French National Centre for Scientific Research
Annual report - 1996

News from the labs

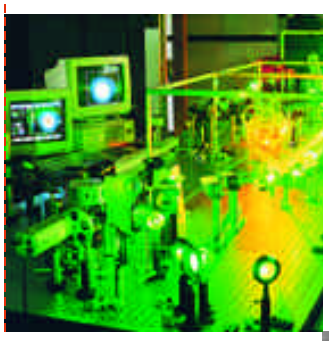
Some of the major scientific events of 1996 in the different scientific departments of the CNRS can be found on the following pages.

Decoherence and the Schrödinger cat

Can the Schrödinger cat be both alive and dead at the same time ? The famous quantum mechanics paradox has just been tested by a team at the Kastler-Brossel laboratory, Ecole normale supérieure. The cat, or rather the kitten, is materialized by a very weak electromagnetic field made up of ten or so photons located in a cavity. After interacting with an atom, itself in a superposition of states, the field finds itself in a quantum superposition of two states with different phases. A second atom then probes the field. As predicted by theory, the quantum superposition disappears due to a decoherence phenomenon. The bigger the cat, or the greater the number of photons, the sooner the superposition disappears; this experiment provides a clearer picture of how the transition from the quantum world to the ordinary world occurs.

(SPM)

Laboratoire Kastler-Brossel (CNRS-Ecole normale supérieure-université Pierre et Marie Curie, Paris).



A view of the 35 terawatt laser chain in femtosecond pulse.

Discovering new sources of X-rays

The most intense femtosecond laser in the world today has just been set up at the Applied Optics laboratory (LOA) in Palaiseau. This "entirely solid" laser produces 35 terawatts of power with a 10-hertz repetition rate (10 laser pulses per second). The pulses are first stretched out in time, then amplified, then compressed back to their initial duration. Beyond the fact that it is a record performance, this new source should enable French and European teams (the LOA is a "large-scale European facility") to study the laser-matter interaction at levels of intensity higher than 10^{19} W. cm^{-2}, in new conditions providing relativistic effects. Thanks to this highly intense laser, new sources of X-rays, either coherent or incoherent, are now being developed and will lead to numerous practical applications in science, technology and medicine.

(SPM)

Laboratoire d'optique appliquée (CNRS-Ecole nationale supérieure des techniques avancées-Ecole polytechnique, Palaiseau).

The detector of the NA50 experiment at the CERN super protonsynchrotron.

Searching for quark-gluon plasma

Is it possible, in laboratory conditions, to reproduce the Universe as it must have been several microseconds after the big bang?
Then, quarks and gluons, the components of the atomic nucleus, were not confined inside the nucleus; they were in a state of matter with a very high density of energy - the quark-gluon plasma.
Now, isolated quarks cannot be observed, since they are always locked in pairs (mesons) or triplets (nucleons), and held together by the gluons, vectors of the strong interaction.

At CERN, a hundred physicists, among whom half belong to IN2P3/CNRS, are working on the NA50 experiment, in which a lead target is bombarded by a lead ion beam from the SPS (super protonsynchrotron) accelerator. The experiment measures the amount of charmed mesons J/X produced in the collisions, and scientists have found that production is much lower than expected. According to theoretical predictions, this is the signature one would expect if a collision had induced the formation of a quark-gluon plasma.

(PNC)

Beyond the standard model

This year, important information has been obtained thanks to two experiments aimed at perfecting our knowledge of the standard model (the reference theory of particle physics) and especially at challenging this model in the hope of gaining a better understanding of the ultimate structure of matter. CERN's electron-positron accelerator, the LEP, has pushed beyond the 160 gigaelectron-volt (GeV) landmark, which means that it can now produce W bosons. The new data has made it possible to measure the mass of the W boson, thus confirming previous measurements made thanks to other methods.
This energy increase will allow scientists to investigate new types of phenomena encountered in a new world of physics.

Event H1 at HERA in Hamburg.

In the H1 experiment at the HERA electron-proton collider in Hamburg, a greater number of events were observed in a positron-proton collision than would have been expected in a standard model experiment. After analysis of the data collected in 1997, physicists should be able to tell whether they are witnessing the early signs of a new phenomenon extending beyond the limits of the present standard model, or whether they are simply facing a statistical fluctuation.

(PNC)

This prime number with 1505 figures represents the number of ways of writing the quantity 1 840 926 as a sum of positive integers. To verify that it is indeed a prime number (we thus managed to break a world record), the equivalent of four years of calculations on a single work station were needed. The result was obtained ten times faster by dividing the task among several work stations linked together in a network.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Cryptography, from laboratory to industry

Academic interest in cryptology is barely twenty years old. The first cryptosystems were based on modular integer arithmetics. The present state of the algorithms is such that huge parameters are needed and ciphering keys of 512 or 1024 bits are often used.

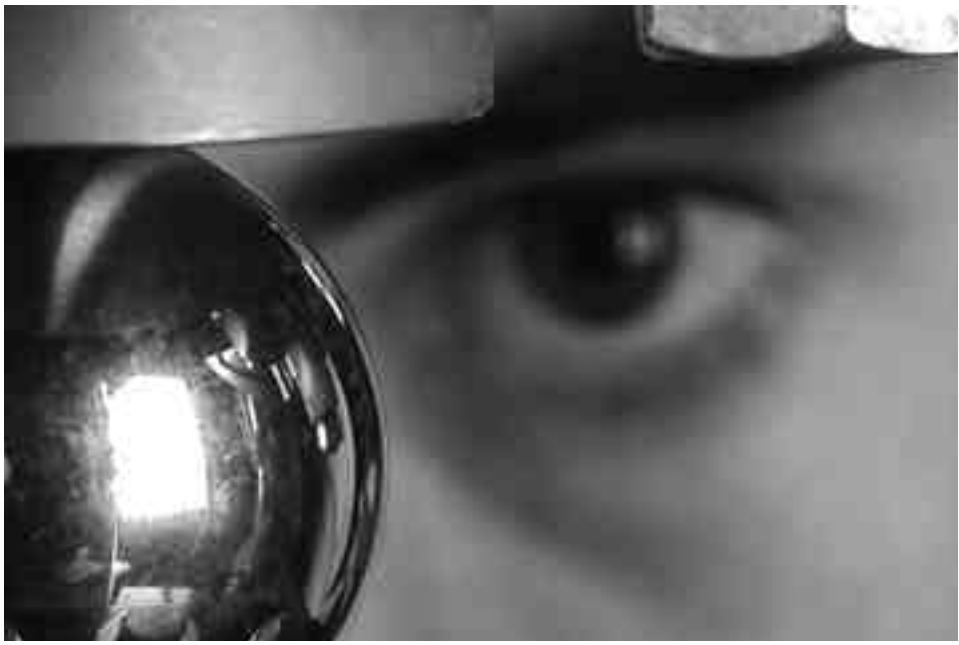
In 1985, elliptic curves, a new paradigm offering the same advantages as modular integers, was developed, thanks to which cryptographic research could continue using the same schemes. However, so far, no one knows how to transpose onto this paradigm the algorithms which were successfully developed with the modular integers.

In fact, the elliptic curves provide the same degree of security while using smaller parameters: 150 bits are enough.

The cryptosystems built with elliptic curves at the Ecole Polytechnique Computer Science laboratory have broken world records in the field. We can now provide the best possible implementation for the parameters of the size required by industrial cryptography.

(SPI)

Laboratoire d'informatique de l'Ecole Polytechnique, Palaiseau.



An ankle-ergometer at the City of Stars

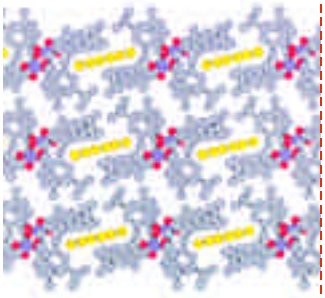
An ankle-ergometer, developed by a French laboratory to study the mechanical properties of the ankle's rotating muscles before and after a space flight, has been set up at a laboratory of the cosmonaut training center of the City of Stars near Moscow. The electrical activity generated by the muscles is recorded by several sensors attached to a movement guide on which the foot is placed. The mechanical events sequence and the data collected and stored led to the elaboration of special software.

The laboratory has thus participated in six space missions to the Mir station and has been able to collect data from about ten cosmonauts, among whom Claudie André-Deshays, the first French woman to fly on such a mission. It would seem that microgravity affects mainly muscle-tendon elasticity. Prototypes of the ankle-ergometer are used to quantify muscle problems and to monitor the impact of training. The ankle-ergometer can thus be used in many other contexts besides space programmes.

(SPI)

Division biomécanique et instrumentation médicale (CNRS-université de technologie de Compiègne); this programme is supported by the National Centre for Space Research (CNES) and the Atomic Energy Commission (CEA).

The Russian cosmonaut A. Viktorenko being tested on the ankle-ergometer at the City of Stars near Moscow.



Network (koilate) obtained by assembling concave (koiland) and convex molecules.

Molecular tectonics

Molecular tectonics deal with large-size molecular constructions whose components (tectons or construction modules) are assembled through noncovalent interactions.
These molecular networks, or hypermolecules, can be elaborated thanks to the self-assembling strategy of complementary molecular bricks which carry a specific assembly programme inside their structure. For the first time, the Organic Coordination Chemistry Laboratory was able to build a solid-state one-dimensional network by putting together concave bricks, called koilands, and convex molecules. The resulting network is a hypermolecule called koilate (molecular thread), where all the components are noncovalently linked through van der Waals interactions. Given the weak nature of these interactions, such a strategy can lead to the creation of flexible crystals, self-restoring systems, etc. The formation of koilates can also serve as a simple chemical model of the adhesion and bonding processes.

(SC)

Laboratoire de chimie de coordination organique (CNRS-université Louis-Pasteur, Strasbourg)

Sports and doping

Testosterone is a sex hormone derived from cholesterol and synthesized by the body. It is eliminated in urine with other metabolites, among which one of its isomers, epitestosterone. When testosterone is ingested by an athlete, the testosterone/epitestosterone (T/E) ratio increases. The International Olympic Committee has recognized the validity of the T/E ratio as a doping detection method. However, in some cases, it remains impossible to determine for sure whether testosterone has been ingested or not. To solve this problem, the Central Chemical Analysis Department of the CNRS has elaborated a new method making it possible to distinguish between endogenous testosterone, which is biosynthesized by the athlete, and exogenous, ingested testosterone. This technique is based on the isotopic mass spectrometry of carbon, whereby the ratio of carbon-13 to carbon-12, $^{13}C/^{12}C$, can be determined, thus showing the origins of a given substance. Once this technique is validated, it could be used as a confirmation test in cases when the interpretation of the T/E ratio remains difficult.

(SC)

Service central d'analyse (CNRS, Vernaison).

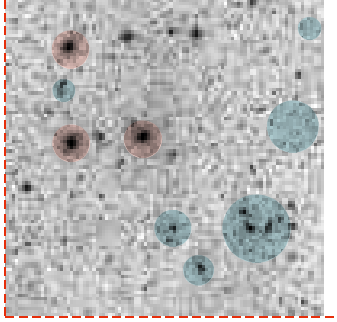
The oldest African elephant

In 1994, at a mineral and fossils sale, researchers discovered a fragment of the jaw of a small unknown mammal. After lengthy investigations and with the help of the Moroccan geological services, they were able to locate the site where the fossil had been found, a phosphate deposit in the Ouled Abdoun basin, east of Casablanca. There, they discovered the most ancient fossils of known proboscideans. These ancestors of the elephant date back to the Paleocene epoch (65 to 35 million years before the present), which means that this order, whose earliest traces had so far been located in the Algerian Eocene epoch, is in fact 7 million years older than previously thought. The fossils, remnants of the oldest ungulates ever discovered, confirm that Africa is the birthplace of elephants. This finding will play a crucial role in the study of the origins of some existing orders of large ungulates, which include horses and ruminants.

(SDU)

Laboratoire "Paléontologie et Stratigraphie" (CNRS-université Paris 6).

Jaw of *Phosphaterium escuilliei*, the oldest elephant in the world.



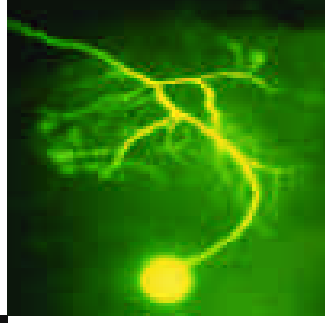
The centre of the Abell 3627 cluster. Three large elliptical galaxies (red) can be distinguished among numerous other galaxies (blue). Because of the density of stars in our Galaxy (black), the galaxies located behind the Milky Way are very difficult to observe.

Tracking down the Great Attractor

Astronomers of the Paris Observatory, of Cape Town University (South Africa), and of the University of New Mexico (USA) have detected the densest cluster of galaxies ever seen from the Southern hemisphere: Abell 3627. It is located behind the Milky Way, which makes observation difficult. This cluster could be the centre of the Great Attractor. Predicted in 1987, the Great Attractor would be a 5.10^{16} solar mass structure which attracts nearby galaxies (including ours) at a velocity of 500 to 600 kilometres per second. Astronomers used the 3.6 m telescope of the European Southern Laboratory, which has a spectrograph and an automatic optical fibre positioner, the 1.9 m telescope of the South African Astronomical Observatory and the 64 m Parkes radiotelescope in Australia. More than 600 new galaxies were detected within Abell 3627, leading to a mass of approximately 10^{15} solar masses, which is considerable. It is situated 300 million light years away, a relatively short distance, and is similar to the Coma cluster, itself 450 million light years away.

(SDU)

Observatoire de Paris (Département d'astrophysique extragalactique et de cosmologie, CNRS-université Paris 7).



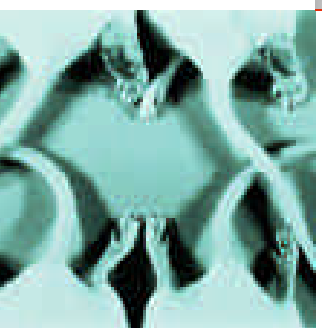
Neuron.

A single locomotion command centre

In mammals, the command of locomotion involves generating centres located in the spinal cord. In Marseilles, a research team headed by the director of the Neurology and Movement Laboratory, François Clarac, has for the first time succeeded in locating these centres in a circumscribed area of the spinal cord. This is a very promising discovery, particularly for the treatment of certain forms of paraplegia.

(SDV)

Laboratoire de neurologie et mouvement (CNRS, Marseille).



Four mice, two of which were infected by leishmaniae. The lesions caused by the parasite in the infected mice can be clearly seen on the soles of the mice's right paws.

Fooling the immune system

In order to multiply in a living body, viruses, bacteria and parasites must find a way to avoid the immune system. Some, like the infamous HIV, keep altering their appearance so as not to be recognized. Others remain "visible", but trick the organism into choosing the wrong type of defense: such is the case of the leishmaniae which produce a specific protein called LACK. This protein forces the organism to produce antibodies which are in fact powerless to counter the leishmaniae but instead block the activation of macrophages, the only cells capable of destroying this parasite. In what way can such a discovery help? One solution would be to prevent the immune system from reacting to the LACK protein, in an approach comparable to the "desensitizing" process practiced in allergy treatments; this could be a way of immunizing the body against complex organisms, such as parasites, which resist ordinary vaccination. This research was conducted by Nicolas Glaichenhaus and his team at the Institute of Molecular and Cellular Pharmacology (CNRS, Sophia-Antipolis).

(SDV)

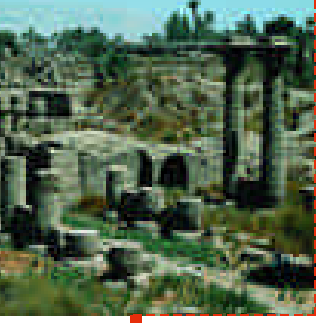
Institut de pharmacologie moléculaire et cellulaire (CNRS, Sophia-Antipolis).

The long-QT syndrome

In an article published in Nature *(November 7, 1996), Michel Lazdunski and his colleagues from the Molecular and Cellular Pharmacology Institute in Sophia-Antipolis announced the cloning of the LQT1 gene in mice. This gene encodes the production of a protein which associates with the IsK cardiac protein in order to form channels bringing potassium ions to heart cells. This process is vital for a normal heart rate to be ensured. Thanks to this discovery, we can understand not only how the potassium channel reacts when affected by the long-QT syndrome, but also gain new insight into the molecular mechanisms which generate cardiac electrical activity. This discovery should eventually lead to the elaboration of new, more effective anti-arrhythmic drugs and facilitate the analysis of arrhythmia caused by certain drugs.*

(SDV)

Institut de pharmacologie moléculaire et cellulaire (CNRS, Sophia-Antipolis).



Karnak, Eastern Temples.

The Karnak temple is exactly 3942 years old

A French egyptologist and CNRS researcher, Luc Gabolde, has succeeded in pinpointing the precise date of the foundation of the Karnak temple in Louxor.
The temple was founded on December 21, 1946 B.C., at 6.30 AM, in other words on the day of the winter solstice, at sunrise. To come up with this date, he used astronomy, classical chronologies, papyruses and a computer.

In 1983, Luc Gabolde deciphered a text in which Sesostris I, sitting under his canopy, announces that he has brought together his court in the tenth year of his reign for the foundation of the Karnak temple, "the fourth month of the Peret season, on the 24th day". To identify this day, Gabolde took as reference point an astronomical event mentioned in a later text of the Sesostris III reign.

The temple of Sesostris I being dedicated to Amon Rê, a sun god, the egyptologist tried to determine its position in relationship to the sun, taking into account the fact that the earth's axis had shifted over the centuries. He thus calculated that its orientation corresponded almost exactly to the position of the sun at sunrise on the day of the winter solstice at the time. The duration of the intermediary reigns between Sesostris I and III being as yet undetermined, Gabolde found that if he took the shortest hypothesis, he could establish the right date as being December 21 - the winter solstice - 1946 B.C. Indeed, that year, the winter solstice corresponded to the new moon, which for the Egyptians was the most auspicious time to build a temple.

(SHS)

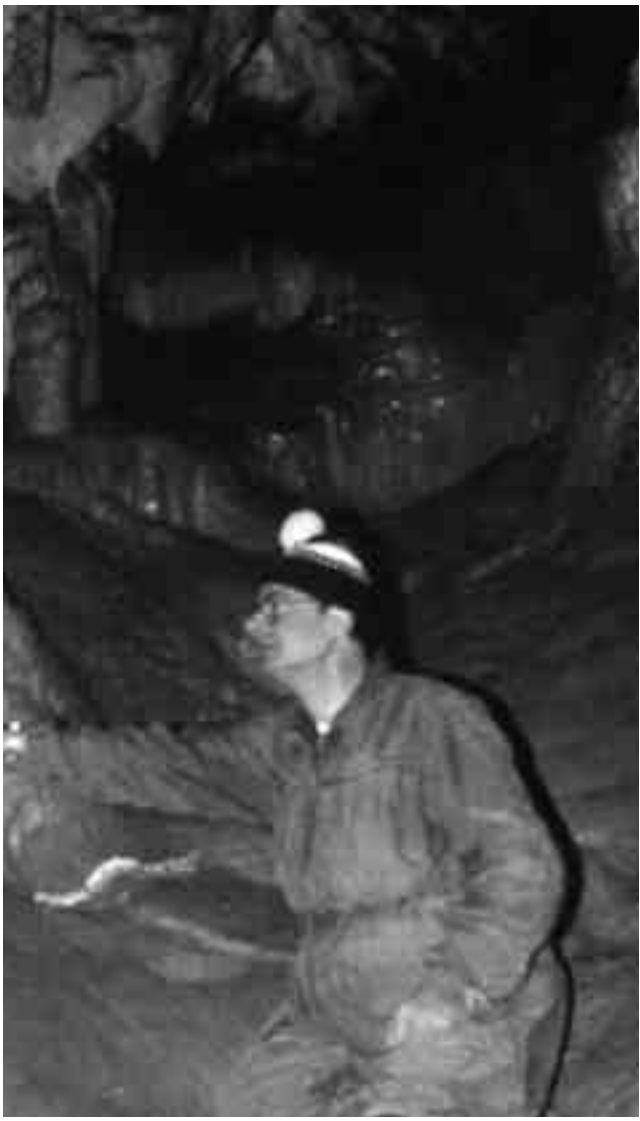
CNRS permanent mission in Karnak, Egypt.

The communist archives

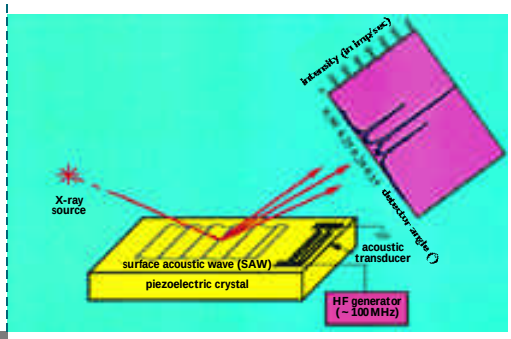
After the collapse of the communist régimes in the Soviet Union and the satelllite countries, researchers gained access to a vast quantity of archives which until then had been closed to the public.
Today, researchers can travel to Moscow to consult Komintern and Kominform archives, those of several communist parties, of the Soviet administration and of the Red Army; in Prague, historians can examine Party and State archives, as well as documents relating to the Prague Spring period. The same can be said for Poland, Hungary and former East Germany.

The quality of these archives, which are well preserved and catalogued, is excellent. Indeed, as Nicolas Werth put it, communism was a "report-centred civilization". Free access to these funds has provided researchers with a gold mine of information, and some libraries have even purchased microfilms of documents. This new influx of information has led to a renewal of historical research on the communist world - the history of the Soviet Union, of popular democracies and communist parties. The insights of such specialists in the field as Annie Kriegel have been confirmed, gaining in precision and form. French researchers, such as Philippe Buton (professor at the University of Reims), Nicolas Werth and Karel Bartosek (CNRS-IHTP) or Stéphane Courtois (CNRS, University of Paris-10), are extremely active in this field.

(SHS)



Cover of the strictly confidential report on kulak terrorism in the countryside, for the period lasting from January 1, 1924 to September 1, 1928, based on information provided by the GPU as of September 1, 1928.
Source: Russian centre for the conservation and study of documentation on contemporary history.



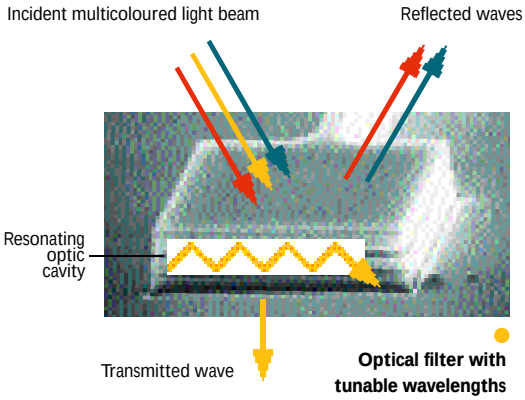
The angular position and the intensity of two satellite beams on either side of the reflected beam depend on the frequency and the amplitude of the sound wave.

Acoustic waves and X-ray beams

Electromagnetic X waves with a wavelength of 0.1 nanometer - the size of the atom - are a precious tool for research on the nature of matter.
In recent years, X-ray sources have increased their power thanks to the development of new generation synchrotron rings. Synchrotron radiation is emitted by electron or positron packets whose trajectories are curved in magnetic fields.
In most applications, it is important to "control" the X-ray beams, in order for example to modify their trajectory or their intensity. A new method has been developed by the cristallography laboratory in Grenoble, together with a Russian team of researchers. This method, which is based on the interaction between electromagnetic X waves with surface acoustic waves, can be used to deviate the trajectory of an X beam or rapidly modify its intensity.

(SPM)

Laboratoire de cristallographie (CNRS, Grenoble), working jointly with Dimitry Roshchupkin, Institute of microelectronics and technology of the Academy of Sciences, Chernogolovka (Russia).



Optical filter with tunable wavelengths for the coloured telecommunications networks.

Information highways and the Opto-Electro-Mechanical Microsystem (MOEMS)

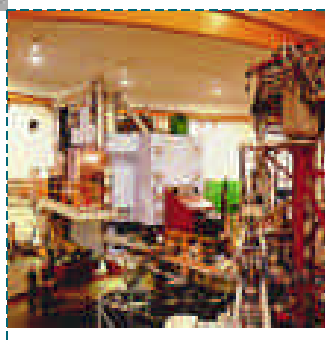
Wavelength multiplexing is considered a key technology in optical telecommunications, the main information conveyor on the information highways of the future. Indeed, in this system, a selection between several wavelengths carrying information is made either at one end or the other of the optical fibre.

This selection can be made with the help of an Opto-Electro-Mechanical Microsystem (MOEMS): this system is made up of a selective optical filter with a vertical micro-cavity of air; the wavelength can be tuned by modulating its thickness thanks to electrostatic force.

Optical information processing systems are centred on two functions, tuning and selecting. In this respect, the MOEMS microsystem can be seen as a miniature optical spectrometer. This technology makes it possible to produce simultaneously hundreds of such systems on a semiconductor III-V microchip no larger than one cm^2 in size.

(SPI)

Laboratoire d'électronique, automatique et mesures électriques (CNRS-Ecole centrale de Lyon), in collaboration with the teams of the Centre de recherche lyonnais en micro-opto-électronique (CRELYMO), in the framework of the European ESPRIT programme.

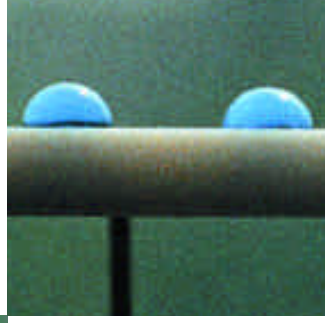


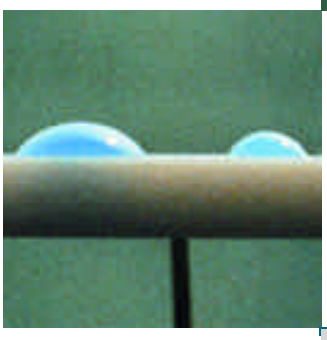
Overall view of Hall C at the TJNAF, with the spectrometers, the cryogenic target and the beam line.

Examining the proton and simple atomic nuclei

A new 4 GeV electron accelerator with a very dense beam has recently been set up at the Thomas Jefferson National Accelerator Facility in Virginia (USA).
Several research teams from the IN2P3/CNRS, in collaboration with French physicists from the French Atomic Energy Commission, are leading two international projects in this facility. The first major experiments are being conducted in two of the facility's three experiment halls.

In 1996, beam measurement equipment built by an IN2P3 laboratory and a deuton polarimeter built and tested by two other IN2P3 teams were installed at the TJNAF.
Both experiments are now ready to register the data needed by researchers to conduct studies aimed at improving our knowledge of the internal structure of the proton and the deuton. This data will also enable them to test models of the strong interaction.
(PNC)





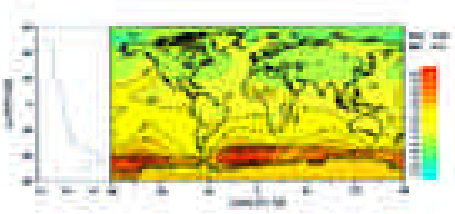
Drops of water coloured by copper sulphate on Teflon® samples. Upper photograph: untreated Teflon®; lower photograph: the Teflon® has been soaked in a magnesium-ammonia solution for 30 minutes.

A new surface treatment for Teflon®

Perfluorinated polymers such as the Tetrafluoroethylene polymer, or Teflon® $(CF_2\text{-}CF_2\text{-})_n$, have a number of qualities which make them invaluable: a high degree of chemical and thermal inertia, strength, low friction coefficient, electric resistivity, etc. However, these assets come with a significant drawback: difficult contact with other materials, in other words problems with adherence, lamination, painting or plating. For Teflon® to be usable, its surface has to be modified without loss of mass. A group of electrochemists has discovered a new treatment of perfluorinated polymers in which the reducing agent is a solution of magnesium in liquid ammonia. This new treatment is softer and easier to monitor than traditional chemical processes: the polymer remains white instead of carbonizing, its surface state is preserved and its hydrophilic capacity is controlled. Thanks to this new treatment, perfluorinated polymers can be glued, wetted and plated.

(SC)

Laboratoire de chimie et électrochimie des matériaux moléculaires (CNRS-Ecole supérieure de physique et de chimie industrielles de la Ville de Paris).



Carbon dioxide and the impact of aerosols on the atmosphere

What future can we expect for our climate and our planet's environment?
To provide answers to such a crucial question for mankind, scientists have simulated various possible situations with the help of numerical modeling. In this example (see figure), the model simulates what would happen to the earth's surface temperature if the amount of carbon dioxide in the atmosphere were to double due to an increase in the use of industrial aerosols. Numerical modeling shows that each hemisphere would react differently: the northern hemisphere would become cooler, whereas the southern hemisphere would become warmer.

(SDU)

Laboratoire de météorologie dynamique (CNRS-Ecole normale supérieure, Paris).

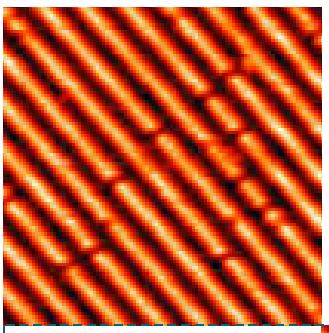
Formation of silicon lines on a silicon carbide surface ß-SiC (100)

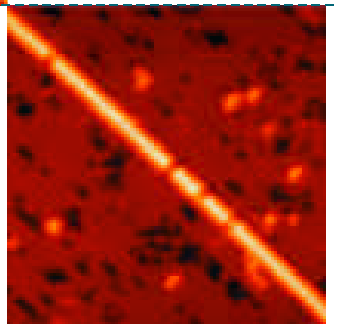
STM (Scanning Tunneling Microscopy) topographies, 200x200 $Å^2$ in size, showing atomic lines (~9 Å in width) on a surface of silicon carbide. The space between the lines can be controlled by monitoring the warming of the surface during the formation process. One can produce either a super-network of atomic lines (top photo), or a single atomic line (bottom photo).

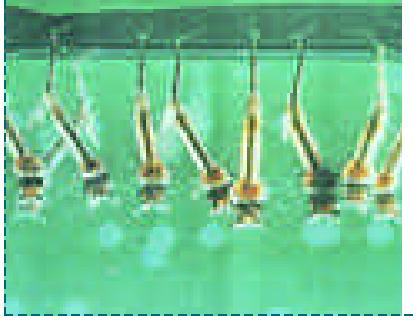
These lines have remarkable properties. They are regularly spaced, self-organized and very long (> 1000Å); their temperature is extremely stable (>600°C); they are formed on a refractory substrate with a wide electronic gap. Atomic lines have significant potential applications in the field of nanophysics.

(Ultimatech)

Laboratoire de photophysique moléculaire du CNRS (research team working under G. Dujardin) and Services de recherches et irradiation de la matière du CEA (team working under P. Soukassian).







Culex pipiens
mosquito larvae.

The 1996 CNRS-ANVIE prize

MtScript is a publishing software for multilingual documents. It has already been used - and greatly appreciated - in more than thirty-two countries.

The problem of multilingualism, and more concretely, that of processing multilingual data is of crucial importance today, given the spread of computers and the internationalization of information networks (Internet); nevertheless, users must be able to communicate in their native language. The aim of MtScript is to meet this need. Thanks to this software, multilingual texts written in a host of languages, French, Spanish, Arabic, Hebrew, Russian, Bulgarian, Greek, Czech, Estonian, Hungarian, Slovenian, Ukrainian, Chinese, Japanese, Korean, etc., can be entered, coded and edited. The authors of MtScript are Malek Boualem and Stéphane Harié.

(SHS)

Laboratoire Parole et Langage,
(CNRS-université de Provence).

How mosquitoes learn to resist

Because of mutations enabling them to survive the ingestion of otherwise fatal toxic substances, insects and other living organisms are becoming increasingly resistant to chemical insecticides. Nicole Pasteur, Michel Raymond and Thomas Guillemaud, of the Institute of Evolutionary Sciences in Montpellier (CNRS-université Montpellier 2), have studied the case of the ordinary mosquito, Culex pipiens. *Mosquitoes often resist certain kinds of insecticides by producing an excess quantity of two enzymes, esterase A and B, which "capture" the insecticide before it reaches the nervous system. Researchers have just shown that this excess production of enzymes is due either to a simultaneous increase in the number of copies of the two corresponding genes, or to the regulation of their expression. Furthermore, they have proved that this form of resistance did not appear separately in different parts of the world but that it in fact originated in a single geographic location and spread from there. Understanding the origins and mechanisms of this phenomenon could be of significant help in the choice of a winning strategy against these pests.*

(SDV)

Institut des sciences de l'évolution
(CNRS-université Montpellier 2).