phase. The distant objects look remarkably similar to the nearby ones. This is an important check as the spectra are "finger prints" for the chemical composition of the supernova ejecta. Contamination of galaxy light or reddening of the objects due to dust can cause changes in the slopes of the continuum emission.

surprising. We should answer the obvious question how secure this result is. There are a few other possible explanations for the faintness of the distant supernovae. They are an intrinsic evolution of the peak brightness of the supernovae, unrecognised dust, or gravitational lensing. Evolution has been the downfall of all previously proposed distance indicators. Take for example regular galaxies. Looking back for several 10^9 years means that a galaxy is composed of stars, which are on average younger than the ones currently in our Milky Way. Since a galaxy with young stars has a larger fraction of short-lived, massive stars, which are brighter and bluer, it will change its luminosity over time. Could Type Ia Supernovae also suffer from evolutionary effects? At first glance, such an evolution is less likely. According to the current models they are explosions of stars, which always end up in the same configuration, a white dwarf at the Chandrasekhar limit. However, even though the bomb always has the same mass, its composition may vary slightly. The explosive carbon burning in a white dwarf depends on the mixture of carbon and oxygen. One could imagine that the distant supernovae have had a different chemical composition at the explosion than their nearby counterparts. Also, stellar evolution predicts that younger white dwarfs are the descendants from predominantly more massive stars. Thus, the parent population of the distant supernovae could be different from the one observed nearby. Unlike for the nearby supernovae we can not use the linear expansion law to check for consistency.

What has been tried in the last few years is to make sure that the distant objects have the same appearance as the nearby ones. This program is still under way, but first results are already becoming available. The observed spectra of the two populations are so far indistinguishable (Figure 5). There is further a very characteristic light curve shape with a second maximum of Type Ia Supernovae in the near-infrared, which by now has also been observed for the distant supernovae. On the other hand, there appears to be a trend to bluer colours for distant supernovae, which, if confirmed, may hint at evolution.

Interstellar dust also dims astronomical objects. Galactic dust distributed in the plane of the Milky Way is the reason we can not observe the Galactic Centre in optical light. But galactic dust not only dims the objects, it also preferably scatters blue light and makes objects appear redder. If the intrinsic colour of an object is know, the observed light can be corrected according to the galactic absorption law. The colour evolution of Type Ia Supernovae is in fact very uniform and by always obtaining colour information for the distant supernovae we can check for dust and correct the brightness, if necessary. But there is nothing that says that the galactic dust is representative throughout the universe. For example, larger dust particles scatter differently so that the supernovae still would be dimmed but not as reddened. Observing programs to check this possibility have been carried out last year and are currently being analysed.

Along the light path of any distant object lie other massive objects. Background galaxies are distorted by the potential wells through which light has to travel and the galaxies are stretched into large arcs, which are regularly observed in massive clusters of galaxies. Another effect of gravitational lensing is amplification or de-amplification of the light. It turns out that distant objects are on average de-amplified, i.e. statistically appear fainter. This would be an obvious explanation of the dimness of the distant supernovae. However, the effect is not large enough, even if all mass would be concentrated in compact objects, and can not explain the distant supernovae. This result is based on model calculations, as this is the only effect that can not be observed with the supernova light itself.

There is one signature, which would almost unambiguously prove that the universe has been accelerating over about half its age. This is the deceleration during the early phases of the expansion. The cosmological constant does not change over time, but since the density decreases the gravitational action should have been much larger during the first few 10^9 years. In Figure 2 this shows up as a non-monotonic evolution. The critical redshift range is around z=1.2, a range that has so far not been explored by the observations. This is stretching the current capabilities of any existing telescope. The supernovae become exceedingly faint and due to the redshift have to be observed at near-infrared wavelengths where the night sky is much brighter than in the optical. Nevertheless, the next observing campaigns will target exactly this redshift range to test whether the acceleration of the universal expansion is indeed the correct interpretation for the dimness of the distant supernovae.

There is a big problem with the cosmological constant. In modern particle theories it is associated with the energy of the vacuum, but these theories also predict a value for the vacuum energy which deviates by more than 50 orders of magnitudes from the cosmological observations. Although this has been a problem all along, the supernova measurements have acerbated this problem, by requiring a non-zero but small (<1) cosmological constant. For these reasons many theorists currently favour quintessence models. But this requires introducing a new particle field and corresponding potentials, which have to be fine-tuned to have an action like the observed one.

But there is more on the horizon. To distinguish between a cosmological constant and quintessence the time variability of the acceleration should be checked. Tracing the supernova distances in detail can do this. A large sample of supernovae out to a redshift of about z=1.5 is needed. Proposals to obtain such samples have already been made.

Type Ia Supernovae together with the recent results on the cosmic microwave background and the masses of clusters of galaxies are consistent with a flat universe, in which about 30% is gravitating matter and 70% is contributed by "dark energy" (cosmological constant or quintessence). Only about 5% of the total energy stem from baryonic matter. Another 5% may be contributed by massive neutrinos.

The opinions of cosmologists currently range from visions of "precision cosmology" to worries about the fact that we have to add new constituents to the universe for which we have currently no explanation at all. This is not necessarily a contradiction. Observers have been furnished with tools over the last decade, which allow them to probe many of the cosmological questions in much more detail and with much higher precision. On the other hand, these new results have shown that our picture of the universe was incomplete and will need further scrutiny.

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About the authors

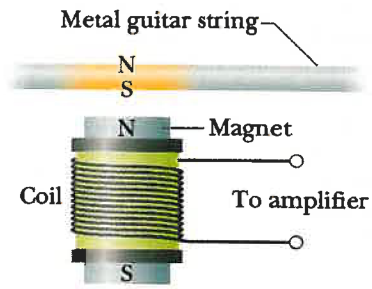
Bruno Leibundgut and Jesper Sollerman work at the European Southern Observatory in Garching, Germany, and are members of the High-z Supernova Search Team. They have concentrated on the physics of supernovae throughout their careers. While Bruno Leibundgut studied the light evolution of Type Ia Supernovae and characterised their capability as standard candles extensively, he also works on other types of stellar explosions, their progenitor stars and their impact on the local stellar environment. Jesper Sollerman concentrated on the very late phases of supernovae when they reveal their ashes. He has further worked on investigations of the Crab Nebula, the remnant of supernova that exploded in AD 1054.

Physics... in action

Dr. Vassilis Lembessis, The University of Southeastern Europe, Athens

The electric guitar is the one instrument that epitomises rock music. As with so many other ear-shattering inventions, physics played its part.

The birth of rock music in the mid-1950s was accompanied with a switch from acoustic to electric guitars. For an electric guitar, we know that we can make a metal string electric with the help



of a magnet. Under the strings we put a series of bar magnets known as the pickups (as shown in the figure). These magnets are placed inside a solenoid having one of their poles very close to the strings. The presence of the magnet produces a north and a south pole in the section of the metal string just above the magnet. When the guitarist plays a string it vibrates, changing the magnetic flux through the solenoid generating an induction current in the solenoid. This current goes to properly designed electronic devices for amplification and the generation of sound.

Thus the operation of the electric guitar is radically different from that of the acoustic. Whereas in the acoustic guitar the sound depends on the acoustic resonance produced in the hollow body of the instrument by the oscillations of the strings, the electric guitar is a solid instrument, so there is no resonance. Instead the oscillations of the metal strings are sensed by electric pickups that send signals to an amplifier and a set of speakers. As the string oscillates toward and away from the coil, the induced current changes direction at the same frequency as the string's oscillations, thus relaying the frequency of oscillation to the amplifier and speaker.

It was Jimmy Hendrix who first understood the electric guitar as an electronic instrument and who showed that we could gain further control over the music by changing the number of turns of the solenoid and thus the amount of electro magnetic flux induced in the coils and therefore their relative sensitivity to string vibrations.

Further reading

Halliday-Resnick-Walker: Fundamentals of Physics 6th Edition, Wiley International.

features

Risks to the Earth from impacts of asteroids and comets

Dr Harry Atkinson, chairman of former UK government task force on the subject

Thirty years ago few took seriously the risk to mankind of impacts on the Earth of asteroids and comets, or "near Earth objects" (NEOs) – apart from a handful of dedicated astronomers. There seemed to be little evidence for such a risk: the craters on the Earth and the moon were generally thought to be of volcanic origin, not made by impacts; and while, since prehistoric times, comets must always have aroused interest, or even dread, their true danger was not understood. As for the main risk, asteroids, they were so small and dark that the first (and biggest) was not discovered until 1802. The first systematic survey of asteroids did not begin until 1970.

Two things brought home the potential dangers: first, a suggestion in 1980 by Alvarez (father and son) et al that the dinosaurs had been extinguished as the result of a large object hitting the Earth 65 million years ago; and second, in July 1994, the collisions of a succession of pieces of a large comet, Shoemaker Levy-9, with the giant planet Jupiter, each piece causing an explosion about the size of the Earth (Figure 1). This triggered the production of two films, Armageddon (with Bruce Willis) and Deep Impact, which made the idea of NEO impacts familiar to a much wider public – but may have registered more as science fiction, with a strong dose of "giggle factor". Arthur C Clark had already pointed to the danger of asteroids in his novel Rendezvous with Rama in 1973, and had coined the term "Spaceguard" subsequently used for surveys and by concerned organisations.

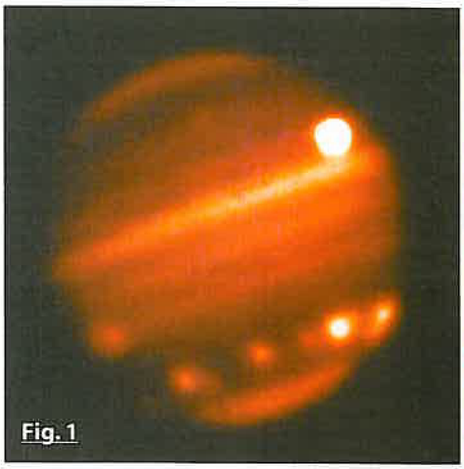
By the early 1990s, however, the US Government had become convinced that NEO impacts were science fact, not science fiction, and Congress initiated expert studies of both the detection and mitigation of NEOs. As a result, NASA was given the task of identifying, over a ten-year period, 90% of all asteroids of diameter greater than 1 kilometre. Observations for this "Spaceguard" survey began in 1998 using dedicated wide-angle US Air Force surveillance telescopes, of aperture 1 metre, each equipped with a large CCD detector array. About 500 of these really big NEOs have already been discovered, about half the estimated total number. The Earth is now seen as orbiting in a sea of near Earth asteroids, as graphically illustrated in Figure 2.

It is remarkable that no other government took the threat seriously – that is until the British minister for research, Lord Sainsbury, set up a task force in January 2000 to advise the government on the nature and risk of NEO impacts and on what the United Kingdom should do in an international context. (This followed the prompting of a British member of parliament, Lembit Öpik, whose grandfather had been an expert on comets and a distinguished director of the Armagh Observatory in Northern Ireland; and campaigning by Duncan Steel and Jay Tate).

The task force, which comprised Sir Crispin Tickell, Professor David Williams and myself (as chairman), reported in September that the risk was indeed real and comparable with other low probability but very high consequence risks taken seriously by governments. The threat from NEOs raises major issues, among them the inadequacy of current knowledge, confirmation of a hazard after initial observation, disaster management, methods of mitigation and deflection, and reliable communication with the public.

The recommendations of the task force covered both science and organisation: for science, that a dedicated international programme of advanced astronomical observations should be set up, particularly to increase knowledge of NEOs of smaller size (down to 300m or less) than those systematically covered by the US survey; these smaller objects can cause great regional or continental damage. For organisation, that steps be taken at government level to set in place appropriate bodies – international, European and in the UK – where all these issues could be discussed and decisions taken. In our view the UK and Europe generally are well placed to make a significant contribution to what should be a global effort.

On 24 February, the British government gave its formal response, welcoming the report and setting out an action-plan



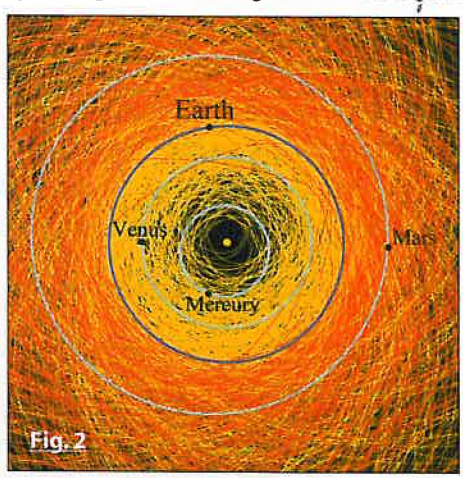


Fig. 1: Impact of comet Shoemaker-Levy 9 on Jupiter, July 1994. Before impact the comet broke into a number of fragments each hitting the planet in a different place, as shown by the belt of bright spots near the bottom of the picture. The impacts created fireballs as big as the Earth. The very bright spot at the top right is the Jovian moon Io. Photographed at infrared wavelengths from Hawaii. [acknowledgement: NASA]

Fig. 2: Orbits of the 800 or so near Earth asteroids of all sizes known at the beginning of the year 2000, with the Sun at the centre. The asteroids which cross the Earth's orbit are in yellow. They are potentially dangerous. The others, coloured red, approach the Earth but cannot strike it. The picture shows that the Earth is hemmed in by a sea of asteroids. [acknowledgements: Scott Manley (Armagh Observatory) and Duncan Steel (University of Salford)]

largely based on our recommendations. For international action, the OECD was suggested as a possible coordinating body.

Nature of hazard

Asteroids and comets are primordial material left over from the initial process of forming the solar system. Both types of object, in their millions and billions, normally orbit the Sun far away from the Earth. The asteroids are in a belt between Mars and Jupiter (2 to 4 Astronomical Units from the Sun, one AU being the Earth to Sun distance). The comets are much further away, either in the Edgeworth-Kuiper belt, 30 to 1000 AU from the Sun, or in the Oort cloud, a spherical shell of comets at the cold outer parts of the solar system at 40 to 100 thousand AU, nearly a quarter of the way to the nearest star.

Very occasionally, individual asteroids or comets are deflected by collisions or by gravitational forces into paths coming close to the Earth. The near Earth asteroids usually have orbits rather similar to that of the Earth, with periods of the order of a year; they are often stony (perhaps as groups of rocks held together only by their own weak gravitational forces), but can be carbonaceous or metallic. The near Earth comets, essentially "dirty snowballs", are in highly elliptical orbits with long periods ranging from scores of years (for example Halley's comet at 75 years) to periods so long that they are essentially "one-offs", like Hale-Bopp. These long period comets are totally unpredictable, and can be seen approaching no more than a year before possible collision, making them particularly dangerous. Fortunately, long-period comets are only a fraction of all comets; and comets in general are less numerous than asteroids: but comets travel faster and therefore have much more energy.

The Table shows that while global effects result only from the relatively small numbers of objects of diameter 1 km and above, the smaller ones are also extremely dangerous – and vastly more numerous. Even those of diameter between 30 and 100m, which do not normally reach the Earth's surface, can cause great damage through blast; an example is the 50m Tunguska object, of energy approaching that of the Bikini hydrogen bomb, which would have devastated a major city if differently placed. Two thirds of NEOs hit the sea: the serious effects of the resulting tsunamis cannot be over-emphasised, for example the Eltanin impact shown in Figure 3 (Ward and Asphaug, 2000).

Taking all sizes and impact frequencies into account, the risk of an individual's dying from NEO impacts over his or her lifetime is estimated at about 1 in 20,000. This is roughly the same as the risk of an average American dying in an aircraft accident. (Chapman and Morrison, 1994)

Nevertheless, the chance of impact of a 1 km NEO is seen from the table to be very small, on average only once every 100,000 years or so. It might be thought that this timescale is so long that the risk could in practice be dismissed. However, in other areas, such low probability but high consequence risks are taken very seriously indeed by bodies such as the British Health and Safety Executive. For example, the Sizewell B

Eltanin Asteroid Impact 2.16ma Tsunami Travel Time in Hours

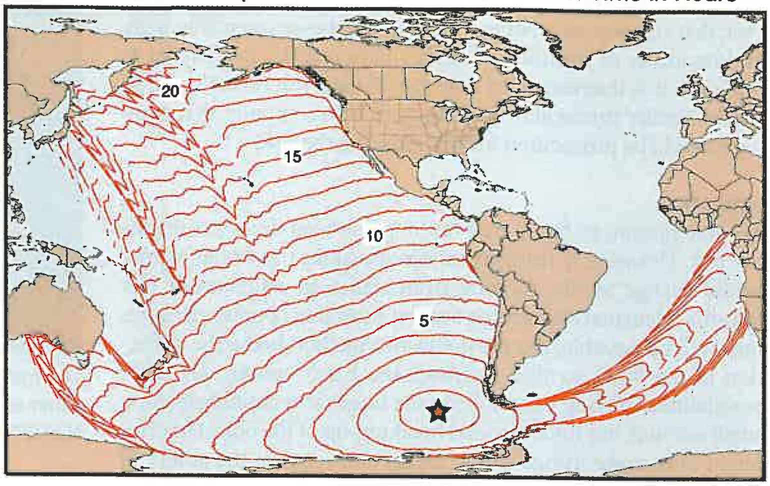


Fig. 3: Calculated progress of tsunami following impact (marked with a star) of a large asteroid, Eltanin, in the SE corner of the Pacific about 2.15 million years ago. Assuming a 4 km asteroid diameter, the initial "crater" in the ocean must have been 60km wide and 5 km deep; after 5 hours the resulting wave would have travelled 3000km and be 70m high. The evidence for the impact comes from the ocean floor which shows damage over hundreds of square kilometres.

[acknowledgement: Steven Ward/Eric Asphaug, Ucal Santa Cruz]

Numbers and effects of impactors of different size (diameter); few of those with sizes in the shaded area survive down to the Earth's surface.

Size	Number	Average interval between impacts	Energy (TNT equivalent Kilo- or Mega-tonnes)	Effect
3m	billions	weeks	2 KT	usually explode harmlessly in upper atmosphere without reaching the Earth's surface. Observed by US defence satellites. However, metallic asteroids can reach the ground; one such object exploded over the Yukon in January 2000, tripping the main electricity network over a wide area.
10m	150 million	decade	65 KT (6 Hiroshima A bombs)	ditto
30m	4 million	<100 yrs	2 MT	explode in upper atmosphere without reaching surface, but blast waves cause serious ground damage (eg Tunguska impact of 50m object in Siberia in 1908, which flattened 2000sq km of forest)
100m	100,000	3,000 yrs	65 MT (5 Bikini Hydrogen devices)	penetrate atmosphere. Serious damage on land; ocean impacts give tsunamis. On average, 5,000 deaths per impact
300m	6,000	40,000 yrs	2,000 MT	major sub-global effects including big tsunamis; half a million deaths probable
1 km	1,000	200,000 yrs	65,000 MT (1,000 Bikini)	global effects similar to "nuclear winter" calculated for all-out nuclear war. Local effects devastating; huge tsunamis if ocean hit. 1.5 billion deaths (quarter of world's population)
10 km	few	100 million yrs	65 million MT (1 million Bikini)	extinction of species (for example of the dinosaurs at the Cretaceous-Tertiary, K/T, boundary 65 million years ago). Most of world's human population would die.

nuclear power station in the UK was originally designed so that the risk of "melt-down" was less than once in 100,000 years. However, that risk was subsequently thought to be unacceptably high, and hundreds of millions of dollars have recently been spent to reduce it. It is interesting to note that if the 1 km object (with its risk of similar timescale) were "owned" by a company, that company would be prosecuted for not reducing the risk.

Mitigation

My assumption, so far, is that nothing has been done to mitigate the risk. However, if mitigation were possible, the whole picture would change totally, moving from statistical estimates of risk towards calculated certainties. Studies show that countermeasures may well be possible, the most effective method being the deflection of the NEO so that it misses the Earth entirely. Of other possibilities, moving people from the target area could help, for a small asteroid, but uncontrolled breaking-up of the object in orbit might only make things worse. Deflection requires the ability to change the object's momentum in orbit. Many ways for doing this have been considered, from solar-sails using the Sun's radiation pressure to high-powered laser beams. At present the only practical approach seems to be to use nuclear explosives. Unfortunately chemical explosives are far too heavy to deliver the punch required. Some tonnes of nuclear explosive would be required to deflect a large asteroid. Current large rockets are capable of launching such a charge in a suitable spacecraft.

Although suitable nuclear charges, designed rather differently from nuclear weapons, have not been made or tested, most of the other technologies required have already been used, for example in the recent Shoemaker-NEAR mission to Eros (Figure 4) in which, for about a year, the spacecraft tracked the asteroid in its orbit around the Sun, much of the time slowly orbiting Eros often only a few tens of kilometres from its surface; finally, early this year, the spacecraft landed safely on the asteroid – after transmitting an unprecedented amount of information about the nature of the object. Going even further, NASA's Deep Impact spacecraft will launch a 1/2 tonne copper projectile at a comet (Figure 5), ejecting material to form a crater more than a hundred metres across and "seven stories deep". The objective is to learn about the inner structure of the comet – but the impact will, incidentally, deflect the comet slightly.

In deflecting an object, it is most important to know its composition and gross structure. As already said, many asteroids are essentially piles of stones: these will simply fly apart unless relatively gentle forces are applied (with accelerations less than 1 metre per second). For this reason the asteroid may need a succession of nudges over a period of time from a succession of nuclear charges. Each charge would be detonated within a radius or two of the object; the x-rays and neutrons from the explosion will eject material from the asteroid's surface, causing it to move in the opposite direction.

While deflection is thus theoretically possible, the use or even testing of nuclear explosives in space would raise serious political problems. Indeed, the use of such means might only be contemplated if a major impact were otherwise inevitable.

It may be worth noting that for no other major natural hazard – for example volcanic action, earthquakes or tsunamis from landslips – may it be possible to act so as to obviate the hazard completely.

Recommendations: more science; international organisation

Essential prerequisites to mitigation are the discovery of the NEO well in advance of possible impact, the accurate determination of its orbit and its composition. That is why the task force gave top priority to a comprehensive survey of objects smaller than those being observed by NASA, going down to diameters of 300m or less; only a tiny proportion of such objects have so far been observed. This needs, on the ground, at least one dedicated wide-angle 3m-class telescope for discovery (preferably through European cooperation), and conventional telescopes for accurate orbit determination and spectroscopic observation of the NEO's composition. Space missions are also most important. We have pointed out the potential value of the ESA missions BeppiColumbo and GAIA for the discovery of NEOs, and have recommended the use of relatively cheap "micro-satellites" to rendezvous with different types of asteroid and comet and gather detailed information at first hand. These would greatly extend the work done by, or planned for, the major rendezvous missions of NASA or ESA. Finally, we recommended multi-disciplinary studies to learn more about the consequences of impacts. The studies would involve astronomers, geophysicists, oceanographers, climatologists, economists and sociologists, and also universities, national research councils and the European Science Foundation.

The above paragraph summarises the task force's first eight recommendations for an enhanced international observational and

Fig. 4: Asteroid Eros, shaped like a potato, is about 33 kilometres long, 13 kilometres wide and 13 kilometres thick. The crater at the top is 5.3 km in diameter. Most known near Earth asteroids are less than 1 kilometre across, much smaller than Eros. Picture taken in February 2000 by NASA's Shoemaker-NEAR spacecraft orbiting Eros at 200 km above its surface. The numerous impact craters show that even asteroids are hit by other asteroids many times in their history. [acknowledgement: NEAR/NASA]

Fig. 5: NASA's Deep Impact mission will project a 500 kg solid mass into a comet (artist's impression) in 2004. A flyby spacecraft will take images and make measurements. The impactor will also take images of the comet's surface prior to impact. The mission aims to increase understanding of the composition and structure of comets. [acknowledgement: Ball Aerospace & Technologies Corp]

scientific programme. Regarding mitigation, we recommended that the UK government, with other governments having the necessary technology, should set in hand studies to look into the practical possibilities of countermeasures, both mitigation of impacts and deflection of incoming objects.

Finally, we made the following recommendations regarding organisation (of which the first two are given in full):

> that the government urgently seek with other governments and international bodies (in particular the International Astronomical Union) to establish a forum for open discussion of the scientific aspects of NEOs, and a forum for international action. Preferably these should be brought together in an international body. It might have some analogy with the intergovernmental Panel on Climate Change, thereby covering science, impacts, and mitigation (including countermeasures). (Recommendation 10)
>
> that the government discuss with like-minded European governments how Europe could best contribute to international efforts to cope with NEOs, coordinate activities in Europe, and work towards becoming a partner with the United States, with complementary roles in specific areas. We recommend that the European Space Agency and the European Southern Observatory, with the European Union and the European Science Foundation, work out a strategy for this purpose in time for discussion at the ministerial meeting of the European Space Agency in [November] 2001. (Recommendation 11)

Regarding organisation in the UK, the task force recommended that overall responsibility be assigned to a single government department; and, most importantly, that a British national centre be created to provide independent scientific advice to the public, parliament, and the government (Recommendations 10 to 14).

The British government has taken a major step forward in its response to the report of the task force. As said in the response, negotiations with and between international institutions, and analysis of complex scientific proposals, take time. It is welcome news that the government has therefore undertaken to provide a further report later this year on its progress in implementing its plans. There is still much to be done and I await further progress in this vital area.

Further reading

Atkinson HH, Tickell C and Williams DA (2000), Report of Task Force on Potentially Hazardous Near Earth Objects, British National Space Centre, London SW1W 9SS. (An electronic version of the report and of the Government's response, together with links to other useful web sites, are on: www.nearearthobjects.co.uk

Chapman and Morrison (1994), Impacts on the Earth by asteroids and comets: assessing the hazard, Nature, 367, 33

Gehrels T (Ed), Hazards due to Comets and Asteroids, University of Arizona Press (1994), ISBN 0-8165-1505-0 (covers comprehensively all aspects of NEOs)

Steel, Duncan, Target Earth (2000), Time Life Books, London ISBN 0-7054-3365-X

Ward SN. and E. Asphaug E (2000), Asteroid Impact Tsunami: A probabilistic hazard assessment, Icarus, 145, 64-78 (and other papers)

Probing the internal structure of stars

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One generally sees only the light which escapes from the outer layers of a star, so the study of the internal structure of such objects has been a purely theoretical subject for many decades. Nowadays, the development of a very efficient discipline called "helioseismology", more generally "asteroseismology", gives us a real view through the Sun and contributes to the revelation, as, in the case of the Earth, of the internal properties of the stellar plasma. One of the major objectives of the satellite SOHO, launched five years ago, is to make progress on the physical mechanisms that describe the solar interior. In pursuit of this aim, three experiments: GOLF, MDI and VIRGO, look continuously at the persistent seismic movements of the solar surface due to the presence of acoustic waves. They use different methods: GOLF and MDI measure the time variability of the Doppler velocity, VIRGO measures the variability of the luminosity. Comparing different techniques contributes to understanding properly all the biases which may pollute the results and gives more and more confidence in our ability to check the internal properties of stars.

The stability of the stars is due to the competition between gravitational forces and radiation pressure but these processes cannot explain the great longevity of the stars. In 1920, Eddington was the first to imagine that the life of stars is dominated by the central nuclear fusion, in producing a nuclear energy which compensates for the energy lost at the surface. The first stage is the hydrogen burning, it is also the longest one, lasting from several million to billion years (about 10 billion years for the Sun). The Sun is more or less at the middle of this stage, producing helium in its nuclear core. This stage is followed by helium burning producing carbon and oxygen, then in some stars followed by carbon burning producing neon, sodium, magnesium, aluminium and silicon, then silicon burning and for the most massive stars iron burning and supernova explosions... Most of the elements we know on the Earth are synthetized in the core of the stars. The understanding of this sequence has been a great discovery of the first part of the 20th century and has allowed us to build up the main features of stellar evolution and one can estimate today for each star of the sky an age as far as we know its luminosity and surface temperature.

Since this epoch, and owing to the development of nuclear physics and atomic physics, one has been able to solve the structural equations which govern the hydrostatic equilibrium, the conservation of mass and the production and transport of energy of any star by introducing fundamental physics such as nuclear reaction rates, the equation of state and photon-matter cross sections for all the different thermodynamical conditions one may find in a star. This theoretical effort supposes that one can define precisely the properties of the plasma from the central region where most of the species are totally ionized up to the surface where molecules begin to appear. Stars evolve in space and time and only large computers may follow such evolution in detail.

To check all these assumptions, astrophysicists have observed a very large number of stars which are representative of all the different steps of evolution. Among them, the Sun represents by itself a unique case for which two kinds of probes are accessible.

The detection of solar neutrinos produced by specific nuclear reactions is a unique tool. The main advantage of this probe is the extreme sensitivity of some neutrino fluxes to the central conditions of the Sun: some reaction rates enhance by a factor of 18 an uncertainty in the temperature (an error of 1% in solar central temperature leads to an error of 18-20% on the emitted flux of neutrinos associated with the decay of ^{8}B). But the main difficulty is the extremely small interaction cross section of the neutrinos with matter (10^{-46} to 10^{-40} cm^2) and consequently with the detector. During the last two decades that one has succeeded to measure neutrinos in different detectors (initially the chlorine interaction with a factor of 3-4 deficit), the neutrinos detected represent only 30% to 60% of the theoretical values of emitted neutrinos depending on the range of energy considered.

In parallel, in the years 1980-90, helioseismic measurements have put some constraints on the external layers of the Sun. The solar sound speed profile has shown significant disagreement with the profile obtained with a model using the simple assumptions of stellar evolution (fig. 1a). These measurements have first contributed to improving our representation of the stars in precisely determining two quantities: the localized transition between radiation and convection and the photospheric helium. These results have shown that one physical process was missing in the calculation: the migration of the elements with time from the surface to the interior. Adding this process has led to improved agreement between the theoretical estimate of the solar interior and the seismic observation, which agree now along the solar radius to within 1% (comparison of fig. 1a and fig. 1b red line). But in doing so, the neutrino predicted fluxes were not in better agreement with the observations, and even a little worse.

So a lot of questions have been addressed to the different communities (astrophysics, nuclear physics, particle physics, plasma physics):

- Are the solar neutrino experiments accurate enough ? Could the long integration time (several years) partly hide the instantaneous information? Nowadays the SuperKamiokande experiment in Japan, a real time experiment, has measured about 4500 solar neutrinos per year since 1996, for which the directivity and energy is determined and there is no longer a problem of statistics. The discrepancy is always present.

- A second series of questions is directly addressed to the neutrino itself and the possibility that beyond the particle standard model, this particle has a mass. The atmospheric neutrino experiments, in detecting υ_{mu}, already suggest that these neutrinos are probably massive and may oscillate with υ_τ neutrinos. Could the Sun reveal some electron neutrino properties not presently accessible in the laboratory? The Canadian experiment SNO, which began operating in 1999, will be able to partly check this point by measuring the different flavours of the neutrinos, thanks to the use of heavy water.

In the two cases previously mentioned, only high energy neutrinos corresponding to the production of boron are measured, which are not the easiest to predict. In the future, improvements in the statistics of the gallium experiments will check the answer and variability of these radiochemical experiments. They are very interesting as they detect low energy neutrinos, in particular those emitted by the interaction between protons which are directly connected to the nuclear energy production. And very soon, other checks will be accessible with the Borexino experiment which is dedicated to neutrinos produced by the electronic capture on ^{7}Be.

Finally, physicists are seeking to find a good way to measure the whole neutrino energy spectrum produced by the reaction rates inside the Sun. This is very important to have a precise vision of the different sources of neutrinos and not an integrated value.

But there is a last series of questions addressed to our knowledge of the solar interior. How do we check the whole calculation of stellar evolution in its details ? Are we so sure of the properties

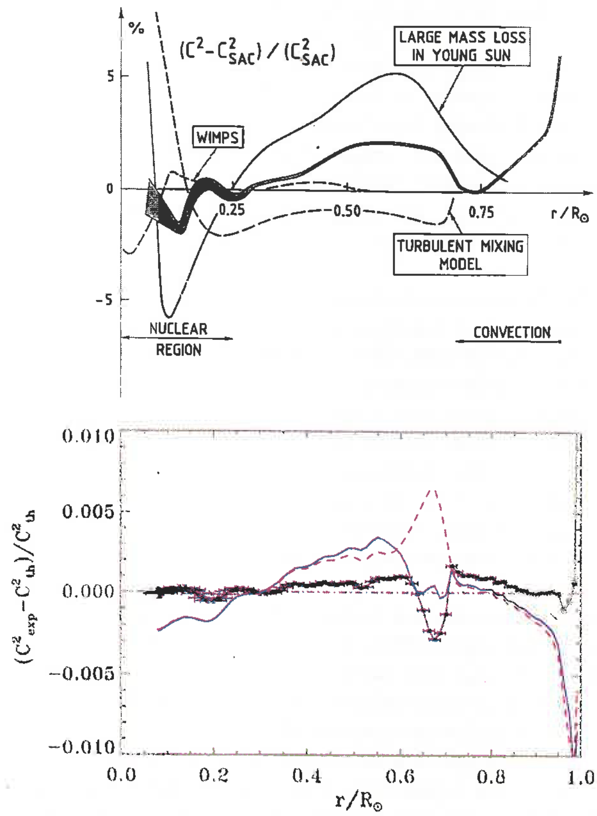

Fig. 1: Relative difference between the squared sound speed in the Sun extracted from helioseismic measurements and the squared sound speed of the Saclay reference solar model.
Fig. 1a: In the nineties, the difference was still large and the nuclear region was badly known. A lot of processes had been invoked to explain the discrepancy between predicted and detected neutrinos such as large mass loss in young Sun, WIMPS and turbulent mixing. Models including such processes are shown and disagree with the observed sound speed (Turck-Chièze et al., Phys. Rep. 1993).
Fig. 1b: the measurements are from GOLF + MDI (Rhodes et al., 1997, Sol. Phys., Bertello et al. ApJ. 1999 and ApJ.lett 2000, García et al. Sol. Phys. 2001). The main improvements of the model (red curve) are the inclusion of microscopic diffusion and fundamental physics (opacities, equation of state, nuclear cross sections). The peak at the base of the convective zone in red curve located at 0.71 R⊙ (solar radius) or 0.98 M⊙ (solar mass) illustrates a region of turbulence. The blue curve corresponds to a model where we add a turbulent term to simulate an hydrodynamical instability at the transition radiation-convection. Finally the black curve, which contains also the error bars of the observations, corresponds to a seismic model where the physical ingredients, namely the pp reaction rate, metallic content and radius, have been adjusted in their known uncertainties to reproduce the Sun seen by acoustic modes (Turck-Chièze et al. ApJ lett 2001).

of the nuclear interaction in a stellar plasma which is not accessible to the laboratory? In order to answer to these questions, the helioseismic community has worked very hard over more than 20 years to reveal the dynamical aspects of the solar interior and has put a major effort into the satellite SOHO to reach the deepest layers from where the neutrinos escape.

The helioseismic probe reveals the properties of the solar interior

The idea is simple: thanks to the movements of several millions of granules at the photospheric surface, the Sun pulsates constantly with periods around 5 minutes. By measuring with high accuracy the frequencies of thousands of acoustic modes which penetrate inside the Sun down to different depths, one may deduce information as a function of depth of some thermodynamical quantities such as the sound speed or the density.

Owing to the small amplitude of individual oscillations (<15cm/s) of a spherical object like a star, one can develop the oscillations in terms of spherical harmonics $Y_l^m(\theta, \phi)$. Observations show that the surface solar oscillations consist of a superposition of a large number of modes, with degrees l ranging from 0 to more than 1500. So one has different ways to measure them. The simplest one consists in measuring the whole-disk integrated light, observing the Sun as a star. This method is used in the VIRGO experiment aboard SOHO and will be used in stellar oscillation research through three missions: the Canadian MOST mission (launch in 2003) and two European projects COROT and MONS which will be launched around 2004-2005. The ESA mission EDDINGTON will then look at the variability of several thousands of stars and detect a large number of exoplanets.

The other way, particularly adapted to the solar disk which is easily resolved, is to observe the velocity oscillations by measuring the Döppler shift of spectral lines. There are two kinds of observation:

- first is the detection of the global Doppler velocity, measured by the displacement of some specific absorption lines (sodium or potassium). This method allows to detect the low degree modes (l = 0, 1, 2, 3) which are the most penetrating ones, as the velocity field is predominantly in the radial direction. This method has already been used in two ground-based networks: BiSON and IRIS. In the case of GOLF aboard SOHO (as in the IRIS network), we measure the global Doppler velocity shift of the sodium lines. Fig. 2 illustrates the frequency spectrum obtained by GOLF. It is the Fourier transform of the time variation residual velocity, after subtraction of the Doppler velocity due to the movements of the Sun-satellite.
- second is the detection of local velocity, separating the sun into pixels, to isolate modes of higher degrees. MDI aboard SOHO uses the nickel spectral line and obtains a Döppler image of the Sun. This instrument is extremely useful aboard SOHO as it also allows a campaign of observations from which one generates the first maps of horizontal and vertical flow velocities.

The advantage of measuring these quantities in space, at the Lagrangian L1 point, guarantees the continuity of the data along year without day/night interruption or effect of atmospheric pollution between different sites in a ground-based network. Consequently, after several years of uninterrupted accumulation of data, one may deduce a spectral answer with remarkable accuracy. This gives access to modes, with very small amplitudes and a velocity down to some mm/s, which are less perturbed by surface variability.

What have we learned from the European SOHO satellite, a joint project of ESA and NASA?

Actually, three thousand acoustic multiplets allow the determination of the differential rotation, the sound speed and the density

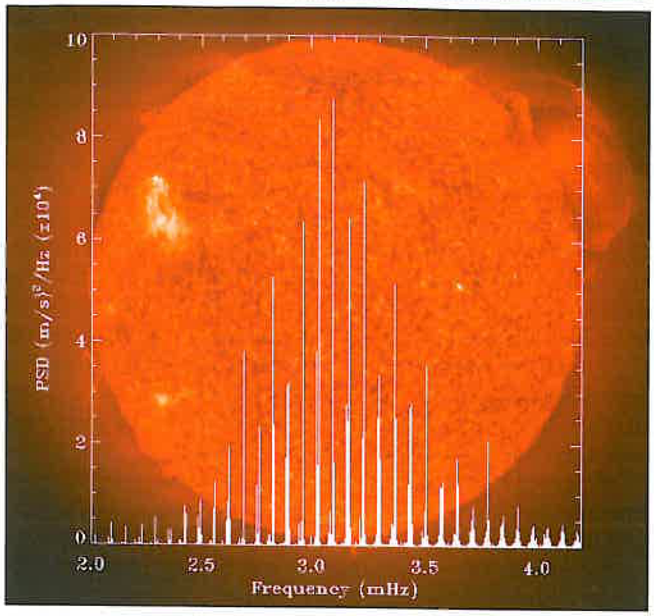

Fig. 2: Frequency spectrum of the acoustic modes obtained with the GOLF experiment aboard SOHO, integrated over 1 year of measurements, superimposed on an EIT vision of the Sun. The modes observed correspond to the most penetrating modes corresponding to degree l= 0,1,2,3 (Gabriel et al. Sol. Phys. (1997) 175, 207-226). Coupled to higher degree modes, they inform on the nuclear core of the Sun.

profiles inside the Sun. The examination of these quantitities is extremely useful to make progress on a dynamical vision of the solar interior and to understand the internal role of rotation and magnetic field in stars.

It has been known for a long time that the equatorial photospheric surface turns quicker than the pole regions. Due to these movements, the Sun does not present a complete spherical symmetry, consequently one observes the acoustic mode frequencies split into 2 l +1 components. In measuring such components, we have access today to latitudinal variations of the rotation down to about 0.4 $R_\odot$ and to the superficial convective movements. This information puts limits on the internal magnetic field and contributes to the determination of the properties of the transition region between the two regimes of energy transport: radiation and convection. We call this region the tachocline region due to the rapid variation of the rotation and the transformation of differential rotation to rigid rotation. We observe a kind of shear flow in this region which induces mixing of elements and lithium destruction (Brun, Turck-Chièze and Zahn, ApJ, 525, 1032-1041, 1999). We begin also to measure a time variability of the rotation in this region with a period of about 15 months (Howe et al., Science, March 2000); if it is confirmed, it will contribute to the definitive establishment of the complex source of the magneticsolar cycle.

We measure nowadays the solar radial sound speed profile from the surface down to 0.05 solar radius with a precision of some 10^{-5}. In comparing this profile to the theoretical profile deduced from stellar evolution (fig. 1b), we can check precisely, for the first time, the hypotheses of the calculation. The present conclusions are summarized here.

The structural equations appear extremely reasonable: the fact that no difference is observed just where the nuclear energy drops to zero (0.3 $R_\odot$, see fig. 1b) confirms the theoretical idea that the Sun is today in hydrostatic equilibrium and not in gravitational collapse.

The treatment of the evolution of the internal composition is now completed to take into account not only the creation and destruction of species through nuclear reactions but also the migration of elements with time and the inhibition of such process by turbulence. Nowadays, with such improvements, we reproduce in the models the photospheric observations very well. The presence of turbulence is well established in the external layers and in the tachocline region. Nevertheless, the remaining difference between observation and theory is significant as confirmed by different instruments and techniques of inversion, and transforms the Sun into a real laboratory of physics, where we have the possibility to check the complex calculations describing the interaction of the photon with matter and the nuclear reaction rates in a plasma of high temperature and density.

The present discrepancies do not favour large dynamical effects in the solar plasma but suggest that the fundamental proton-proton interaction, governed by the weak interaction, is underestimated by no more than 2% and that the inner composition of the heavy elements is under control to better than 5% (fig. 1b). We have examined in detail different possibilities of turbulent mixing in the inner core which would have decreased the central temperature or the high energy neutrino emission and found no evidence of such process in the seismic data (Turck-Chièze, et al., Sol. Phys., vol 200). This is the first time that this conclusion can be drawn because the verification of all the physical processes needs the precision attained with SOHO. Effectively, a variation of the thermodynamic quantities by several % would have induced large variations for neutrino predictions but very tiny modifications of the sound speed (of the order of several 10^{-3}). So, in order to be sure of the nuclear density or sound speed profile, we need to verify that the acoustic mode excitation is well understood, that several biases (as asymmetry profile or magnetic perturbation) are extremely reduced. All these conditions have justified a lot of studies on the 3 instruments aboard SOHO, several tens of publications and the measurement of the lower global modes which are less sensitive to the perturbed surface as their external turning point is below.

With the present seismic results, it seems extremely difficult to invoke an astrophysical explanation for the deficit of neutrino detection on Earth (Turck-Chièze et al., ApJ lett, 2001, in press). The astrophysical and the particle physics community need now to secure the knowledge of the energy spectrum and transport of neutrinos. The most exciting idea this year is to deduce some properties of the electron neutrino from the deficit observed between the calculation of neutrino emission *deduced from helioseismology* (see fig. 1b black line) and neutrino detection on ground but we cannot ignore the presence of the strong and well organized internal magnetic field which may have some impact on the neutrino travel inside the Sun. Accompanying measurements in laboratories, such as the possibility to measure opacity cross sections with high energy lasers (LMJ in France and NIF in United States) for specific elements such as carbon, oxygen and iron would be useful to confirm the interpretation of the present seismic results and validate the extremely sophisticated calculation of photon-matter interaction (Rogers and Iglesias, in Solar Composition and its evolution- from core to corona, 1998, Kluwer Academic publishers, ed C. Frälich, p61).

We have not yet a definitive measurement of the rotation of the core which is extremely difficult to extract from acoustic modes. The analysis of very long series of data over several years is useful not only to improve the resolution and the ratio signal/noise but also to pass through two inherent difficulties of helioseismology, namely, the indirect effect of the stochastic excitation of the modes and of the magnetic field which both complicate the determination of the frequency. The longest lifetime modes have narrow profiles, are less disturbed by turbulent surface but have very small amplitude. Obtaining these modes could help to determine the central rotation profile. The rotation profile in the central region will give us information to determine which scenario of stellar angular momentum evolution is favoured.

The SOHO mission will still observe several years with a large benefit for stellar evolution

The main motivations of the whole seismic community is twofold:

We are gaining confidence with the ground networks and the satellite in operation in our ability to extract reliable information on the solar interior down to the nuclear region from the characteristics of the acoustic modes. But if we have now a clear dynamical vision of the Sun in the convective zone and just below (B. Fleck et al., ESA Bulletin, 102, May 2000), we have still only a static vision of the radiative zone. This is due to the inherent character of the acoustic modes. We know effectively that these modes are not the most sensitive to the solar nuclear core, since the most penetrating radial acoustic modes spend only 5% of their time in this region and their wavelength is large so one gets only mean information on a rather large region (typically 10% in mass or radius). So we are looking for another type of modes, called gravity modes which live in the radiation zone. Unfortunately, their surface velocity is less than 1 cm/s, and their long period (between one and several hours) corresponds to a range of frequency, susceptible to large perturbations by other superficial processes such as granulation, supergranulation and active solar regions. Discovering them would give better spatial resolution on the solar core and offer the possibility to access the density profile with a higher spatial resolution in the radiative interior. It would be extremely interesting also to determine the presence of instabilities which may be produced by the modes themselves in the radiative region of the Sun. Presently g-mode candidates are under study using 4 years of the GOLF instrument data and are searched for in other instruments. Confirmation of their existence will occupy the rest of the SOHO mission. We hope that the present Sun is not too active and that good data are delivered around the solar maximum.

Another interest in continuing the SOHO observation for several more years, is to confirm through the solar maximum the understanding of the internal pulse of the dynamo in the Sun. The variability of the solar rotation in the tachocline region must be firmly confirmed by observations over time. If it is the case, it will be a key point in the understanding of solar and stellar activity.

At the beginning of a new century, we may say that helioseismic data have demonstrated our ability to probe a star down to its core. We have verified in detail and extended the hypotheses of stellar evolution established purely theoretically in the twenties. It is a very great success of the astrophysical community that demonstrates its ability to work at very high accuracy (some 10^{-5} on data and 10^{-2} on physical processes). If we succeed also in the next two goals (central rotation and internal solar dynamo), we will be able to describe to what extend the Sun, a very common star, is a dynamical object. This will be fundamental to building a bridge between very dynamical objects (young stars), slowly evolving stars (at the hydrogen burning stage) and stars at the final dynamical stage of stellar evolution, by introducing naturally the influence of rotation and magnetic field in astronomical objects.

One may really say that we are now able to see deeply inside the sun; the next step will be the exploration of other stars.

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directory

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Fizika B

Czech Republic Academy of Physics, Institute of Physics
Czechoslovak Journal of Physics

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The European Physical Journal: Applied Physics
The European Physical Journal B
The European Physical Journal D
The European Physical Journal E: Soft Matter

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Physica A
Physica B
Physica C

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Physics Mathematics
Institute of Physics Publishing
Classical and Quantum Gravity
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Journal of Physics G: Nuclear and Particle Physics
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IOPP and the DPG
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Journal of Biological Physics

Il Nuovo Cimento
Il Nuovo Cimento B
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Romanian Academy
Romanian Journal of Physics

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Collaborating Societies

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The Japan Society of Applied Physics, Japan
The Physical Society of Japan, Japan

Marrying education with science: An interview with Leon Lederman

By Carlos Fiolhais and Carlos Pessoa

Schools are not preparing people for the life they have to live, but to some "other lives", from societies which do not exist anymore. However, according to Leon Lederman, Physics Nobel Prize winner in 1988, it is necessary and possible to "prepare people for a new world". He was in Portugal last September, giving a talk at the meeting of the Portuguese Physical Society. He gave us an interview speaking passionately about his experience on introducing science in schools. Teachers, he defends, are the "key" to the change, which makes teacher formation – oriented towards experimentation – a requisite in the process. Lederman's experience shows that educators "do not know science", since "education is not married with science". Conclusion: "We have to marry these two communities, since that would bring mutual benefits."

Everyone speaks about a crisis in science education, in particular in Physics. What is your opinion about this?

I think that yes, there is a crisis. There has always been a crisis, it goes back a long time. The notion of people understanding science goes back into history. Today the crisis becomes more serious because in the twentieth century, even in the end of the nineteenth century, there were vast and very important technological advances. And the crisis happens because of the applications of science to society.

Science is then victim of its own success?

Yes, I would say science is a quest for knowledge—a search for truth—and this is value-free, there is no such thing as bad-knowledge. We try to find the truth about the world in which we live. We believe there is an objective truth to Nature and that is what science works on and that is fine. But, in fact, science does have applications to society and so, to measure the crisis, one must relate it to the importance of science to society.

There would be no argument today that science through its applications is having an enormous effect on how people think, how people behave and the optimism or pessimism as to how you view the future of human society in the twenty-first century. You can measure this by the huge influence of technology. Let us take the invention of the steam engine, in the nineteenth century: it had a big effect. It changed industry. It created industrialisation. It allowed Americans to explore the entire continent, and tie this vast land together by means of trains. But this was a slow change, a gradual change; the invention from the time of the steam engine till its deep implications for society took many decades, maybe fifty years. The same thing happened with many of the others profound technologies of the early twentieth century. But in the late twentieth century... if you look at a web site and if I say that I am downloading the CD-ROM data from the Yahoo web site, people would say this is a strange language. From Mars, maybe, spoken by aliens. However, the kids know this language and speak it perfectly.

Leon Lederman – Photograph courtesy of Fermilab

So society is being changed by science, but schools do not change.

That is the problem. The problem is that if you talk about education then you could ask the question "what is the purpose of schools?" and people would give you a variety of answers but I think a good answer which you would agree with is that the purpose of schools is to allow children who graduate, let us say who are high-school age, seventeen-eighteen years old, to cope, to manage in the new world in which they emerge. The problem is that this world is different from the world of their teachers and is different from the world of their parents.

Are schools preparing young people for life?

But schools do not prepare people for the life which they expect to live. They prepare people to some other lives.

Lives from yesterday?

That is right. And if so you ask whether it is possible to prepare people for a new world, the answer is, of course, that is possible. That is what we physicists know all about. We physicists, for example, and I think that this is also true for a few chemists, biologists (I am joking!), we are trained for the unexpected, we are trained for the surprise, we are trained for the unusual, we know that, when we go with a rocket to a some rather strange place, that nothing will be as we expected.

Do you like to be surprised?

We love to be surprised. This usually indicates we are about to learn something new. If there is no surprise, that is disappointing to me. So, that is why I believe science education is a key to all education because it is the notion of preparing people for the unusual, for the unexpected, and that is what the new world is into which these people emerge. Our world will change. Once upon a time, after high school, you learned to operate some machine, a lathe, some machinery and you worked that for forty or so years and you retired. They gave you a gold watch and you lived a very calm and quiet life. However, now you come in one day and someone took away the machine, and there is another machine run by a computer and you have to learn how to program a computer and your profession is changed. All professions are like that, they keep changing.

Does that happen all over the world?

Of course I am concentrating on perhaps 20% of the world, the industrial part and maybe the more advanced of the developing countries. In the third world countries we have different situations but also a crisis in education. But the crisis has different dimensions and some of them are not so different if you look at the youngest children. I do a lot of work in Chicago with the young children up to age of twelve years, from pre-school to twelve years old. The problems are very common all over the world. Even in villages in Africa, if you like... I worked for the International Council of Scientific Unions, in Paris, and there I was chair of a committee on capacity building and I learned a lot about education in African villages and in third world countries. I came back to Chicago and I said to my colleagues "You will not believe this, but there are some cities that have problems almost as bad as Chicago". So it is not unique, and in primary school, the cultural differences are minimal. Children are children all around the world. The parents have cultural differences, the children do not. And so the teaching of children is a rather internationally common problem! Because, for example, what's the trouble in Chicago? The teachers do not know any science, they do not know any mathematics, primary school teachers have to teach everything. At two o'clock they have to teach science. The teacher's insecurities are immediately perceived by children who are very wise. Teachers are not so happy, and children sense the insecurity of the teacher teaching these subjects. And, in some schools, wisely they do not teach science, they skip it because the teachers are totally ignorant.

You said that scientists believe in the objectivity of Nature. But you know that, among the educational community, there are people who do not share this view. They say that everyone has the right to his own view about the world. What do you think about this so-called post-modern theories?

Science is the only universal culture and although we hold all scientific thrones to be tentative, there are large bodies of scientific belief that have been subjected to objective tests over generations. Did you ever hear of a post-modernist going to a post-modern surgeon for medical treatment?

So you do not make much of that?

No, I think that is nonsense. I think that post-modernists have certain problems of their own and I hope they can solve these problems before they go crazy. But their attitude towards science is total nonsense. It comes from their own insecurities and their own hostility, if you like, towards a subject, knowledge.

I mean the issue is, is there an objective reality to the world and we believe that there is an objective reality. Like Einstein. Yeah, not quite like Einstein. Well, you know soften Einstein a bit...

So you have taken some innovative actions in Illinois. What are the most effective ones?

I can talk about my work in primary schools. The Chicago public school system has 400 000 children and the poverty level is high; over 60% are poor. You know... parents make very little money, some of them are very poor, some of them moderately poor, but most of them are poor in some way and, since the school system is poor, teachers do not want to teach in these schools. The streets are dangerous, the buildings are old and it is not a very pleasant place to live or a pleasant place to teach. So they do not get the best teachers. They have a handicap in that sense. Anyway, we entered that system with an intervention: some scientists from Fermilab, from the University of Chicago, from others universities in Chicago, together with the business community and some teachers who were willing to join a new experiment. I got money because I had been Director of Fermilab; the budget there was hundreds of millions of dollars, so if I asked the Department of Energy for one million dollars...

So you knew the politicians?

I knew the politicians, I got money from the federal government, I got some money from the state of Illinois, and some money from businesses and so on. And we started a not for profit organisation called "The Teachers Academy", "The Teachers Academy of Mathematics and Science"...

Is that a school for teachers?

A school for teachers—that is right. We negotiate with a school. There are 530 schools in Chicago, about 450 of them are primary schools. Each school has an average of maybe 30-40 teachers in the school. So we go to a school, we talked to the principal of the school, we negotiated an agreement with him. More than 80% of the teachers would join our program and then we started this program, we designed it over three or four months during one summer in 1989-1990 and we opened up for teachers in September of 1990 for ten schools, with about three hundred teachers – and they came to us two days a week; we sent substitutes into the classroom to take their place. Originally the teachers said no, "we will not abandon our children to any person", so the substitute and the teacher worked together for two weeks. We call it "bonding", they got together until finally the teacher said "OK, I will trust my children with this person". This was our first realisation that these teachers really care and love their children.

First thing was then to prepare teachers.

That is right and we organised courses for the teachers in which the standard word was "Hands on", a curriculum in which children do things, you know, experiments with light, etc. In French it is called "mains à la pâte". These curricula were developed long ago, in the sixties. Berkeley was a good source of some these teaching materials and, here and there, other people have tried these materials. In the sixties, when they were first implemented in certain places, that was extremely successful. But then the movement died someway. So we started to revive this. And with various curricula including some curricula invented in Chicago by a professor of the University of Illinois. The best program I know something about is called "TIMS" which is "Teaching Integrated Maths and Science".

Is it a curriculum?

Yes, a curriculum. I will give you an example. In kindergarten, children are discussing an experiment. The teacher has a big bowl of candy, little coloured candy.

The thing that children do like.

That is right. All with different colours. The first thing that happens is that the furniture of the classroom changes. Instead of having, you know, children sitting on chairs with desks, in order to pay attention, and the teachers lecturing, blah, blah, blah… Instead of that, in our school, there is a table and some kids are standing around the table and the kids are in a team, there are a lot of tables and the teacher is walking around. Occasionally, the parents come in, they can help. They walk around, make sure that the kids are doing what they should do, which is an experiment. So the kindergarten experiment is jellybean. It is candy. So each of the team members goes up and takes two hands full of jellybeans and puts it on the table.

What can they do with that?

Then they say, let us organise the jellybeans and everything they do is first discussed. You know, the teacher asks the question and the kids give the answers. Look at that bowl of jellybeans. How many are there? Are there more reds than blues? Children say: "Well, we have to count them". Children know how to count. That is all they know. Let us try with this. They put the jellybeans, then they decide to organise the jellybeans and put all the red ones in one row, next the blue, next the yellow, next the green, and they organise and get a distribution for it. That is just like as we do at the Fermilab. We collect the data, we discuss the experiment, and then organise the data. We did not tell them that this is a histogram…

It is a question of working at a low or at a high level?!

That is right. The teacher says: "Now you are going to discuss the data". So, for example, the teacher says: "Suppose you are blindfold, than you go up and take eight jellybeans. What do you know? How often would you get a black one?" So they look at their distribution: "No, I do not have a black one", "Yeah, I have a black!" So in the whole classroom there is only one black. So you will almost never get a black one, the probability to get a black one is small.

In this way they get acquainted with the notion of probability.

Little by little. It is the first introduction to distribution functions, to discussing probability. Like, for example, what is the colour most likely they will get and they look at red, it is the biggest colour and we also ask a quantity of questions like: "How many more reds than blues?" They cannot subtract but it is easy to make them drill with the rule as they can count the surplus of reds.

You have nice actions. I think we could do something similar here.

There are hundreds of such experiments going from kindergarten all the way to the seventh grade (thirteen years old). These experiments do not teach you anything about science, they teach you how you do science, how you answer questions, for example.

That is what science is about!

That is right. I give you another example about a soap bubble experiment. The teacher has a lot of boxes. So they take the boxes from the TV advertisements, Tide and various other soaps. They discuss soap quality and eventually the teacher gets the kids interested in the bubbles. And so she makes a little mixture, a little bit of detergent in the water and she takes a little wire in a circle and blows bubbles. Well, eventually, by her suggestions, they get interested in measuring how long the bubble lasts, so each table should use a stopwatch. Anyway, they measure the lifetime of a soap bubble, they catch a bubble and they start a watch; when a bubble breaks they stop and read the time. They do this thirty or forty times. Eventually, they do a graph, a graph with a lifetime of bubbles and then the teachers says "What's the chance a bubble lives twenty seconds?" and...

Do they manage to learn science in this way?

The process of science. These are the things which essentially dominate in the first few grades. Occasionally the teacher will do some science, will say the names of planets,...

More formal science?

Yes, a little bit more formal, the teacher should inject some relevant things.

Some science facts?

The first ideas of surface tension, why the bubble stays together at all. And the contents of science gets richer and richer as you go on. So, by the sixth grade, you are doing a lot of science, but the process of how you answer questions sticks with them, is always reflected back. That is the technique, but the teachers have to be very well trained.

That is the key!

Yeah! The teacher is the key. Because, no matter what sort of fear they will have, ultimately the door closes and teacher is there. That is why we work so hard with the teacher, the teacher no longer knows everything. The teachers are allowed to say: "I do not understand, I do not know, let us find out". Every science classroom that we have, in the corner there is a modem, a telephone, some books, some CDs, some videos.

So there is computer technology around?

As much as we can. We first went to these schools in Chicago, we said - "do you have a computer?" - and there was a lot of embarrassment and finally they showed us the closet in which the computer has never been unpacked.

Let us make a conclusion: stay with these teachers for three years, giving them a minimum of about one hundred hours contact of Mathematics, about the same number for science, and about thirty or forty hours of technology: how to turn on a computer, how to use software, etc. They begin to show incredible results even though their original training was zero. I have experienced this and the teachers keep saying: "If I had do this ten years ago I could have been such a good teacher!"

They can still become!

That is the point. When that happens, the children start to become stars in the standard tests given by the state of Illinois to all the children of the state. So we have many schools like ours, poor and so on, and they stay at the low level. And you have the schools where we are, where the students are going up, very steeply, in their ability to solve math problems. There are no good science tests. We went to the State Capitol and we argued with the people about the tests in Science because they do not have right science tests. That answers the question "should professors be involved?" Absolutely. They have got to get involved in the system at the highest possible level.

The educators do not know any science because the education is not married with science. We have got to marry these two communities, the education community and the science community. There are a lot of mutual misunderstandings. But that marriage would bring mutual benefits!

Thank you very much, Prof. Lederman.

The word from Brussels

Tom Elsworth

I am writing this article as a relief from preparing two proposals for Framework Programme 5 funding. Many readers will know I am sure, what a tedious, complex and expensive process this is. More of that below but suffice to say at this point before hysteria sets in, that the proposal forms are just the first hurdle to be overcome and certainly not the largest. Success at this stage is followed by the dreaded "contract preparation forms" then the beastly bureaucracy of reports during the contract and finally the titanic tussle to wrest the final 10% of funding from the "Commission Services" clutches.

Now that is off my chest we can be a bit more serious and consider again how the new Framework Programme for 2003 to 2006 is progressing. It will not be for the last time either!

The Research Council meets on 26th June (a few days in the future for me). On the agenda is an "orientation debate" on the programme. This means I think, a sort of preliminary discussion at which it is hoped national positions may emerge and perhaps move somewhat towards each other. But nothing formal can come from it pending the European Parliament getting their act together. The relevant Committee is holding a public hearing in Brussels also on 26th June. The informed thinking in Brussels is that the fully developed views of the parliament are not likely to be available before October. This puts us well into next year as the earliest point at which the Research Council could reach a common position (the Council meeting planned for 1st October will be too soon).

Meanwhile, the Commission is pressing on with development of the research programme proposals that would make up the new Framework Programme. The proposed budget total is Euro 17.5B made up of

- Integrating and strengthening the European Research Area (essentially the specific scientific research programmes to be supported) Euro12.505B
- Structuring the European Research Area (essentially the old Horizontal Programmes) Euro3.505B
- Independent research in the nuclear field (the EURATOM programme) Euro0.9B
- JRC programmes made up of Euro 0.715B non-nuclear and Euro0.33B nuclear.

As discussed in earlier articles there is a planned to be a new set of three funding instruments called "Networks of Excellence", "Integrated Projects" and "Joint Participation in National Programmes". The latter is a new departure details of which are starting to emerge (but it seems a bit like the contract of Association structure that my old colleagues from the world of fusion research know all about). The Commission has recently sent an explanatory communication to Council and Parliament about the use of what is called "Article 169" for this purpose. They say the following:

"The possibility of using Article 169 arose following a request by the Lisbon European Council that the Council, the Commission and the Member States develop appropriate mechanisms for networking national and joint research programmes on a voluntary basis around freely chosen objectives."

"The idea is to provide open, flexible support for proposals making an effective contribution to closer co-ordination of the research activities conducted within different frameworks in Europe".

"The Community must participate in projects if the partners are to receive Community funding. The Community would be involved in defining and monitoring the implementing strategy, but not in day to day management of the activities.

The conditions under which Community funding would be granted remain to be decided although three strategies are outlined as below:

- The same set percentage of the total budget for the jointly implemented programmes in every case;
- A contribution set in absolute figures, taking account of the amount allocated to the area concerned in the Framework Programme and of the proportion of that area covered by the activities planned;
- An amount to cover the costs directly linked to joint implementation of the programmes and calculated on the basis of those costs."

What then do the people who really count in all this – that is the researchers themselves – think of it? The European Science Foundation has given its views in an excellent document" European Framework for Research, an ESF position paper". Amongst various sensible points they recommend

- Greater flexibility; the rigid application of large scale funding may exclude smaller countries and groups
- A two stage application process; sifting through a very simple initial proposal form (they estimate the typical cost to the proposer of the present proposal system at Euro 30K or more)
- The socio-economic relevance of a proposal should not have to be established in every case being largely self evident if the proposal fits into the Framework Programme
- Simplification, greater delegation to participants, the use of grants rather than contracts.

One can only give a hearty yes to all of these points.

ALLEA – All European Academies, the federation of European national academies of sciences and humanities strongly backs the ESF position.

A further recent position paper has been published by FORATOM, dealing with the EURATOM framework. The key points they make are that nuclear power is now increasingly recognised as a key option for tackling energy security and climate change but yet the programme provides little funding for research into nuclear fission (a mere Euro5OM) and reduces the funding for nuclear fusion to Euro700M from Euro788M. This will not be sufficient to realise the pilot ITER plant.

These reductions seem especially curious at a time when USA is launching ambitious new programmes for fusion and innovative fission reactor designs (the so called Generation IV, almost entirely dominated by US interests). Clearly the EU is in danger of sacrificing its undoubted competitive edge in the nuclear field. It seems probable that our children will be forced to buy General Atomics power stations rather than from Framatome. Curiously, our saviours here may be our friends in Canada. The Government of Canada announced on June 7th its formal offer of a site for ITER. The EU fusion programme fortunately, has very good and longstanding relations with Canada (but when push comes to shove the Atlantic is far wider than the Great Lakes).

Perhaps I could encourage all interested members to speak up for the necessity of a properly funded EURATOM programme. The European Parliament is considering the matter, many Parliamentarians have outmoded "Green" ideas but many of the younger ones do not. For everyone's information the relevant rapporteur is M. Gerard Caudron of France.

Calls for Proposals

Calls published on 1 June 2001
Competitive and Sustainable Growth
Fixed deadline call – call for proposals for indirect RTD actions
Opening date: 01.06.2001
Closing dates: See Call text

Calls published on 31 May 2001
Quality of Life and Management of Living Resources Energy, Environment and Sustainable Development (Part A)

Joint Call for proposals for RTD actions on the establishment of the European Network of Biodiversity Information (ENBI)
(QoL/ENV-2001-ENBI)
Opening date: 31.05.2001
Closing dates: 28.09.2001

Joint Call for proposals for RTD actions on the health and environmental implications of endocrine disrupters
(QoL/ENV-2001-ENDDO)
Opening date: 31.05.2001
Closing dates: 14.09.2001

Quality of Life and Management of Living Resources
Call for proposals for RTD actions on Transmissible Spongiform Encephalopathie
(QoL-2001-TSE)
Opening date: 31.05.2001
Closing dates: 18.10.2001

Call for proposals to extend existing contracts under the specific programme for research, technological development and demonstration on "Quality of life and management of living resources" (1998 to 2002) to include partners from the Newly Associated States (NAS)
(QoL-2002-NAS)
Opening date: 31.05.2001
Closing dates: 15.02.2002

Call for proposals for RTD actions on Genomics and Human Health
(QoL-2001-DC8)
Opening date: 31.05.2001-06-17 Closing dates 18.10.2001

Calls published on 15 May 2001
Promotion of Innovation and Encouragement of SME Participation
Mechanisms to facilitate the setting-up and development of innovative firms (Second Call)
Thematic Networks and Accompanying Measures
(INN/01/01
Opening date: 15.05.2001
Closing dates: 14.09.2001

Finally, another cri-de-coeur, another appeal to all EPS members not to miss their opportunity to modify the new programme before it is too late. Things are moving quickly on Framework Programme 6. Make your views known; speak to your representatives (official and political) in Brussels. Speak also to your professional organisations in your own country and your national politicians at home. You can keep in touch with what is going on by a regular look at the CORDIS web site (www.cordis.lu) and the Research Directorate web site (europa.eu.int/comm/research) dedicated to this issue. My contacts at the Research Directorate tell me that they are planning an FAQ section dealing with the new Framework Programme. It will go live shortly on the Research Directorate web site.

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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At the Research Council meeting in Luxembourg on 26 June, '...the EU Ministers for Research have today agreed that the EU should concentrate its research efforts in seven areas: biotechnology, nanotechnology, aeronautics and space, food safety, sustainable development and citizens and governance in a knowledge based Europe. We also agree that the resources to promote greater mobility for researchers in Europe must increase significantly,' said the chairman of the Research Council, Thomas Östros, following the meeting.

Research ministers gave the Commission the task of drawing up an action plan on creating closer ties between science and society, to be presented before the end of 2001. The council urged member States to find different ways of stimulating a dialogue between science and society, a dialogue on research findings, their areas of application and any possible ethical issues that may arise from research.

The Research council adopted a resolution on the promotion of women's participation in the research community. Ministers agreed to encourage both the Member States and the Commission to intensify efforts to increase the proportion of women who implement and administer research programmes, to develop sex disaggregated statistics and to develop indicators to follow developments in gender equality in European research cooperation more effectively.

'Today's discussion demonstrates that there is broad agreement among the Member Stats on the main principles for research in the EU. The Council has pursued the discussion in depth during the Swedish Presidency and has created good preconditions for continued efforts. We have now laid a solid foundation for the final decision in 2002,' said Thomas Östros.

Euroscience:

Placing the future of science in the hands of scientists

Jean-Patrick Connerade, Imperial College University of London, President of Euroscience

Science and the European Future

There exist many well-established organisations with a scientific agenda and European credentials that promote the European spirit through Science and Technology. For years, the pursuit of scientific research has advanced European unity, because science, by its very nature, tends to be international and collaborative. Most of us agree that our future is European. Thus, all the scientific agencies and all the major European laboratories and international organisations claim to have developed their own 'European strategy'.

So, why Euroscience, and what is special about this comparatively new Association

The Constraints of National Agendas

The reason is: national politicians, far from relinquishing their hold over scientific policy, continue to exercise national control over European agencies and organisations to such an extent that they have not really fulfilled their international expectations. In fact, rather than promoting a genuinely international spirit, they have become uncomfortably multinational, with a tension between their mission statement and what they are actually allowed to do. In fact, most attempts to achieve a genuine European dimension in Science and Technology are somehow still thwarted by the protectionism of National agencies.

The official European rhetoric surrounding the 'single market' is not really consistent with the way European science has been pursued so far. Rather than open up the whole European area to free cooperation and friendly competition between scientists, the Ministries and their research councils have remained defensive. They continue to micro-manage science nationally, and to insist on what is effectively a funding monopoly within national borders.

When challenged on this point, they usually try to brush criticism aside with the remark: 'Oh yes: there is competition between funding agencies: you can apply for European Union funding as well as for National Research funds'. However, we all know what that means: the European Union has always had its hands tied. The rules are drawn up by the Council of Ministers in such a way that the Union is simply not allowed to compete with National Agencies. The whole process is riddled with complicated restrictions the main purpose of which is to stifle any open competition between agencies that fund science.

In truth, when it comes to real action, our leaders are sadly lacking in European vision. Europe is fine, provided it does not interfere with the status quo, and that Ministries do not have to sacrifice any of their local power to set it up.

European scientists have been overtaken in what should be their greatest asset: internationalism. Somehow, one might be forgiven for thinking that they have lost the initiative because so much of their work is actually carried out behind the 'protection' of National Agencies. That is precisely where Euroscience comes in.

The birth of Euroscience

In reality, scientists are hardly to blame. The problem lies rather with administrative controls and the rules and regulations which surround both funding and the 'free movement' of researchers, teachers and engineers who work in Europe. That is why many working scientists, frustrated by the lack of progress in this area, came together in 1997 to try and initiate a new and different approach. That is the origin of Euroscience.

A mission statement on the aims of Euroscience can be found at euroscience.org. Beyond these general aims, we would like to see every scientist in Europe able to apply to any funding agency in Europe, and to give our 'European science area' the same scale size and flexibility as corresponding areas in the USA or in Japan. We would like to see large and thriving European scientific communities rather than the present mosaic of research groups, which tend to clusters according to national boundaries. We would like to see an end to narrowly defined directed programmes, and to encourage a much broader coordination of research. We do not accept the argument so commonly advanced, that small-scale science should remain national, and that only expensive programmes of research justify the recourse to European collaborative funding. We would like to see a European dimension to all our research, big or small. Of course, such changes do not occur overnight. The real question is: what path should one follow to reach such ambitious goals?

Bottom up rather than top down...

At Euroscience, we believe we have something new to contribute in this general discussion. In a nutshell, it is the way the European Union should be built in the area of scientific research. Instead of the 'top down' approach, which has been the norm so far, in which initiatives are taken at ministerial level and handed down via a bureaucracy, we would prefer to see a 'bottom up' approach, led by active scientists, with the emphasis on facilitating and mutual trust, rather than dirigiste programmes and detailed control.

Where are the problems now?

We believe that the European dimension makes our profession more attractive to young people and more rewarding to all. However, the spirit must be the right one. Typical of the present approach are the rules and procedures for lengthy grant applications whether for a multi million Euro contract or for a few relatively modest travel grants per laboratory, and maybe one postdoc position. Many European researchers dread the complexity and slowness of the application procedure to the extent that they avoid applying for European support.

If we really wonder why so many of our youngest and most talented scientists are fleeing to the USA or giving up science for international market-based activities, perhaps we should look at the system we have now and ask ourselves a few simple questions. Does it attract young scientists? When was the last time they actually could exercise true freedom of choice in determining their research? If we were young researchers today, would we join such a system?

It is fashionable to blame the bureaucrats in Brussels for all our ills, but is that fair? In fact, they have to follow the whims of the national governments, none of which wants to relinquish any control. They have to put up with the constraints of all the different systems we have been operating for so long, and which no Government wants to change. So, many of the problems are actually not of their creation, although, in the end, they always take the blame for the hideous complexity of the rules.

How can we break out of the cycle? The answer may be to stop haggling over minor points and start debating broader issues. The key to progress should be dialogue. Hiding behind our various national traditions and hoping that, somehow, Europe will happen anyway because history moves on, just makes matters worse. Leaving the real debate about European Science Policy to politicians or managers, who neither practise science nor understand its full requirements, can never help.

That is why Euroscience emphasises the need for a proper European forum to deal with all big questions about science. Not only are there plenty of these, but many are already in the public arena. How should we respond to the European citizen on issues concerning orphan diseases, food safety, pollution, cloning, nuclear energy and global warming? Why does the public so often end up blaming scientists when things go wrong? Of course, we all realise the cause is lack of information. But why was information lacking in the first place? Could it be because we are too quiet? How does the public get the wrong idea? Again, the answer could be: because there was no real dialogue.

Such issues are very practical. They cut across all the sciences. They are also very difficult to deal with, as they require a solid understanding of many disciplines. The dialogue is not only with the public. It is also between ourselves. We are both scientists and European citizens, and need to demonstrate to our fellow citizens how much we care about public issues by having full and frank debates. A real debate involves informed scientists holding a range of different opinions about such questions. Once this has been generally appreciated, and once the public realises that we are in good faith, the public will become our greatest ally in our dealings with politicians.

That is the ultimate aim of our Association: our real strength must be as a 'grass roots' organisation: the ordinary working scientist talking directly to the ordinary citizen. If you agree with that, then you really shouldn't just sit there nodding: you should join us.

For Information on how to join Euroscience, contact
Raymond Seltz (General Secretary)
Euroscience, 8 rue des écrivains
F-67000 Strasbourg, France
e-mail: r.seltz@euroscience.ws
http : //www.euroscience.org

Book Review

Lucifer's Legacy - The Meaning of Asymmetry

Author: Frank Close   Publisher: Oxford University Press

The subject of symmetry and asymmetry is indeed quite fascinating. The fundamental properties of our observed universe are a direct consequence of the presence of specific symmetries and how some become broken. However, most of the explanations at pre- and university level employ too much emphasis on the concepts of force, field, equations of motion or trajectory. Only too little, too late the crucial ingredient of symmetry is presented with its primordial importance within the whole framework of describing the nature's behaviour.

In "Lucifer's Legacy: The Meaning of Asymmetry", Frank Close produced a stimulating and entertaining book. As one reads through the several chapters, namely from chapter 2 onwards and focuses the attention on well written excerpts (like chapters 4 or chapters 9, 10 and 11) it becomes clear why this book reached the top-ten best-selling list of physics books at Amazon.co.uk. The author aims and achieves in being both provocative as well as instructive regarding many aspects of our presence in the universe: the molecular "handness" in chemestry and biology; what is really "mirror symmetry"; the attempt to understand the origin of mass; together with the relation between matter-antimatter and the violation of discrete symmetries (the known Charge-Parity (CP) symmetry violation and its connection to the time (T) reversal within the CPT symmetry).

There are however some particular options the author chose about which I do not agree. To begin with, I consider the introductory chapter rather weak and almost failed in motivating me for the remainder of the book. While I could understand where the author was aiming at, it should instead in my opinion capture the reader's interest in the first paragraphs. Maybe the title's announcing Lucifer's Legacy attract and kept some readers' interest. I also found that the book lack enormously in bibliography and other references (e.g., web access, journals) where one could get further details. For instance, it would be of great assistance to some teachers and students to know where to get more information on how the electroweak interaction can determine the Sun's behaviour as we observe it. Furthermore, while particle physics got a lot of attention, space-time and cosmology symmetries were almost ignored. That was a bit unfortunate since space-time symmetries as well as symmetries intrinsic to particle physics are both mandatory at the level of recent unification theories such as superstrings.

Nevertheless, the book got an overall quite positive appraisal. As mentioned, the author manages to elucidate and gather the reader's interest in crucial chapters. In fact, it provides at a basic but fundamental level the essential explanations of why and how symmetries/asymmetries are indeed important in describing the universe. This book should therefore constitute recommended reading for any student and teacher at a pre- and university level alike. in spite of its weaknesses, the book will stimulate the interest and curiosity of many students, directing them to further studies and investigation. Thus, I would without hesitation recommend it to the readers of Europhysics News.

Dr. Paulo Vargas Moniz
GATC - Departamento de Fisica
Universidade da Beira Interior Rua, Portugal

Books for review

The Physics of Particle Accelerators
Klaus Wille
Oxford University Press, 315 pp.

The Genius of Science
Abraham Pais
Oxford University Press, 356 pp.

Chaos and Harmony
Trinh Xuan Thuan
Oxford University Press, 366 pp.

If you are interested in reviewing one of the above books, or in receiving books for review in general, please send us name, and contact co-ordinates, along with the your field(s) of specialisation to:

Book Reviews
EPS Secretariat
BP 2136
68060 Mulhouse Cedex, France

noticeboard

Officers elected

The EPS Executive Committee at its last meeting in June unanimously elected:

Per Anker Lindgard as Vice-President
Ryszard Sosnowski as Vice-Secretary
Maria Allegrini as Vice-Treasurer

Council 2002

The EPS Council meeting will be held on March 22 and 23 2002 in Berlin at the Magnus Haus. We would like to thank the Deutsche Physikal Gesellschaft for their kind offer to host the meeting. Please reserve these dates in your diary.

The New President of Euroscience

The new President of Euroscience was elected in Paris at a meeting of the Governing Body in March. He is a physicist, and a long-standing member of the European Physical Society. He was a founder member of the Save British Science Society, and was its Honorary Treasurer until last year. The photograph shows the past president Professor Claude Kordon, on the right, and the new president Professor Jean-Patrick Connerade, on the left. Both are responding to a toast after the meeting in Paris.

Good luck

The EPS Secretariat would like to wish the best of luck to Mireille Schmitt, who has decided to go to bigger and better things in Paris. Thanks Mireille.

Christine Bastian is out of the office on maternity leave. She's expecting her baby later this summer and should be back in the office towards the end of the year.

Framework Programme 6

Debate is now open on the overall objectives of the European Union's Framework Programme 6. All members are encouraged to look at the document and provide their input, either to the EPS secretariat, or directly to the commission to make your opinion known.

HEP Awards

The High Energy Physics Board of the European Physical Society announces the following awards that will be given at the HEP-EPS 2001 Conference in Budapest, on July 16th 2001.

2001 EPS-HEP Prize
To: Prof. Donald Perkins (Oxford University)
"For his outstanding contributions to Neutrino Physics and for implementing the use of Neutrinos as a tool to elucidate the Quark Structure on the Nucleon".

2001 Young Physicist Prize
To: Prof. Arnulf Quadt (Bonn University)
"For his outstanding contribution to the measurement of the F2 Structure Function in Deep Inelastic Scattering and extending its measurement to low values of momentum transfer and fractional momentum x".

2001 Gribov Medal
To: Prof. Steven Gubser (Caltech)
"For his outstanding work that has revealed a deep connection between gauge theories and gravitational interactions in the framework of string theories. This made it possible to compute and understand interesting properties of a gauge theory in 3+1 dimensions from a gravitational theory in 4+1 dimensions".

2001 Outreach Prize in High Energy Physics & Particle Astrophysics
To: Dr. Christine Sutton (Oxford) and Prof. Erik Johansson (Stockholm)
"For their innovative use of electronic and printed media to bring HEP to wider public, including professional colleagues, students and school, and in particular their collaboration developing computer interactive packages for educational master classes".

G. Mikenberg, Chair HEPP-Board, EPS

EurPhys

A qualification for physicists

The designation European Physicist (abbreviated as EurPhys) is a qualification for physicists that was established by the EPS in 1995. The fundamental reason for its creation stems from the fact that times are changing. Gone are the days when a permanent position is offered to most successful students upon graduation from university. Permanent employment may become the exception rather than the rule, so physicists, like most professionals, have to be able to adapt to a new career more than once.

In this changing climate, the possibility to adapt one's activities becomes an important asset. Adaptation includes continuing education and the ability to take initiatives in organizing work for oneself and for others. It also includes mobility. Mobility is facilitated by professional qualifications which are widely recognised.

Formal professional qualifications exist in many occupations. Generally, a person receives such a qualification on the basis of a combination of academic attainments and experience in a profession. Where they exist, however, there are for some professions wide differences between formal systems of recognition, in the body awarding the qualification, in the criteria applied, and in the code of conduct by which an applicant is expected to abide.

Such differences may restrict the opportunities for citizens of a given country to exercise their profession elsewhere. In the case of the European Union (EU), the European Commission, which has been active for some time in promoting the mutual recognition of academic degrees, is now also taking initiatives regarding professional qualifications. The EPS includes the EU countries as well as most of the European countries that are not part of the Union. It has therefore been a special challenge for the EPS to establish for its EurPhys qualification widespread and efficient recognition both within the EU and between the EU and non-EU countries.

National societies, institutes and associations covering various fields of science and technology have collaborated in establishing several European Registers for qualified professionals. In physics, the situation is somewhat different from that found elsewhere owing to the existence of the EPS which one can join directly or participate in through a national society. Given its unique position, the Society has set up the European Register of Physicists and the necessary procedures for handling applications for entry on the Register.

To be admitted to the European Register of Physicists, the academic qualification must be in physics or in a physics-related area which is acceptable to the Qualifications Committee. It must have involved the equivalent of at least three years full-time university-level education.

Evidence of at least two years of appropriate experience gained in a professional capacity after graduating is also required. This experience could include research and development, project management, supervision and the training of others, safety management or other relevent activities.

The remaining period, which must have lasted for at least two years, may consist of either education leading to an academic qualification or appropriate experience involving responsibilities and deemed satisfactory by the Qualifications Committee. It must also include a period during which the applicant has acquired aptitudes or skills needed to exercise in the chosen profession and in a responsible capacity.

These requirements clearly show that EurPhys is not an alternative to degrees awarded through traditional academic channels. Instead, it is complementary to the hierarchy of academic degrees: it requires evidence for a minimum of practical experience, performance and professional behaviour along with a minimum level of recognised academic training.

Similar provisions apply for engineers, chemists, biologists and geologists.

Those included on the European Register of Physicists are:

- able to use the designation European Physicist and its abbreviation EurPhys;
- kept informed, by means of a section in Europhysics News, the Bulletinof EPS, and a special electronic newsletter, about professional aspects relating to the practice of physics and of developments in the professional recognition of physicists.

Inclusion of a physicist's name will give the public an assurance that the physicist concerned has satisfied the Register's requirements and has agreed to adhere to the Code of Conduct.

The Register is open to all physicists in Europe. For admission it is necessary to produce evidence satisfactory to the Commission on Professional Qualifications of the successful completion of a minimum total period of seven years' professional formation, including:

- at least three years' university education in physics or in a physics-related discipline to an academic level acceptable to the Committee on Professional Qualifications;
- at least two years' responsible post-graduation experience which may include a period of training;
- at least two years' additional university education and/or appropriate post-graduation experience.

The initial phase of post-graduation experience may include training, whether formal or otherwise, but a candidate will be expected to demonstrate a capacity for independent judgment in work related to physics or its applications. The nature of the experience may include research, project management, supervision and training, and health & safety management. Candidates will be expected to demonstrate an awareness of responsibility to the public when this is implicit in the nature of their work.

The Committee on Professional Qualifications evaluates the application. It is assisted by independent experts familiar with the regions in which applicants have trained and worked. The Committee then makes a short summary and a recommendation. If the Committee reviews is satisfied, you will be invited to pay the registration fee of Euro 100 for admission to the European Register of Physicists for an initial period lasting five years. However, people who have been Individual Ordinary Members of EPS for longer than 10 years are exempted for paying the Euro 100.

You will be provided with a formal certificate of registration. From then on you will be able to use the designation European Physicist (EurPhys). Thereafter, registration will be renewable without the need to submit a new application (although you might be asked to update your first application).

Information and application forms can be obtained on the WWW EurophysNet service at http://www.eps.org/eurphys

Upon completion the form should be sent, together with the non-refundable application fee of Euro 35 to the secretary of the Committee on Professional Qualifications.

Dr. E.W.A. Lingeman

The EPS Quantum Electronics and Optics Prizes sponsored by NKT, and Fresnel Prizes were presented at the CLEO Europe Focus meeting held in Munich in June this year.

The EPS QEOD Prizes

Our thanks to the sponsor of the QEO prize, NKT and our congratulations to all of the winners.

Theodor W. Hänsch
Max-Planck-Institut for Quantum Optics, Garching, Germany

The EPS QEO Prize 2001 sponsored by NKT for fundamental aspects is awarded to Theodor W. Hänsch for his innovative contributions to laser spectroscopy, in particular regarding precision spectroscopy of hydrogen.

Theodor W. Hänsch was born on October 30, 1941 in Heidelberg, Germany. After receiving his doctorate from the University of Heidelberg in 1969, he went to Stanford University, were he became a Full Professor of Physics in 1975. In 1986 he returned to his native Germany, and he is now a Professor of Physics at he Ludwig-Maximilians-University of Munich and a Director at the Max-Planck-Institut for Quantum Optics in Garching.

His early work includes the study of quantum interference effects in coupled three-level systems, the first narrowband tunable dye laser, the invention of commonly used techniques of Doppler-free laser spectroscopy, and the first proposal for laser cooling of atomic gases. More recently, he and his coworkers have pioneered atomic lattices bound by light, and they have introduced a revolutionary simple technique for measuring the frequency of light with ultrashort pulses. Much of this work has been motivated by the quest for ultraprecise spectroscopy of the simple hydrogen atom.

Prof. Hänsch has received numerous prizes and awards, including the Stern-Medal of the German Physical Society (2000). He is also a member of the American Academy of Arts and Sciences (1981–), the Bavarian Academy of Sciences (1991–) and a foreign Associate of the National Academy of Sciences (2001–).

Algis Petras Piskarskas
Vilinius University, Department of Physics, Lithuania

The EPS QEO Prize 2001 sponsored by NKT for applied aspects is awarded to Algis Piskarskas for his pioneering research and development of ultrashort pulsed light sources based on optical parametric generation and oscillation.

Algis Piskarskas was born in Kedainiai, Lithuania in 1942. He received his PhD in 1969 from M.Lomonosov University under S. Akhmanov and R. Khokhlov, coauthoring papers in nonlinear optics demonstrating the first KDP optical parametric amplifier (1965) and KDP parametric oscillator (1966). In 1968 he launched the first picosecond KDP optical parametric generator. In 1969 he joined the Physics Faculty at Vilnius University, working on with ultrafast lasers and nonlinear optics.

In three decades of scientific activity he contributed significantly to the fundamental and applied research of parametric light conversion in nonlinear crystals. He coauthored a series of original papers demonstrating such new parametric processes as chirp reversal, chirp enhancement, parametric diffraction, chirped pulse parametric amplification, and parametric combining of incoherent light beams in OPA and OPO. Particularly valuable results in his laboratory have been obtained on ultrafast travelling wave parametric generation in BBO and LBO crystals leading to development of UV – IR tunable picosecond and femtosecond OPGs. He has contributed to ultrafast physics of primary processes in photosynthetic molecules, dye aggregates and colour centres demonstrating an exclusive potential of continuously tunable ultrafast OPGs. Currently working on nonlinear optics of powerful femtosecond light pulses, he is also interested in laser applications in biology and medicine.

In 2000, his laboratory was selected by the EC as Centre of Excellence (together with the laboratory of Biochemistry) for the project "Cell Biology and Lasers: Towards New Technologies". With more than 240 papers, he frequently gives invited talks at international conferences. A.Piskarskas has received many prizes, including the National Prize of Lithuania in Science (1994). This year he was elected as Vice president of the Lithuanian Academy of Sciencies.

Konrad Banaszek
Centre for Quantum Computation, Oxford, UK

The Fresnel Prize 2001 for the fundamental aspects is awarded to Konrad Banaszek for his outstanding contributions to our understanding of non-classical light and its application in quantum information processing, especially advancing our understanding of highly correlated "bi-photons" – pairs of highly correlated photons such as those produced by down-convertors.

Konrad Banaszek was born in Gdynia, Poland in 1973. He received his Masters and Ph.D. degree cum laude from the Physics Department at the Warsaw University in 1997 and 2000, respectively. His Ph.D. thesis was about measuring quantum state in phase space which was supervised by Prof. K. Wodkiewicz. Since then he has been a postdoctoral researcher at the University of Rochester and the University of Oxford. Konrad is distinguished for his theoretical work in quantum optics. However, while principally a theorist, he has also made highly regarded experimental advances. His main achievemens have been made in the following areas: (1) Applications of sophisticated data processing algorithms to quantum state reconstruction, and the quantitative assessment of information gain versus state perturbation. (2) New methods for testing Bell inequalities for continuous variables. (3) Important analyses of general methods for "optimal" quantum information processing schemes. (4) The first detailed analysis for source coding for quantum communications schemes. (5) First experiments in the world to examine the strength of correlations in bi-photons generated in quasi-phase-matched waveguide down-converters. In all of these areas, he has pioneered new techniques, provided invaluable new insights and shown qualities of leadership remarkable in someone so young.

Ronald Holzwarth
Max-Planck-Institut for Quantum Optics, Garching, Germany

The Fresnel Prize 2001 for the applied aspects is awarded to Ronald Holzwarth for pioneering a revolutionary new technique to measure the frequency of light with extreme precision. The complex harmonic laser frequency chains of the past can now be replaced by a single compact mode-locked femtosecond laser.

Ronald Holzwarth was born in 1969 in Germany. He received his Diploma degree in Physics at the University Tübingen in 1997. In 2001 he finished his Ph.D. thesis under the guidance of Prof. T. W. Hänsch at the Max-Planck-Insitut of quantum optics in Garching, Germany. Dr. Ronald Holzwarth has pioneered a revolutionary new technique for measuring the frequency of light with extreme precision using Kerr-lens-modelocked ultrabroadband Ti:sapphire lasers. He has introduced techniques for controlling the spacing and position of the modelocked laser frequency comb so that hundreds of thousands of absolutely known reference frequencies throughout the visible and near infrared region become available. By comparing two different femtosecond laser frequency comb synthesizer, he has demonstrated agreement within 5 parts in 10-16. Dr. Holzwarth has pioneered a new technique with enormous impact for frequency metrology, for which he very successfully demonstrated first applications. His "clockwork" will lead to a new generation of atomic clocks, based on narrow optical resonances in atoms, molecules, or ions.

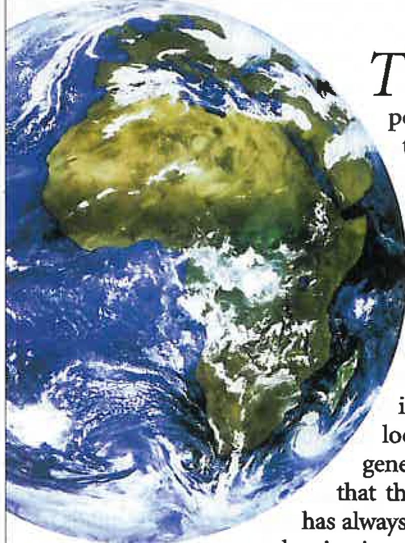
Previous recipients of the EPS QEO Prizes

1996 – Hamburg	Claude Cohen-Tannoudji Sune Svanberg
1998 – Glasgow	Orazio Svelto Vladilen Letokhov
2000 – Nice	Herbert Walther David Hanna

Previous recipients of the EPS Fresnel Prizes

2000 – Nice	Fabien Bretenaker Arnaud Brignon

Life in the Universe - Is there anybody out there?



The Universe is indescribably huge. Can it be possible that humanity is the only form of intelligent life that exists in all this immensity? Are we really alone? Throughout history there have been reported sightings of creatures from elsewhere. Science fiction novels and films with flying saucers and bizarre looking aliens are part of our general culture. The possibility that there is life in the Universe has always excited the general public and scientists are equally enthusiastic. Physicists, biologists, chemists, cosmologists, and astronomers are researching all over Europe to try to answer the age-old question: is there life in the Universe?

The European Organization for Nuclear Research (CERN), the European Space Agency (ESA) and the European Southern Observatory (ESO), in cooperation with European Association for Astronomy Education (EAAE), have organised a competition to find out what young people in Europe think. The European Molecular Biology Laboratory (EMBL) and the European Synchrotron Radiation Facility (ESRF) are also involved.

This programme "Life in the Universe" is being mounted in collaboration with the research directorate of the European Commission for the European Week of Science and Technology in November 2001. Competitions are already underway in 23 European countries to find the best projects from school students between 14 and 18. The projects can be scientific or they can be a piece of art, a theatrical performance, poetry or even a musical performance. The only restriction is that the final work must be based on scientific evidence. Two winning teams from each country will be invited to a final event at CERN in Geneva on 8-11 November 2001 to present their projects to a panel of International Experts at a special three day event devoted to understanding the possibility of other life forms existing in our Universe. This final event will be broadcast all over the world via the Internet.

The home base of the "Life in the Universe" project is a vibrant web space where details of the programme can be found (lifeinuniverse.org). It is still under development but already has a wealth of information and links to the national web sites, where all entries are posted.

Is there other life in the Universe? We do not know - but the search is on!

Photograph copyright: ESA ©

A model approach for future conferences

Steve Brooks, Institut de Biologie, Université de Lille, UMR 8525 CNRS

A joint initiative of the French Académie des Sciences and the Aventis – Institut de France Foundation, the annual European conference for young scientists, Scientia Europæa, was held in September 2000 at Bischoffsheim, in the foothills of the Vosges mountains, near Strasbourg and claimed its star in the firmament of prestigious meetings.

Begun in 1996, Scientia Europæa has now played host to a total of more than 230 biologists, chemists and physicists present at its various assemblies in order that they discuss their own research via the presentation of posters, while examining the potential for international, interdisciplinary collaboration. The 5th such meeting, the largest to date, included 52 researchers from 34 European countries, with participants from Albania and Georgia for the first time.

National scientific academies and renown research institutions from Madrid to Moscow are invited every year to submit nominations for the selection of participants. In 2000, there were more than 400 candidates, all talented scientists. Each year the panel undertakes to create a group which balances subjects, age and experience while providing the opportunity for the more modest European scientific communities to participate.

The participants however are not the only visitors to the conference since the discussion sessions are punctuated by official lectures. The speakers have included Nobel Prize Laureates such as Jean-Marie Lehn and Pierre-Gilles de Gennes, the President of the Académie des Sciences, Guy Ourisson and a range of internationally renown scientists covering the major disciplines, who drawn by the originality of Scientia Europæa, have been happy to endorse the meeting with their support, while accepting the challenge to present their work to such a varied audience.

For many of the participants, Scientia Europæa offers a unique opportunity to meet researchers of the same generation, who despite their difference in scientific speciality and culture share similar experiences and strive to surmount common problems. Equally, the diversity of the scientific domains represented encourages a convivial ambiance for open discussion rather than the competitive atmosphere of many thematic conferences. This meeting of fertile minds has inspired the formation of international, interdisciplinary collaborative partnerships.

A trinity of scientific smiles following the presentation to (left to right) Salvatore Magazu, Zoe Pikramenou and Beata Vertessy of the Scientia Europæa Prize for 2000 by Mr Igor Landau, member of the Aventis Board and at which Guy Ourisson and Jean-Marie Lehn officiated.

During the five years of the conference these interactive projects have multiplied and served to reinforce the aims and embody the spirit of the meeting. The participants are motivated by the singular privilege of being amongst their peers, while paradoxically finding themselves perhaps the sole representative of any particular speciality.

Such was indeed the case in 1999, when physicist Bo Brummerstedt Iversen (Aarhus, Denmark) and inorganic chemist Sergiu Palii (Chisinau, Moldova) were presented with the first ever Scientia Europæa Prize. The award, a cheque for 60,000 Euros to fund the continuation of the project entitled "Engineered Bio-catalysis", along with a handsome trophy were recompense for a collaboration of three years standing. The two winners met and formulated their research programme during the inaugural edition of the conference. They are hoping to contribute to the fundamental understanding of enzymatic catalysis, electron transfer processes and the electronic structure of transition metal systems. Initially, following the study of the physical characteristics of settled reactions, the most appropriate synthetic conditions are to be determined for the development of new enzyme mimics employing existing and/or novel methodologies.

Scientia Europæa 2000 boasted a trio of prize winners each from a different country, each from one of the three principal scientific disciplines. Only twelve months since their first encounter, enzymologist Beata Vertessy, (Budapest, Hungary), chemist Zoe Pikramenou, (of Greek origin but currently located at Birmingham, UK) and physicist Salvatore Magazu, (Messina, Italy) have developed and initiated a collective programme of research which benefits from their individual expertise. Indeed, the results of complimentary biological, chemical and physical techniques applied to 'real' model systems will enable a complex protocol of investigation to be presented and subsequently applied to a specific 'in-depth' viewing of the macromolecules of life. The team have developed their interdisciplinary approach as a just appreciation of Nature's own following of the scientific rules and conventions of evolution. In this way it is appreciated that each has an investigatory role to play within the framework of the project.

The direction of scientific subject development will forever be founded upon the principles of discovery and of the resultant genealogical diversification of subject matter. In respect of this Scientia Europæa offers the opportunity to prepare closer links between those different topics, bridging the distances which evolve either within a single discipline, or more interestingly trans-disciplinary. The communal application of singular expertise, such as those described above, has lessons for all those of us who had left behind, with some relief, the topics for which Nature did not select us.

The success of this regular assembly of young scientists from the many corners of the continent might one day influence and render the organisation and co-ordination of future scientific networks a more cohesive and manageable whole. With two projects established upon such sound foundations and celebrated in 1999 and 2000, others already underway or in the development stages, perhaps this might best be referred to as simply the end of the beginning. The proof of this perspective is not only clear in the important role that a meeting of this kind plays in uniting the disparate elements of scientific domains within a calendar dominated by thematic meetings but equally in the voluntary aspect of Academies more recently applying their own candidate selection procedures which serves quite simply to enrich the appreciable essence which already pervades Scientia Europæa each year.

WESTFÄLISCHE
WILHELMS-UNIVERSITÄT
MÜNSTER

-Department of Physics-

The Institute for Nuclear Physics invites applications for a
Professorship (C4)
for Experimental Physics in particular Nuclear Physics

to begin in Fall 2002.

Candidates should have a record of first-rate research in the field of interactions of nuclei and hadrons at high energies.

The successful candidate should be willing to take a leading role within the research programme "Physics of Subatomic Particles" of the Department of Physics and is expected to make substantial contributions to the international activities of our Institute in the field of ultrarelativistic heavy ion collisions (PHENIX, ALICE). Candidates will participate in the general teaching and administration duties of the Department.

Qualification requirements are: Ph. D. in Physics and "Habilitation" (or equivalent).

Qualified women are strongly encouraged to apply. Given equal qualification, candidates with disabilities will be given preference.

Applications with a curriculum vitae, scientific curriculum, list of publications, up to 5 recent reprints and a listing of teaching experience should be sent by September 15, 2001 to

Dekan des Fachbereichs Physik
der Westfälischen Wilhelms-Universität Münster
Wilhelm-Klemm Str. 9
D-48149 Münster - Germany

CALL FOR PROPOSALS

LIGHT-ION FACILITY EUROPE (LIFE)
IN GRONINGEN, JÜLICH AND UPPSALA

The three laboratories **Kernfysisch Versneller Instituut** (KVI) at Groningen, **Institut für Kernphysik** at Forschungscentrum Jülich and **The Svedberg Laboratory** (TSL) at Uppsala jointly offer the means for research in the fields in nuclear and medium-energy hadron physics with proton and heavy-ion beams in a wide energy range at their accelerators AGOR, COSY and the Gustaf Werner-cyclotron/CELSIUS, respectively. They have united their efforts in this research field in the framework of LIFE (Light-Ion Facility Europe). Scientists from member states of the European Union and from associated countries are entitled to apply for support to use the beams and facilities of these institutes through contracts signed with the European Commission in the framework of the Access to Research Infrastructures action of the Improving Human Potential (IHP) programme. Proposals will be reviewed by the International Programme Advisory Committees of the respective laboratories and by a joint LIFE Facility Co-ordination Group. Approved projects dealing with research meant for publication in the open literature will be given access to beam lines, experimental equipment, infrastructure, etc. free of charge. The scientists concerned will also be eligible for financial support through the IHP programme to cover their travel and subsistence expenses.

Information about the individual laboratories, available equipment, proposal forms and deadlines, and other procedures is available from
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CALL FOR PROPOSALS

the Mid & Far-IR User Facility

FOM

FELIX

The free-electron laser user-facility FELIX in the Netherlands provides continuously tuneable radiation in the spectral range of 40 - 2500 cm^{-1} (4 - 250 μm), at peak powers ranging up to 100 MW in (sub-) ps pulses, and is being used for scientific research in (bio-) medicine, (bio-) chemistry and (bio-) physics. Research proposals are solicited for the periods:

1 March 2002 - 31 August 2002, with **deadline 1 December 2001**, and

1 September 2002 - 28 February 2003, with **deadline 1 June 2002**.

Beam time will be allocated based on a review of the submitted research proposals by a programme advisory committee.

Access is **free of charge** for all non-proprietary research. Researchers from EU-countries and Associated States other than the Netherlands are eligible for support under the *Access to Research Infrastructures action of the Improving Human Potential Programme of the European Community*.

Further information on the characteristics of FELIX and on ancillary equipment, as well as guidelines for the submission of proposals, are available via the internet:

http://www.rijnh.nl/felix

UNIVERSITY OF NEUCHATEL

FACULTY OF SCIENCES

The Physics Department has an opening for a position as

Full professor in experimental condensed matter physics

Preference will be given to candidates conducting research projects in one of the following domains:

Electronic and structural properties of surfaces and interfaces

Physics of materials with novel electronic properties

The candidate will have access to national laboratories such as SLS (Swiss Light source) and SINQ (Spallation source). He (she) will participate in teaching in the field of general and experimental physics.

Beginning: October 1, 2002

Positions at the University of Neuchatel are open equally to women and to men.

More detailed informations can be obtained from the Director of the Institute, Rue Breguet 1, CH-2000 Neuchatel (e-mail: hans.beck@unine.ch) or under ***http://www.unine.ch/phys/***.

Applications, including curriculum vitae, list of publications, research projects and three references are to be sent to the following address by October 31, 2001:

Département de l'instruction publique et des affaires culturelles, Service de l'enseignement universitaire, Château, CH-2001 Neuchatel, Switzerland

UNIVERSITÉ DE GENÈVE

The Faculty of Sciences, University of Geneva, Switzerland, has an opening for a position as

Full Professor or Associate Professor
in experimental condensed matter physics
(Professeur ordinaire ou Professeur adjoint)

Responsibilities: This is a full time appointment comprising at least 6 hours of teaching per week and research activities in the area of condensed matter physics. The successful candidate is expected to conduct a vigorous research in experimental condensed matter physics. We especially encourage candidates active in the field of novel spectroscopies applied to metals and strongly interacting electron systems in general.
Degree of requirements: Ph.D. or equivalent
Starting date: 1st April 2002 or as agreed
Applications, including curriculum vitae, a list of publications and a short research plan are to be sent to the

Dean of the Faculty of Sciences
30, quai Ernest-Ansermet
CH-1211 Genève 4, Switzerland

where further information concerning the job description and working conditions may be obtained.
Closing date for applications: October 31, 2001.

In an effort to involve both men and women in teaching and research, the University encourages applications from women.

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