SEMICONDUCTOR HETEROSTRUCTURES: STATE-OF-ART AND FUTURE TRENDS

Z. Alferov*
Ioffe Physico-Technical Institute, St Petersburg, Russia

The early history of the semiconductor heterostructures and their applications in different electronic devices is described. The lecture also contains a short historical review of the physics, technology of preparation and applications of quantum wells and superlattices. Recent progress in quantum wires and especially quantum dots structures and future trends and perspectives of these new types of heterostructures are discussed.

* Corresponding author:

ITER: REALIZING THE PROMISE OF FUSION ENERGY

P Barabaschi*
ITER International Team
Boltzmannstr. 2 - Garching - D85748 - Germany

For many decades nuclear fusion research has been devoted to pursuing an almost unlimited source of energy. Thermonuclear fusion is in fact one of the very few options, potentially acceptable from the environmental, safety and economic points of view, for providing energy over the long term, which is able to support a growing world population and a move away from consuming fossil fuels. World-wide research efforts have brought the leading programmes to the threshold of conditions that might be expected in a fusion reactor. Advances in understanding in microscopic turbulence affecting energy confinement as well as macroscopic stability affecting plasma pressure have arisen from a range of smaller experiments. These developments together with the development of necessary fusion technologies have brought the global fusion programme to a level of knowledge that allows it now to address the challenge of exploring the physics of a burning plasma in an experimental device incorporating all the key features of fusion technology in reactor-relevant conditions and thus demonstrating the scientific and technological feasibility of fusion power for peaceful purposes. ITER was conceived to meet this objective.

The history of co-operation on ITER began in the mid 80's when government leaders in summit meetings called for more substantial international co-operation in order to increase the efficiency and minimize the cost of fusion power development. After a decade of focused work, both in engineering and in physics, the ITER Engineering Design Activities (EDA) led to a design that gives confidence in the achievement of its technical objectives and in demonstrating the environmental attractiveness of fusion.

The success of the ITER EDA demonstrates feasibility and underlines the desirability of jointly implementing ITER in a broad-based international collaborative frame. It supports the ITER Parties' declared policy to pursue the development of fusion through international collaboration. Their entry into negotiations on a Joint Implementing Agreement for ITER construction and operation, which will fix the site, choose the Director-General, and determine their financial and technical share of each Party, is a very positive step in their commitment to the implementation of this policy. Given the expected success of these negotiations, a new era is opening in which fusion laboratories will have more dependable external support where they follow programmes focused on the immediate needs of developing fusion as an energy source.

This paper clarifies the above remarks, offers an outlook of the main issues of fusion plasma physics, and covers the principal features of the ITER design in relation to the groundwork it is expected to cover along the path to developing a viable and attractive source of power generation.

* Corresponding author: phone: (+49) 89 32994126, fax: (+49) 89 32994316, e-mail: barabap@itereu.de

CHARACTERIZATION OF THE CHARGE TRANSPORT AND ENERGY TRANSFER PROCESSES IN ORGANIC SEMICONDUCTORS

J.-L. Brédas*
Department of Chemistry, The University of Arizona
Tucson, Arizona 85721-0041, USA

Energy transfer and electron transfer are found to be key processes in the working mechanisms of devices based on organic semiconductors. Here, we provide a theoretical description of the energy and electron transfer phenomena that take place in a variety of organic materials. Materials under study include single crystals of conjugated oligomers (such as oligoacenes, oligothienylenes, and their derivatives), discotic liquid crystals (based on triphenylenes and derivatives), conjugated polymers, and donor-acceptor oligomer wires.

We first focus on the characterization of the charge (electron and hole) transport processes. The intrinsic electron and hole mobilities of well-ordered and disordered materials are discussed on the basis of Marcus theory and extensions thereof.

A second topic concerns the relative efficiencies of interchain versus intrachain energy transfer processes and the dependence on distance of the transfer mechanism (superexchange vs. hopping). Here, we will discuss this issue in the framework of a theoretical approach based on an improved Förster model applied to polyindenofluorene.

Finally, we model the mechanisms of photoinduced charge transfer from a ?-electron donating group to a ?-electron-acceptor moiety separated by a bridge of increasing size made of p-phenylenevinylene oligomers. It is found that while superexchange is the dominant mechanism for short bridges, incoherent transfer through hopping along the phenylene vinylene segment takes over in longer chains (for ca. three phenylenevinylene repeat units).

* Corresponding author: phone (520) 626-6561, fax (520) 621-8407, e-mail: jlbredas@u.arizona.edu

TEACHING ELECTRONS AND PHOTONS NEW TRICKS WITH STATE-OF-THE-ART TECHNOLOGY: QUANTUM CASCADE LASERS, OPTICAL MICROBILLIARDS, AND QED-BASED NANOMECHANICS

F. Capasso*
BELL LABORATORIES, LUCENT TECHNOLOGIES
600 Mountain Avenue, Murray Hill, NJ 07974

State-of-the-art semiconductor nanostructures based on molecular beam epitaxy (MBE) and microelectromechanical systems (MEMS) based on silicon integrated circuit technology have made it possible to achieve unprecedented control of the boundary conditions of electrons and photons. This has led to the design of new artificial materials and quantum devices with tailored properties, to microstructures in which controlled deformation are used to exploit wave-chaos phenomena for photonic applications and to micromachines based on vacuum fluctuations.

I will illustrate the above with examples from our research: (a) Quantum Cascade Lasers, fundamentally new light sources that cover the entire wavelength range from the mid to the far infrared by tailoring layer thicknesses; (b) Asymmetric microresonators in which KAM transition to chaos, "scars" and high directional emission from bow-tie modes have been observed; (c) High precision measurements of Casimir forces with MEMS and the demonstration of new actuators and sensors that exploit these forces.

* Corresponding author: email: fc@lucent.com

SEMICONDUCTOR SPINTRONICS

T. Dietl*
Institute of Physics, Polish Academy of Sciences
al. Lotników 32/46, PL-02668 Warszawa, Poland

The information revolution, which has surprised us over the last few decades, has occurred due to the restless exponential growth of information amount that can be processed, stored, and transferred per time and area unit of relevant devices. Spin electronics (spintronics) is a young interdisciplinary field of nanoscience. Its rapid development, like that of competing new branches of electronics – molecular electronics, bioelectronics, electronics of polymers, …, – has its roots in the conviction that the progress that is being achieved by miniaturization of active elements (transistors and memory cells) cannot continue forever. Therefore, the invention of future information technologies must involve new ideas concerning the design of both devices and system architecture. The main goal of spintronics is to gain knowledge on spin-dependent phenomena, and to exploit them for new functionalities. Hopes associated with spintronics stem from the well-known fact that the magnetic fields present in the ambient world are significantly weaker than the electric fields. For this reason magnetic memories are non-volatile, while memories based on the accumulated electric charge (dynamic random access memory – DRAM) require a frequent refreshing. Today's research on spintronics involves virtually all material families, the most mature being studies on magnetic metal multilayers, in which spin- dependent scattering and tunneling are being successfully applied in reading heads of high-density hard-discs and in magnetic random access memories (MRAM). However, in the context of spintronics particularly promising are ferromagnetic semiconductors, which combine complementary functionalities of ferromagnetic and semiconductor material systems.

In the talk, recent progress in semiconductor spintronics will be reviewed emphasizing findings important for either classical or quantum information devices. In particular, the demonstration of isothermal and reversible switching of magnetization by light and the electric field in ferromagnetic semiconductors will be described. Various schemes enabling injection and manipulation of electronic or nuclear spins in non-magnetic semiconductors and their nanostructures will be discussed. The role of confinement and dimensionality will be presented together with prospects for coherent control of single spins in solid-state environment.

References

For reviews on spintronics, see, e.g., T. Dietl, Semicond. Sci. Technol. 17 (2002) 377; Acta Phys. Polon. A 100, Suppl. (2001) 139, www.arXiv.org/abs/cond-mat/0201279; S.A. Wolf et al., Science 294 (2001) 1488; H. Ohno, F. Matsukura, and Y. Ohno, JSAP International, No. 5, January 2002, pp. 4-13, www.jsapi.jsap.or.jp.

* Corresponding author: phone: (+48) 22.8435324, fax: (+48) 33.8430926, e-mail: dietl@ifpan.edu.pl

PHOTONS AND PHONONS IN MESOSCOPIC SYSTEMS

E.N. Economou*
FORTH, P.O. Box 1527, 71110 Heraklion, Crete, Greece
and Dept of Physics, Univ. of Crete

Over the last fifteen years artificial structures and/or self-assembled materials have been designed and fabricated in order to control the flow of electromagnetic, acoustic, and elastic waves. A common characteristic of these structures is that they produce gaps (or pseudogaps) in the spectrum of these waves. There are two basic mechanisms responsible for the appearance of gaps (or pseudogaps) : resonant scattering and destructive interference. The latter is greatly enhanced in periodic structures (hence the frequently used name photonic and phononic crystals), while the former is usually (but not always) achieved by matching the wavelength to the characteristic dimension of each elemental scatterer. Several examples will be presented to illustrate the interplay between periodicity (or the lack of it) and resonant scattering in the formation of gaps. Finally, recent work on inelastic light scattering by mesoscopic phonons in self-assembled colloidal periodic or glassy systems will be reviewed.

* Corresponding author: e-mail: economou@admin.forth.gr

CLUSTERING IN NEUTRON-RICH NUCLEI

M. Freer* for the Charissa and DéMoN collaborations
School of Physics and Astronomy, University of Birmingham, Birmingham, B15 2TT, UK

Clustering in light alpha-conjugate nuclei is often a dominant structural mode where the clustering degree of freedom is liberated with increasing excitation energy until the point is reached at which the nucleus condenses into a collection of alpha-particles. The most exotic of these alpha-condensates are the predicted chain-states where the alpha-particles are linearly arranged. The experimental evidence for such structures is sparse, the α-α system (^{8}Be) is well documented, measurements of reduced widths and rotational behaviour of this nucleus verify the existence of the underlying cluster structure [1]. However, there is a lack of convincing evidence for the existence of chain-states in the 3α system. The 0^{+} (7.65 MeV) excited state is believed to be linked with an extended structure with an overlap with a bent chain structure, however the linear structure remains to be found [1]. It is possible that the lack of experimental evidence for such a structure reflects the instability against bending modes. Indeed calculations using the Molecular Orbit approach [2] predict the instability of 3α-chain. However, the same calculations indicate that the introduction of valence neutrons, particularly in the instance of ^{16}C, may stabilise these alpha-chains. The role of valence neutrons in such cluster systems is well documented in the beryllium isotopes where the neutrons occupy molecular orbits, covalent in nature [3]. For example, the α+n+α system (^{9}Be) is bound whereas ^{8}Be undergoes alpha-decay. It is possible that such a covalent bonding mechanism enhances the stability of other alpha-cluster structures.

The talk will present the latest developments in the study of molecular structures in beryllium and carbon isotopes, and examine the possibility that clustering is actually the dominant structural mode at the neutron drip-line, where neutrons exist in molecular type orbits, exchanged between the clusters.

[1] M. Freer and A.C. Merchant, J. Phys. G **23** (1997) 261, and references therein.
[2] N. Itagaki, S. Okabe, K. Ikeda, and I. Tanihata, Phys. Rev. C **64**, 014301 (2001).
[3] W. von Oertzen, Z. Phys. A354 (1996) 37, W. von Oertzen, Z. Phys. A357 (1997) 355 and W. von Oertzen, Nuovo Cimento, 110 (1997) 895.

* Corresponding author: e-mail: M.Freer@bham.ac.uk

FRACTURE AND FRAGMENTATION OF DISORDERED SOLIDS

F. Kun*
Department of Theoretical Physics, University of Debrecen
P.O.Box: 5, H-4010 Debrecen, Hungary

The response of a heterogeneous solid, such as concrete or fiber reinforced composites, to an external load strongly depends on the way the load is applied. Under a constant or a quasistatically increasing load disordered materials display a non-linear macroscopic behavior followed by sudden microscopic movements due to the formation and propagation of microfractures, which can also result in a break-up of the specimen into two pieces. The precursory microscopic activity preceding final failure can be observed experimentally by means of acoustic emission analysis. Experiments and model calculations revealed a power law size distribution of bursts over a wide range. Despite the efforts and successes that have been achieved recently, the analogy of fracture to phase transitions remained unclarified.

When a disordered solid is subjected to a high stress for a very short time the solid breaks up into many smaller pieces in a dynamic way. Fragmentation, i.e. the breaking of particulate materials into smaller pieces is a ubiquitous process that underlies many natural phenomena and industrial processes.

In most of the realizations of fragmentation processes the energy is imparted to the system by impact, i.e. typical experimental situations are shooting a projectile into a solid block, free fall impact with a massive plate and collision of particles of the same size. The most striking observation about fragmentation is that the size distribution of fragments shows a power law behavior independent on the microscopic interactions and on the relevant length scales. The origin of the power law distribution of fragment sizes is still under intensive research. Most of the theoretical investigations in these fields rely on large scale computer simulations of lattice and fiber bundle models.

We present recent developments on the computational modeling of fracture and fragmentation phenomena of disordered solids. We study the creep response of solids to a constant external load in the framework of fiber bundle models. A novel fiber bundle model is introduced where the fibers are viscoelastic and their interaction is realistically modeled by an adjustable stress transfer function. Computer simulations showed that increasing the external load on the specimen a transition takes place from a partially failed state of infinite lifetime to a state where global failure occurs at a finite time. The nature of the transition between the two regimes strongly depends on the range of interaction: in the mean field limit it is continuous characterized by power law divergences, while for local interactions the transition becomes abrupt. The creeping system evolves into a macroscopic stationary state accompanied by the emergence of a power law distribution of interevent times of the microscopic breakings.

We present a two-dimensional dynamical model of breakable disordered solids and elaborate the impact fracture and fragmentation of solids at low imparted energy.

* Corresponding author: Phone: (+36) 52 417266, fax: (+36) 52 416181, e-mail: feri@dtp.atomki.hu

Simulating collisions of two solid discs we show that, depending on the imparted energy, the outcome of a collision process can be classified into two states: a damaged and a fragmented state with a sharp transition in between. Analyzing the energetics of the impact and the resulted fragment size distributions we give numerical evidence that the transition point between the damaged and fragmented states behaves as a critical point. The transition proved to be the lower bound for the occurrence of power law size distributions.

Most of the theoretical investigations in this field rely on large scale computer simulations of lattice models where the elastic medium is represented by a spring (beam) network and disorder is captured either by random dilution or by assigning random failure thresholds to the bonds. The failure rule is discontinuous and irreversible: when the local load exceeds the failure threshold of a bond the bond is removed from the calculations. A very important class of models of materials failure are the fiber bundle models, which consist of a set of parallel fibers having statistically distributed strength. The sample is loaded parallel to the fibers' direction and a fiber fails if the load on it exceeds its breaking threshold. After a failure event the load is redistributed on the intact elements.

IS PHYSICS THE PRIVILEGE OF DEVELOPED COUNTRIES?

J.L. Morán-López*
Institute for Scientific and Technological Research of San Luis Potosi
San Luis Potosí, México

Despite the poor economic situation in most of the Latin American countries, there was important scientific activity in the region during the last century. Some examples, extracted from those countries, show that physics is not restricted to wealthy countries.

The first physics research activity in Latin America dates from the late 1940s. With the exception of some experiments on cosmic radiation, early physics research was almost completely theoretical. Along with a well organized scientific activity, undergraduate programs in physics first appeared in the 1940s and graduate programs only in the 1950s. After sixty years of continuous education, in general, the number of physicists is still too small to contribute significantly to the economic development of this large region. Exceptions are Brazil, Mexico, and Argentina, countries that have an important number of physicists that started to contribute to achieve better economic standards. In these countries, there is a growing interest at some universities and research centers to establish bridges with industry.

The first research groups worked mainly in theoretical physics, including cosmic radiation, gravitation, and nuclear, atomic, and high energy physics. Research in optics, statistical physics, and solid state physics developed in the 1970s. Nowadays the most active field of research is materials science. Most of the contributions meet the highest international standards.

One can conclude that the precarious economic development in Latin American countries in the past century did not hinder the implementation of educational programs in physics and the creation of important research groups.

* Corresponding author: e-mail: moran-lopez@ipicyt.edu.mx

HOW MUCH COULD NUCLEAR POWER CONTRIBUTE TO THE MITIGATION OF CO_2 EMISSIONS

H. Nifenecker[1*], D. Heuer[1], J.M. Loiseaux[1], O. Méplan[1], A. Nuttin[1], S. David[2] and J.M. Martin[3]
[1]*ISN 53 ave. des Martyrs Grenoble cedex F38026 France*
[2]*IPN Bat. 100, 15 r. Clemenceau, F91406 Orsay, France*
[3]*IEPE, BP47, F38040 Grenoble Cedex 09, France*

Temperature stabilization requires that CO_2 emissions be limited to less than 2-3 Gt Carbon equivalent, from the present level of more than 6 Gt. Using the WEC-IIASA models as predictions for world energy consumptions and renewable energies contributions, while increasing as much as reasonably achievable, the nuclear contribution at the expense of fossile energies, we find that, even for the most energy consuming scenario with an increase of primary energy demand by 250% in 2050, a nuclear intensive scenario assuming the development of a 2000 GWe pool of PWR reactors by 2030 and of an additional 6000 GWe pool of U-Pu or Th-U breeding reactors by 2050 would lead to temperature stabilization at a level 2 degrees above the pre-industrial level.

[*] Corresponding author: e-mail: nif@in2p3.fr

NEW EFFECTS OF SYMMETRY-BREAKING IN MAGNETIC FIELDS

G.L.J.A. Rikken*
Grenoble High Magnetic Field Laboratory, Max Planck Institut für Festkörperforschung, 25 Av. des Martyrs, F-38042 Grenoble, France

The interaction of light with matter can be strongly influenced by magnetic fields and sometimes in quite unexpected ways. A powerful and elegant way to predict the effects of magnetic fields is the use of symmetry arguments, as will be illustrated. Along these lines, we will discuss the observations of several new magneto-optical phenomena, like the photonic Hall effect and magneto-resistance, magneto-chiral anisotropy and magneto-electric Jones birefringence. These new effects illustrate the usefulness of the symmetry approach, and show at the same time that our detailed understanding of light-matter interaction is still incomplete. Underlining the universality of the symmetry approach, we will show that these new effects have ramifications into other areas of solid state physics and chemistry.

* Corresponding author: e-mail: rikken@polycnrs-gre.fr

RECENT PROGRESS AND FUTURE DEVELOPMENTS IN GRAVITATIONAL PHYSICS

G. Schäfer*
Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena

After the renaissance of gravitational physics in the sixties of the last century, progress in the field of high precision measurements resulted in new steps in the development of gravitational physics towards the realization of gravitational wave astronomy and, more remotely, the unification of all forces.

The talk summarizes the past and future experimental activities in both areas of gravity. Emphasis will be given to Earth-based and space-borne experiments for
(i) testing the foundations of general relativity, particularly the equivalence principle for which Loránd von Eötvös became famous in relativity and the universality of gravitational redshift;
(ii) verifying gravitomagnetism with high precision;
(iii) revealing the wave content of the gravitational field; and
(iv) proving the very existence of black holes.

The gravitational wave astronomy will be sketched and schemes for the unification of all forces will be mentioned includinga short discussion of cosmology.

* Corresponding author: e-mail: gos@tpi.uni-jena.de

THE IMPORTANCE OF BEING DISCRETE: THE EMERGENCE OF COMPLEX SOCIAL DYNAMICS FROM SIMPLE INDIVIDUAL INTERACTIONS

S. Solomon*
Physics Department, Hebrew University of Jerusalem

The discrete microscopic structure of the macroscopic objects was postulated since the time of Democritus. The crucial relevance of this fact for their actual properties became evident in the modern times starting with the Dalton laws in chemistry and culminated in physics with the statistical atomic-molecular mechanics of Boltzmann and Maxwell.

It turns out that in systems with auto-catalytic interactions (proliferation, contagion, information spread) as most biological and social systems are, the discreteness of the elementary components and interactions (e.g. giving birth to a new individual, informing a neighbor of a new product, adoption of a new idea by an individual, contracting a disease) is even more crucial. Indeed, for many of such systems the continuum approximation (ignoring microscopic discretness) would predict an uniform, static (life-less, trade-less, idea-less) asymptotic state. In reality such systems present generically emergent spatio- temporal localized objects with unexpected collective dynamical properties: adaptability, resilience and sustainability.

I will present this generic mechanism of emergence of macroscopic complexity from microscopic noise and its application to a few social phenomena.

* Corresponding author: e-mail: sorin@cc.huji.ac.il

DECONFINED NUCLEAR MATTER, WHAT HAVE WE LEARNT FROM THE SPS?

J. Stachel*
University of Heidelberg

In calculations within lattice QCD at finite temperature a phase transition is found where partons become deconfined and chiral symmetry is restored. The new phase formed is called the Quark-Gluon Plasma. The current best temperature for the phase transition is 170 MeV at zero net baryon density. With increasing density the critical temperature decreases. In the laboratory temperatures in this range can be achieved in collisions of atomic nuclei at relativistic energies. The experimental program to study the formation of the Quark-Gluon Plasma started at the CERN SPS in 1986, initially with light beams of oxygen and sulfur of 200 GeV per nucleon. Since 1994 also lead beams have been used. This talk will summarize results obtained by the seven experiments in this program. There is strong evidence from the combined data on production of hadrons, di-leptons and photons that indeed in such heavy ion collisions a new form of matter is formed. The system is at the critical temperature at the time when hadron yields are frozen in and at a significantly higher energy density earlier. The various observables and their connection to the Quark-Gluon Plasma formation will be discussed. A short outlook to the collider program will be given.

* Corresponding author: e-mail: stachel@physi.uni-heidelberg.de

REMEMBERING EUGENE WIGNER AND PONDERING HIS LEGACY

L. Tisza*
Massachusetts Institute of Technology
Cambridge, Massachusetts, 02139

We celebrate the centenary of Eugene Wigner who was almost of the same "quantum age" as Heisenberg and Pauli. However, the latter were intimately involved in adapting Bohr's quantum theory to the mathematical description of atomic spectroscopy and were among the main architects of the upgrading of old quantum theory into quantum mechanics (QM). By contrast Wigner graduated in 1925 as chemical engineer in Berlin. Although he was fascinated by the quantum theory he was exposed to at the Berlin Colloquium, he returned to Budapest to work in the tanning factory where his father was director. His mentor Michael Polanyi soon rescued him by getting him invited as an x-ray technician to Berlin. The factory was a total dead-end, but I will argue that the chemical training and his sensitization to mathematics in school were positive influences, since QM was basically a novel confluence of physics, mathematics and chemistry. (See the excellent summary in the November 1977 issue of "Fizikai Szemle".)

Wigner's training prepared him for an important role in the Manhattan Project, where he was put in charge of constructing the plutonium producing Hanford facility. He guided the industrial contractor to upgrade traditional chemical engineering techniques to include nuclear phenomena, thus solving the novel cooling problems.

Years before this event, Wigner's background already helped to shape his contribution to fundamental QM, although in a subtle way. His early experience in x-ray crystallography brought him in contact with symmetry. This resonated with his liking for mathematics stimulated in gymnasium and greatly supported by his prodigy friend Johnny von Neumann. All this added up to a program of applying the theory of group representations to atomic spectroscopy. The papers that he wrote in 1927-9, some of them jointly with Neumann, are seminal in the field. He collected the material in a widely read book that helped to overcome the community's aversion to "Gruppenpest". The issue was the conflict between the analysis of the continuum and the discontinuity of algebra, reflecting the discontinuity of chemistry.

Wigner extended the range of his activities to molecules, solids and nuclear physics, always focusing on problems of symmetry and invariance. His nuclear physics achievements and work on symmetry earned him the Nobel Prize in 1963. Wigner's highly mathematical theory of the Lorentz group will be discussed. His tensor-space parametrization as against the complex spinors of Dirac raises problems of ways to choose the optimal mathematical formalism in the natural sciences.

Wigner has a paper addressing this problem "The unreasonable effectiveness of mathematics in the natural sciences." This is a widely read paper; it has great charm; it

* Corresponding author: e-mail: tisza@mit.edu

is utterly free of jargon, but its understated yet sharp sense of humor may have caused it not be taken seriously as a philosophical – methodological statement. A considerable effort will be made to counteract this impression, and to show that the paper deserves a serious consideration for improving the methodological habits formed during the halcyon days of the early last century. In celebrating men of great originality we should heed not only the problems they solved but also those they posed.

WHAT HAVE WE LEARNT WITH THE LEP MACHINE?

D. Treille*
CERN, Geneva, Switzerland

Twelwe years of physics at the LEP electron-positron collider of CERN have brought an impressive harvest of results. The Standard Model (SM) of Particle Physics has been tested quantitatively at the per mil level and found to provide an excellent description of all experimental facts. Theories attempting to go beyond the SM in order to cure some of its generic defects have been severely constrained.

The extreme accuracy of several measurements gave access to the effect of virtual particle exchanges and provided key information on their existence and/or properties. The evolution of the couplings of the basic forces with the energy scale has been measured, suggesting the possibility of a Grand Unification at very high energy, in an extension of the SM called Supersymmetry.

The highest energies obtained at LEP allowed to perform direct searches for the Higgs boson or alternative scenarios, supposed to explain the origin of mass and the breaking of the Electroweak Symmetry. New particles postulated by Supersymmetry were also looked for. No discovery was made, but limits on the mass of these particles or the magnitude of new effects were set and, for some versions of the theory, are already quite significant.

All these experimental achievments were due to several technological and instrumental breakthroughs, concerning the machine as well as the detectors. They will be briefly described.

* Corresponding author: e-mail: daniel.treille@cern.ch

CROWD CONTROL

T. Vicsek*
Department of Biological Physics,
Eötvös University, Budapest, Hungary

The interpretation of collective human behavior represents a great challenge for sciences. Here we discuss an emerging approach to this problem based on methods of statistical physics. We demonstrate that in cases when the interactions between the members of a group are relatively well defined (e.g, pedestrian traffic, network formation, synchronization, panic, etc) the corresponding models reproduce relevant aspects of the observed phenomena.

Among several realistic situations weinvestigate systems mimicking peple trying to leave a dangerous location during panic (http://angel.elte.hu/~panic). Our results suggest practical ways of minimising the harmful consequences of such events and the existence of an optimal escape strategy, corresponding to a suitable mixture of individualistic and collective behaviour. In addition, another kind of collective human behaviour - the synchronization of expressing satisfaction of audiencies (e.g clapping) - will be described.

(The above results have been obtained in collaboration with A-L.Barabási, A. Czirók, I. Farkas, Z. Néda and D. Helbing)

* Corresponding author: e-mail: vicsek@angel.elte.hu

SINGLE ATOM EXPERIMENTS AND THE TEST OF QUANTUM PHYSICS

H. Walther*
Sektion Physik der Universität München and
Max-Planck-Institut für Quantenoptik,
85748 Garching b, Germany

In recent years quite a few experiments on the interaction of radiation with single atoms in cavities and traps have been performed emphasising the quantum features of the interaction. A brief review of recent experiments of this type will be given. Since traps allow to probe the same atom for a long time and in addition to study the detailed time behaviour of the radiation-atom interaction e.g. by observing quantum jumps, it is promising to combine optical cavities with high quality factors with the known trapping techniques. It has been shown that a single atom laser with interesting new features can be realised. In the talk special emphasis will be given to the application of trapped ions for quantum information processing and to frequency standards.

* Corresponding author: phone (+49)89 32905 704, fax: (+49)89 32905 314,
e-mail: herbert.walther@mpq.mpg.de

THE ORIGIN OF COSMIC RAYS

A. Wolfendale*
Department of Physics, University of Durham, Durham, UK.

The facts that the energy density of cosmic rays is the same as that of starlight, the energy range – per particle – extends to the highest energies known to mankind and that we do not know where cosmic rays come from all lead to the subject of origin being an exciting one.

The lecture will survey the scene – from 109 eV to 1020 eV – and give the author’s own preferences.

* Corresponding author: phone: +44 191 374 2160, fax: +44 191 374 3848,
email: a.w.wolfendale@durham.ac.uk

An outline of future trends and prospects for the development and application of these latest types of heterostructures is presented. 1998 American Institute of Physics. S1063-7826 98 00101-X. 1. INTRODUCTION. It would be very difcult today to imagine solid state physics without semiconductor heterostructures. Semiconductor heterostructures and especially double heterostructures, including quantum wells, quantum wires, and quantum dots, currently comprise the object of investigation of two thirds of all research groups in the physics of semiconductors.